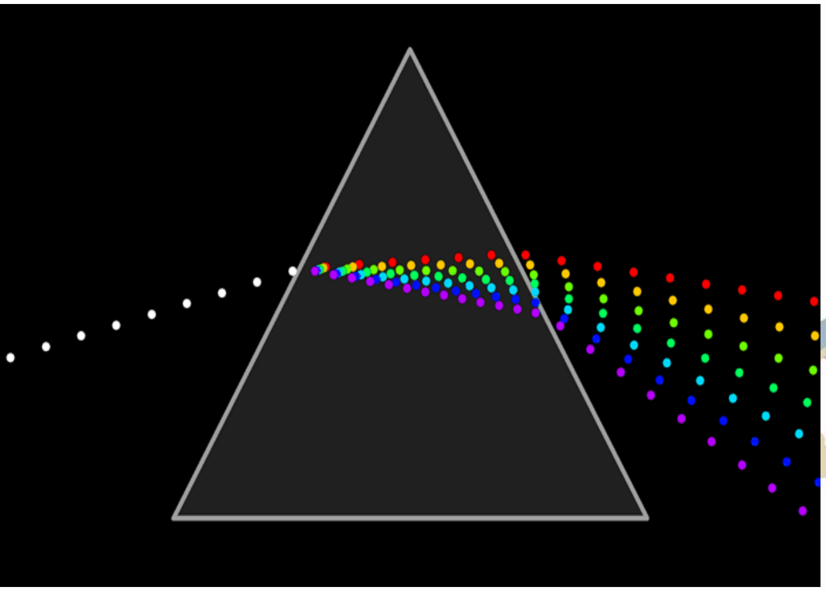


Physics/ Grade 10

Unit Three – Optics

Chapter 11 – Refraction of Light

Prepared Presented by: Mr. Mohamad Seif

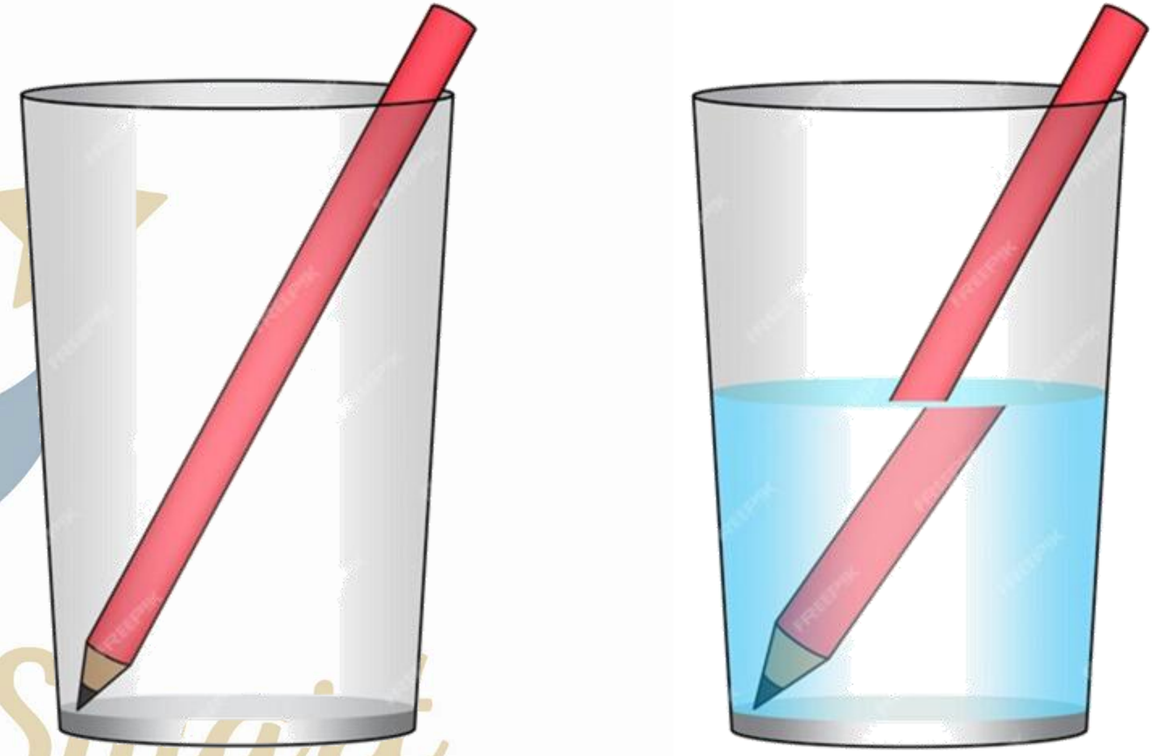
OBJECTIVES

1. Definition of refraction
2. Determine the index of Refraction
3. Laws of Refraction

Refraction of Light

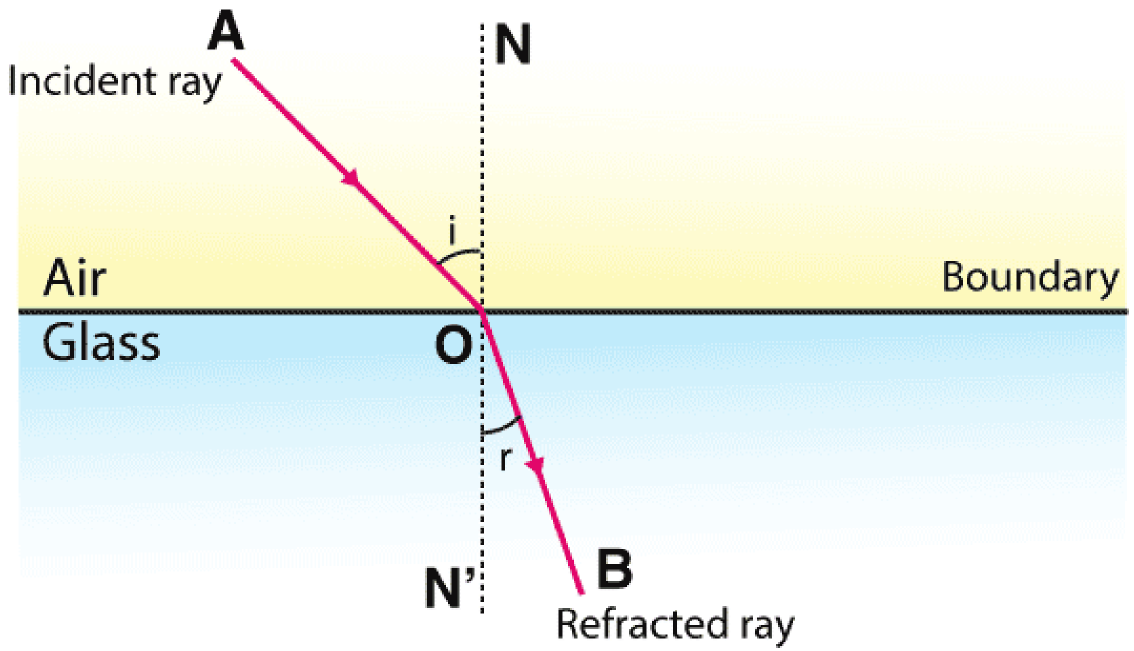
What is refraction of light?

Refraction of light is a sudden change in the direction of light, when the light crosses the surface separating two transparent mediums.



Definition of Refraction of light

- **AO:** **incident ray of light.**
- **OB:** **Refracted ray of light**
- **NN′:** **Normal.**
- i: **angle of incidence**
- r: **angle of refraction**



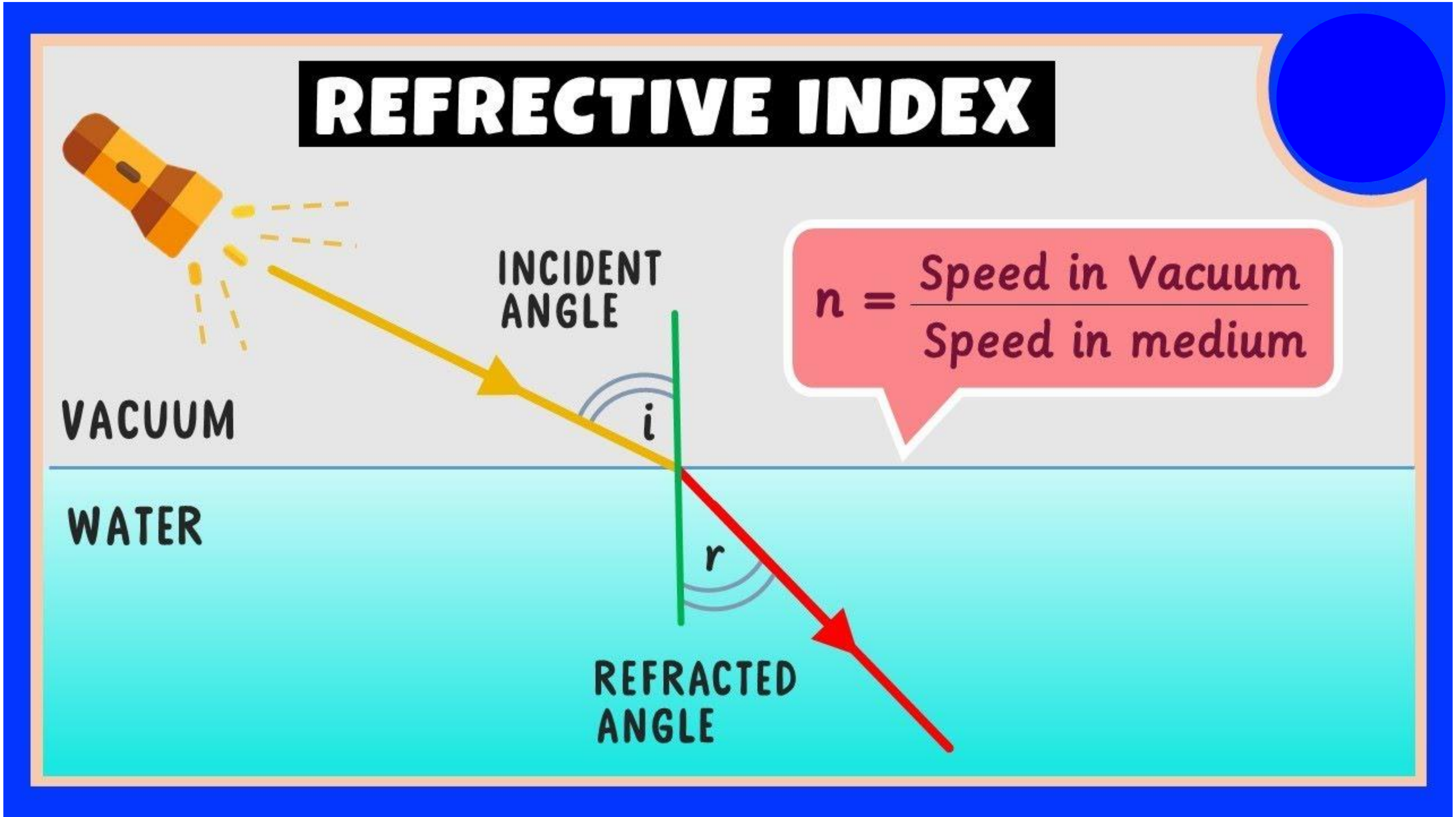
Index of Refraction

What is index of refraction?

In optics, the refractive index (or refraction index) of an optical medium is a number that gives the indication of the light bending ability of that medium.

The refractive index determines how much the path of light is bent, or refracted, when entering a material

Index of Refraction



Index of Refraction

Medium	Refractive Index
Vacuum	1
Helium	1.000036
Water (typical)	1.30
Sugar Solution (30%)	1.38
Glass (typical)	1.5
Diamond	2.4

Density of medium

Low Density

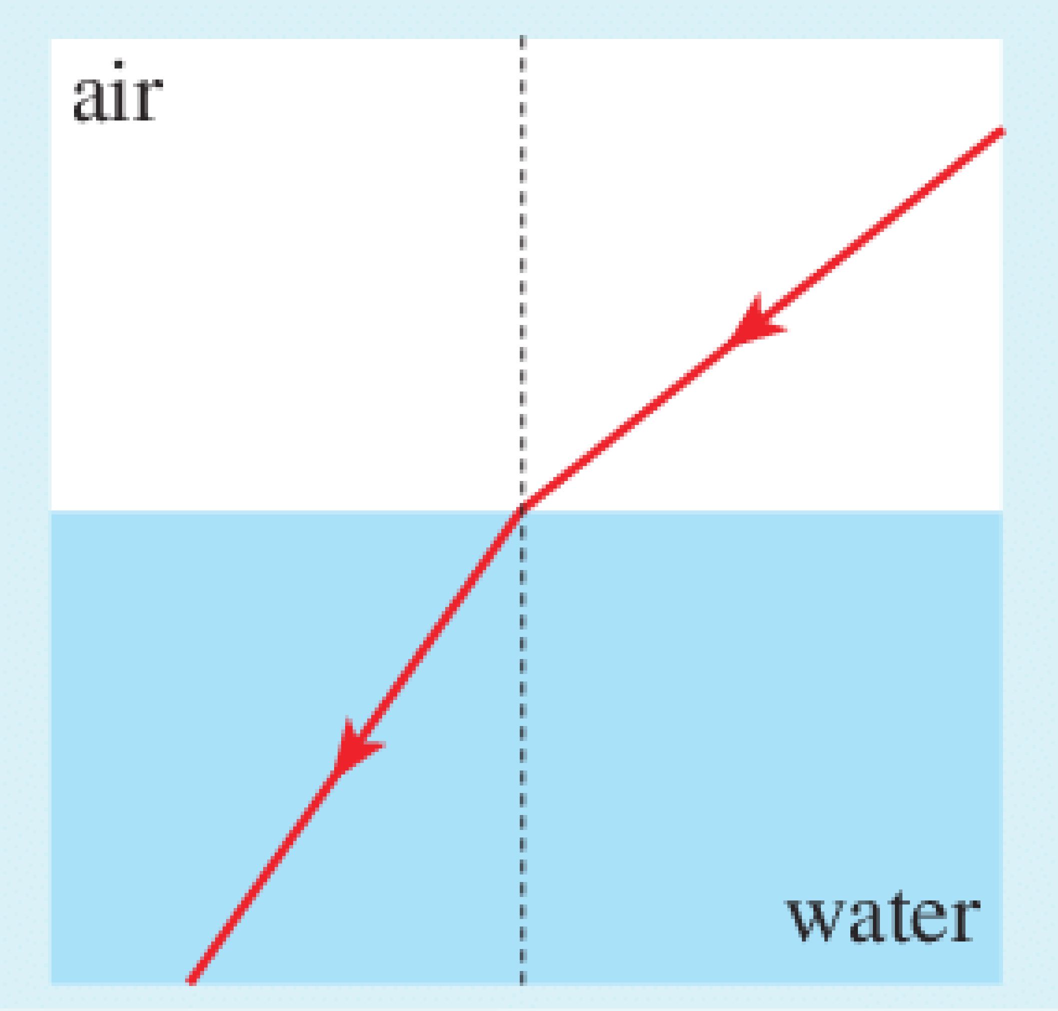
↓

High Density

Index of Refraction

Application 1:

A light ray passes from vacuum to water as shown.
The speed of light in air is $c = 3 \times 10^8 m/s$, while the speed of the light in water is $V = 2.25 \times 10^8 m/s$.



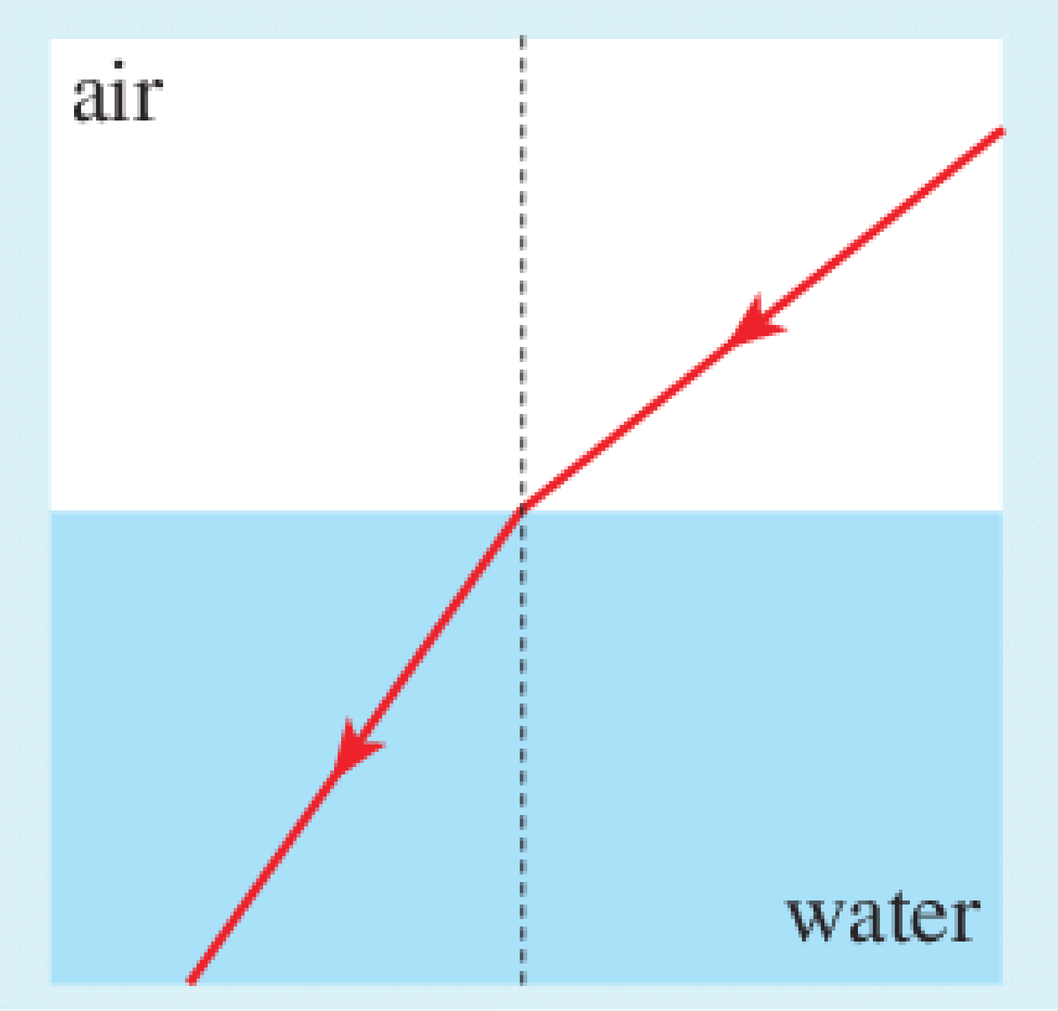
Index of Refraction

1) Calculate the index of refraction of water.

$$n = \frac{speed\ in\ vacuum}{speed\ in\ water}$$

$$n = \frac{c}{V} = \frac{3 \times 10^8}{2.25 \times 10^8}$$

$$n = 1.33$$



Index of Refraction

2) Calculate the speed of light when it crosses a glass prism, knowing that $n_{glass} = 1.5$.

$$n = \frac{speed\ in\ vacuum}{speed\ in\ glass} \Rightarrow n = \frac{c}{V}$$

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

$$V = 2 \times 10^8 m/s$$

Index of Refraction

Note

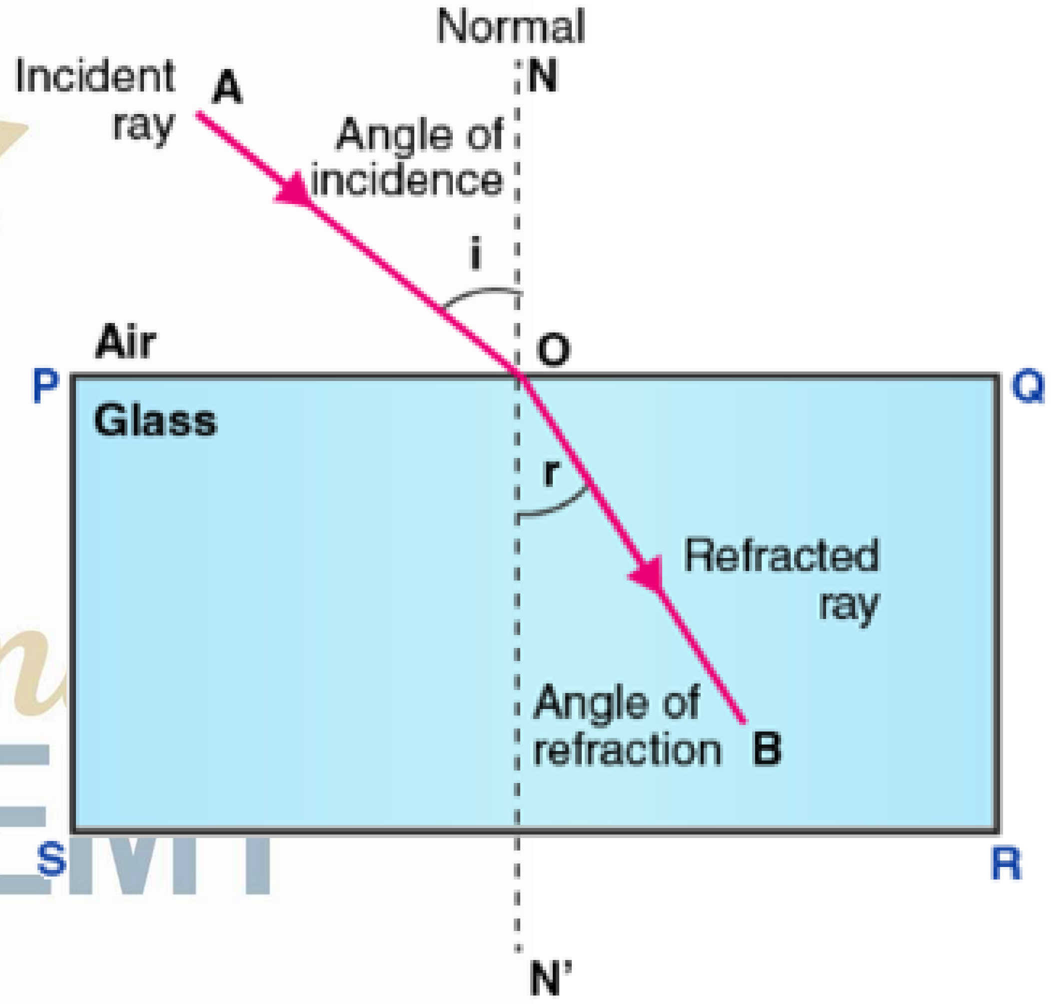
The medium with the smallest index of refraction is called the less refractive medium

The medium with the larger index of refraction is called the more refractive medium or an optically denser medium

Laws of Refraction

First law of refraction:

The incident ray, the refracted ray, and normal to the surface of separation of two media, all are in the same plane of incidence.

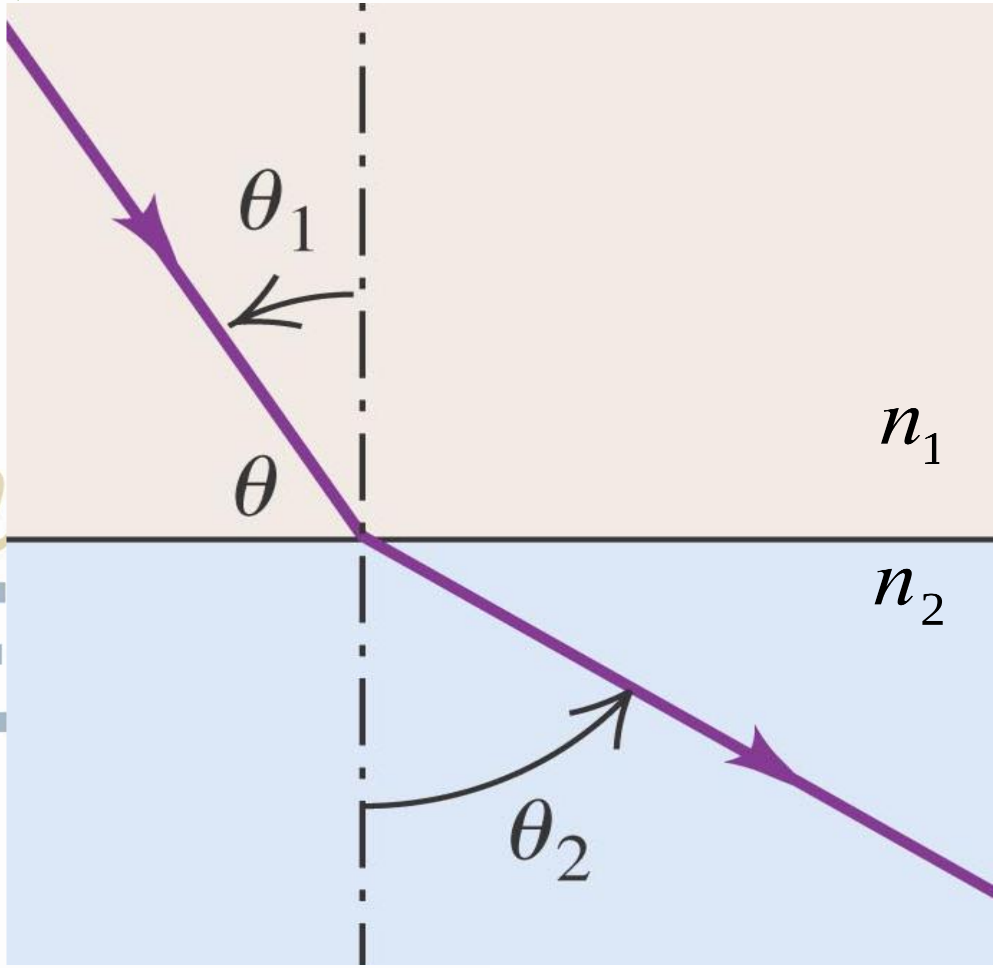


Laws of Refraction

Second Law of refraction (Snell's Law):

When light passes from medium (1) of index of refraction n_1 to medium (2) of index n_2 then:

$$n_1 sin(\theta_1) = n_2 sin(\theta_2)$$

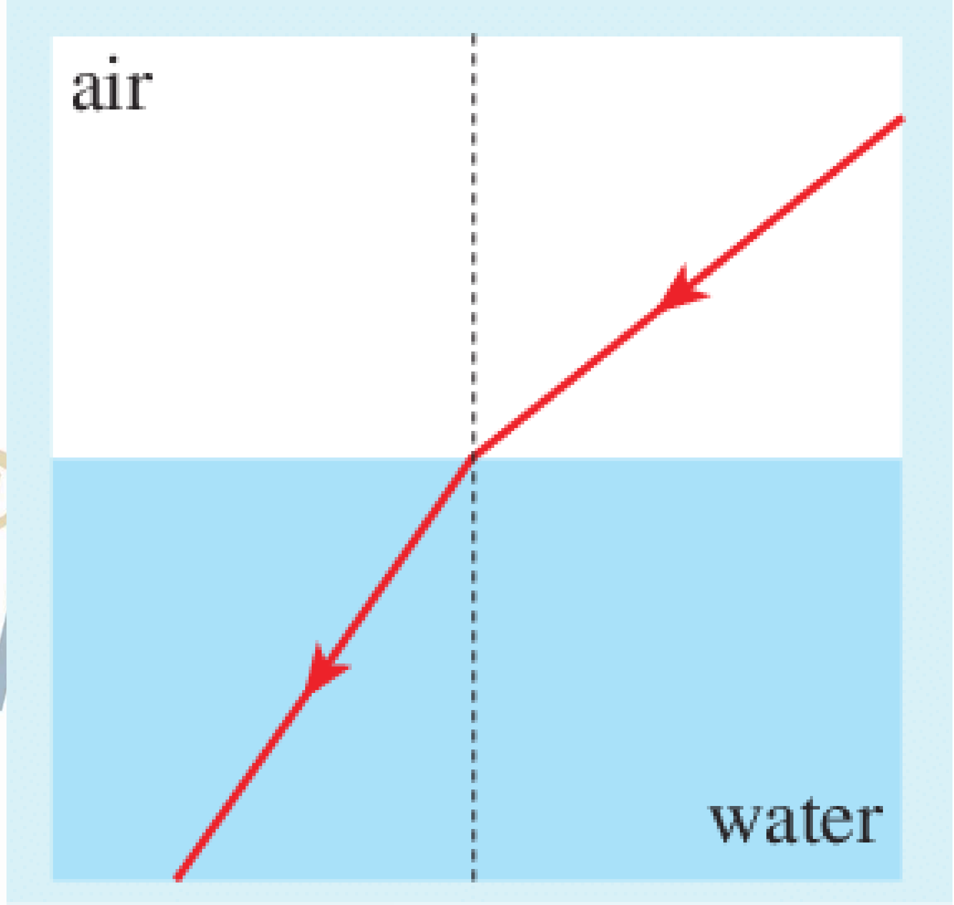


Laws of Refraction

Application 2:

A light ray in air is incident to the surface of separation between air and a medium (A).

The angle of incidence in air of the light ray is $= 60^{\circ}$ and emerges with an angle of 30°.
Calculate the index of refraction n_2 of medium (A).



Laws of Refraction

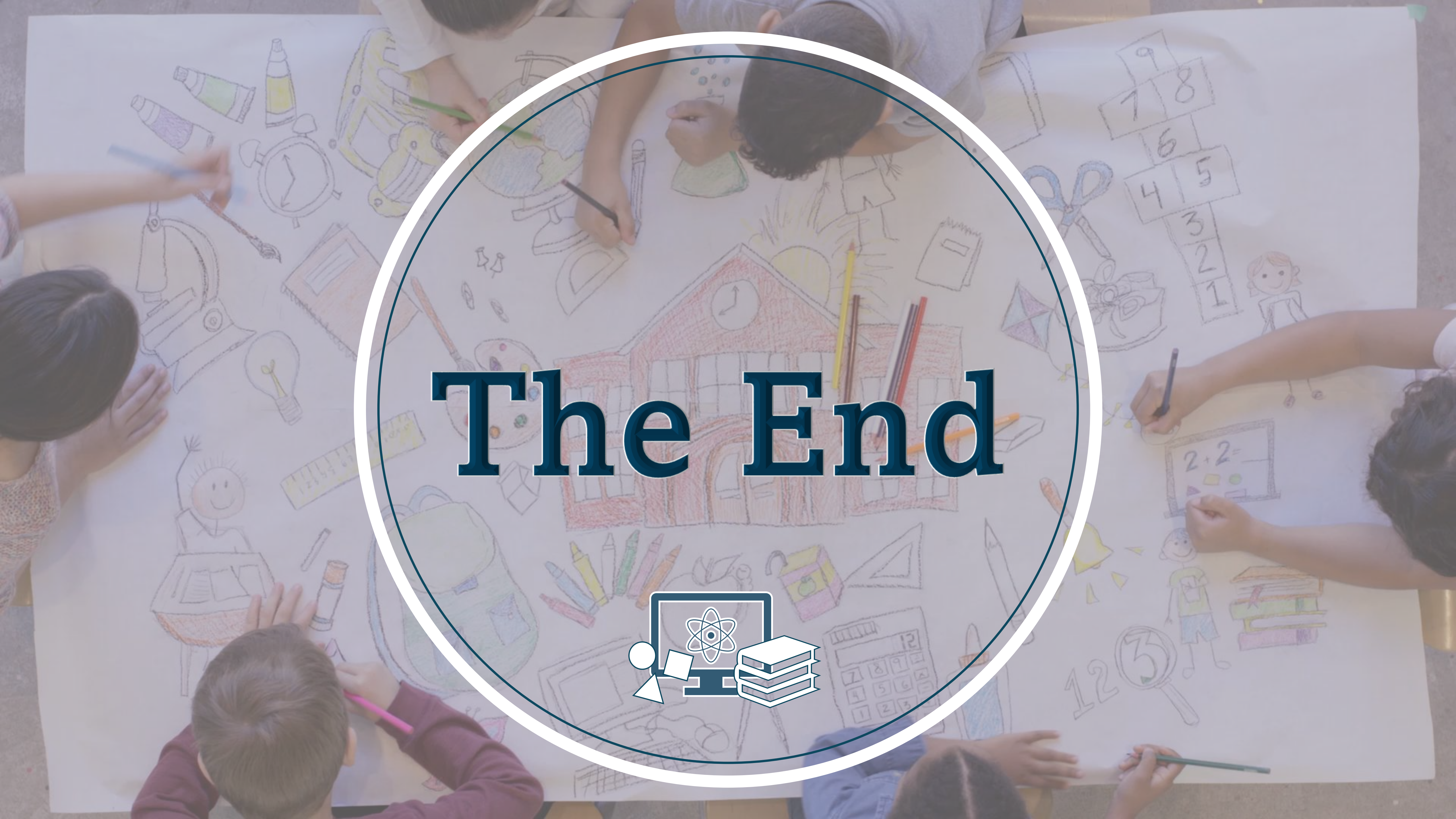
Apply Snell's Law of refraction:

$$n_1 sin(\theta_1) = n_2 sin(\theta_{2)}$$

$$(1) sin(60) = n_2 sin(30)$$

$$n_2 = \frac{1 \times sin(60)}{sin(30)}$$

$$n_2 = 1.73$$



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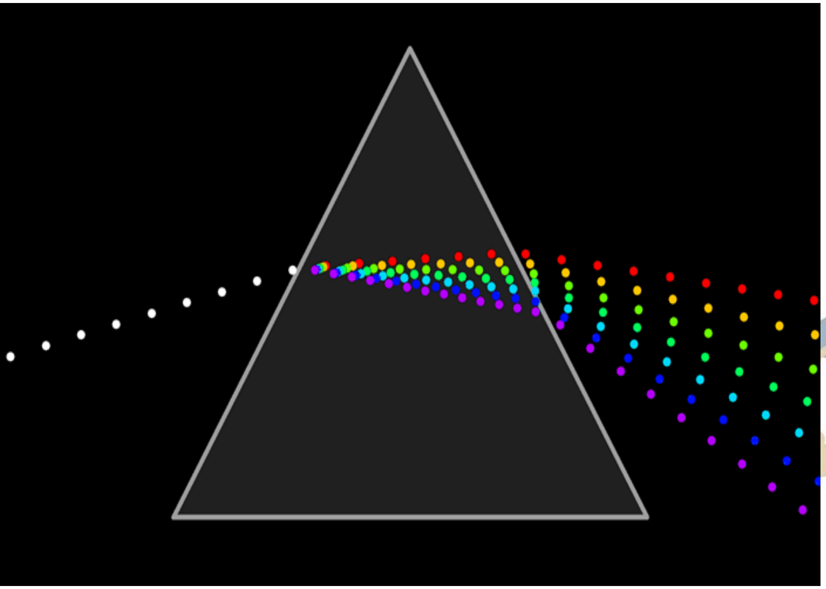


Physics/ Grade 10

Unit Three – Optics

Chapter 11 – Refraction of Light

Prepared Presented by: Mr. Mohamad Seif

OBJECTIVES

1 Cases of refraction

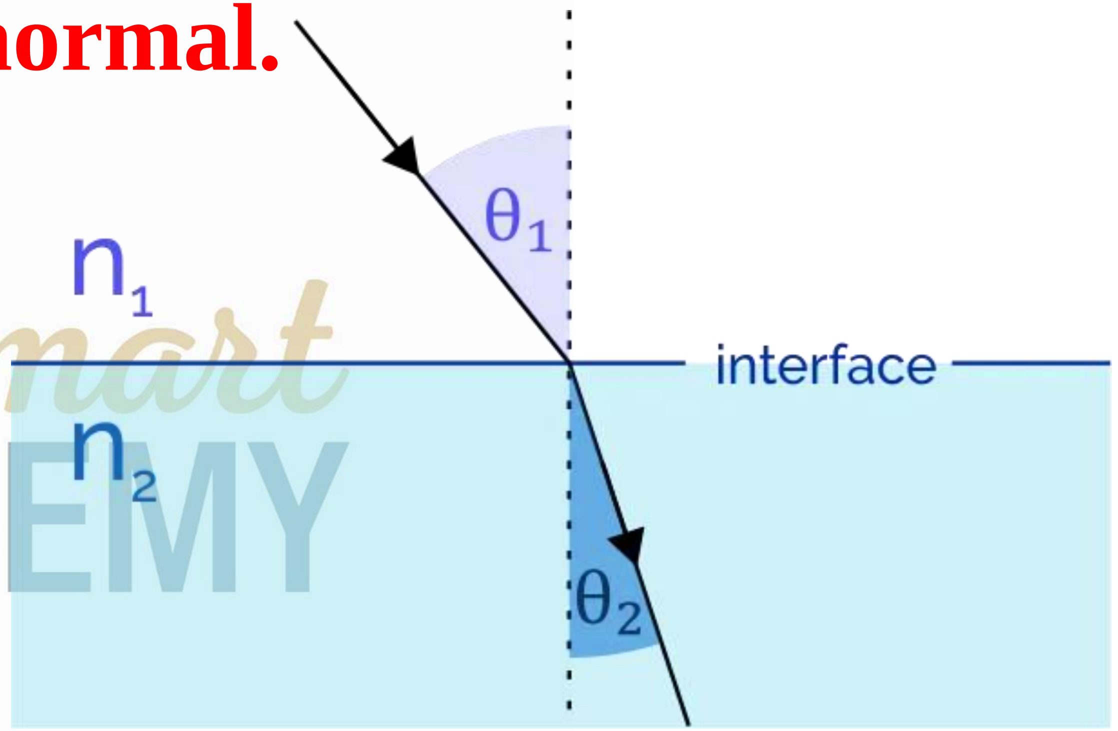
Cases of Refraction

Case 1:

If a light ray passes from a medium (1) of less index (n_1) to medium (2) of more index (n_2); that gives ($n_1 < n_2$), then the ray is refracted towards the normal.

We notice that the angle of refraction is smaller than the angle of incidence:

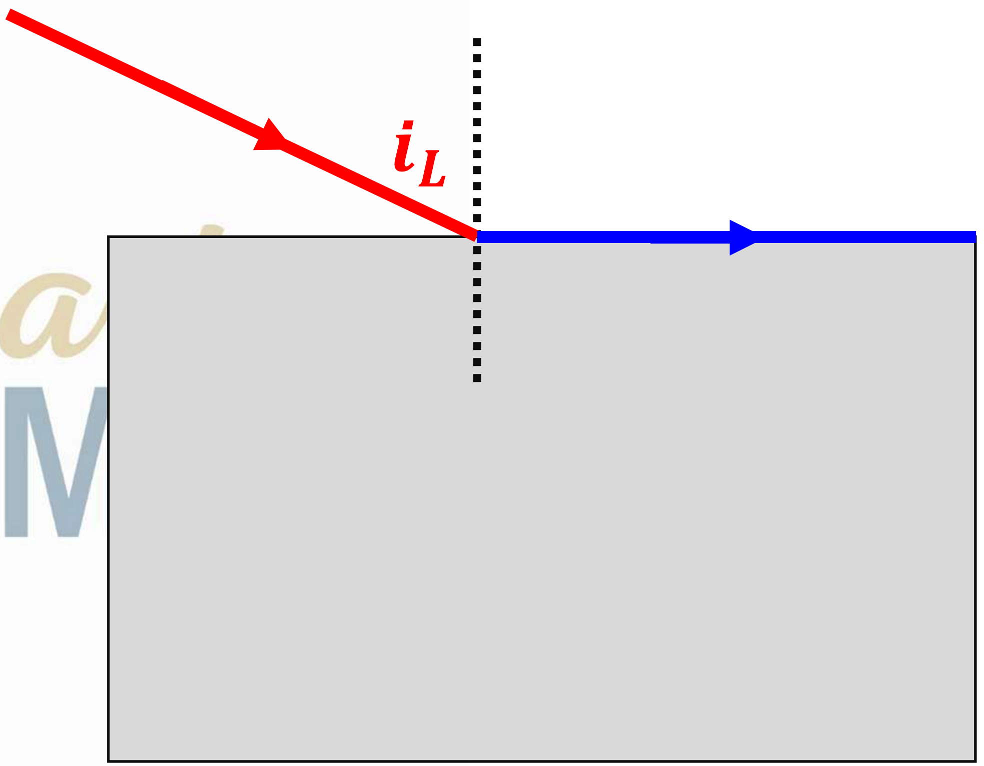
$$\theta_1 > \theta_2$$



Cases of Refraction

Case 2: If a light ray passes from a medium of more index to medium of less index: $n_1 > n_2$: compare i with i_L

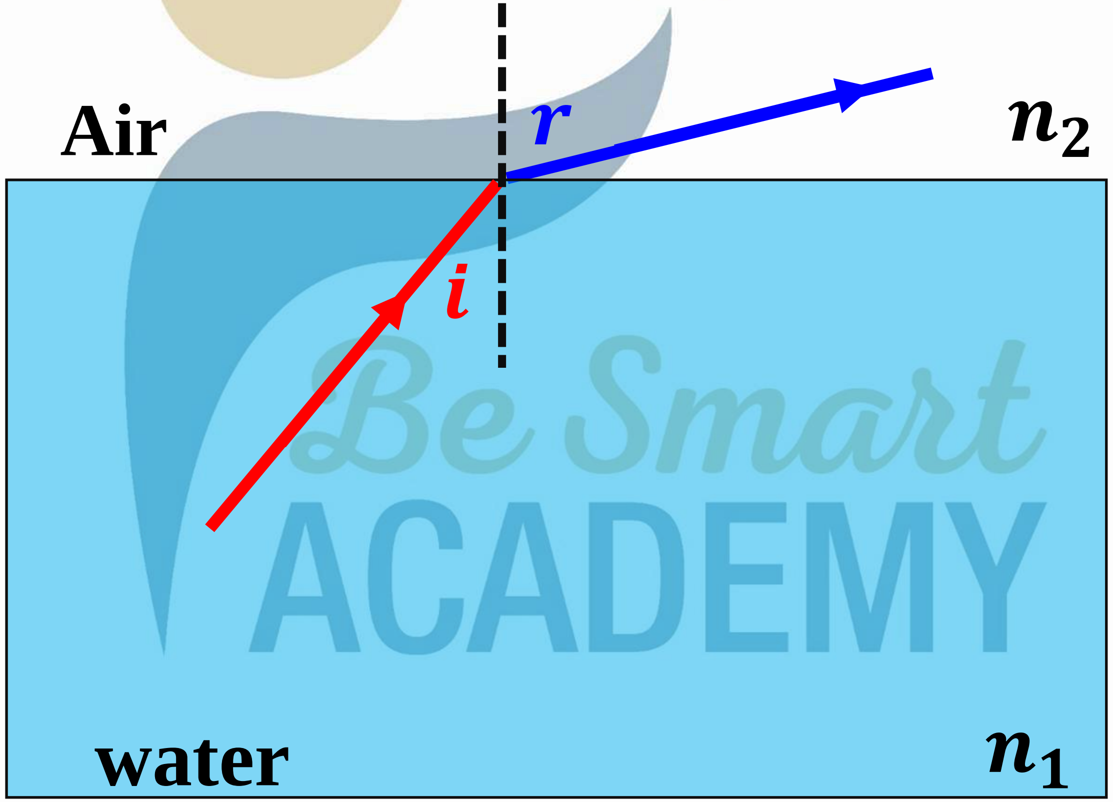
Limiting angle (i_L): is the incident angle that corresponds to an angle of refraction of 90°.



Cases of Refraction

a)If $i < i_l$ then:

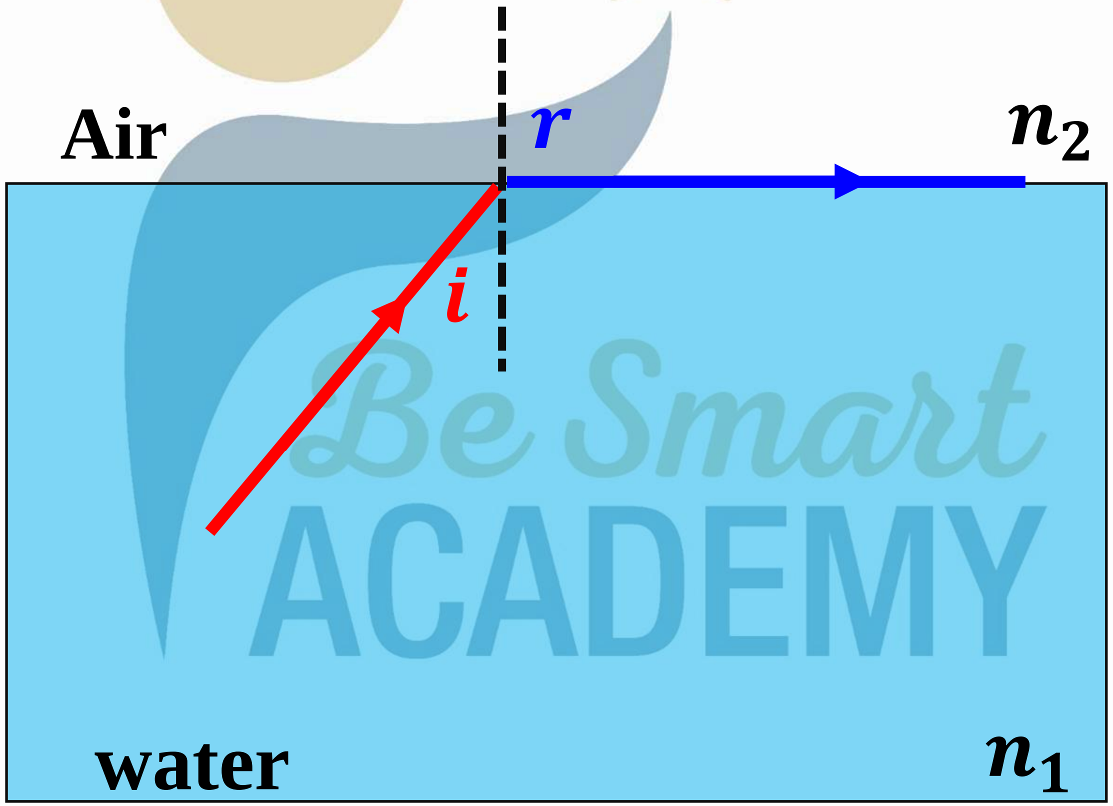
The ray is refracted away from the normal.



Cases of Refraction

If $i = i_l$:

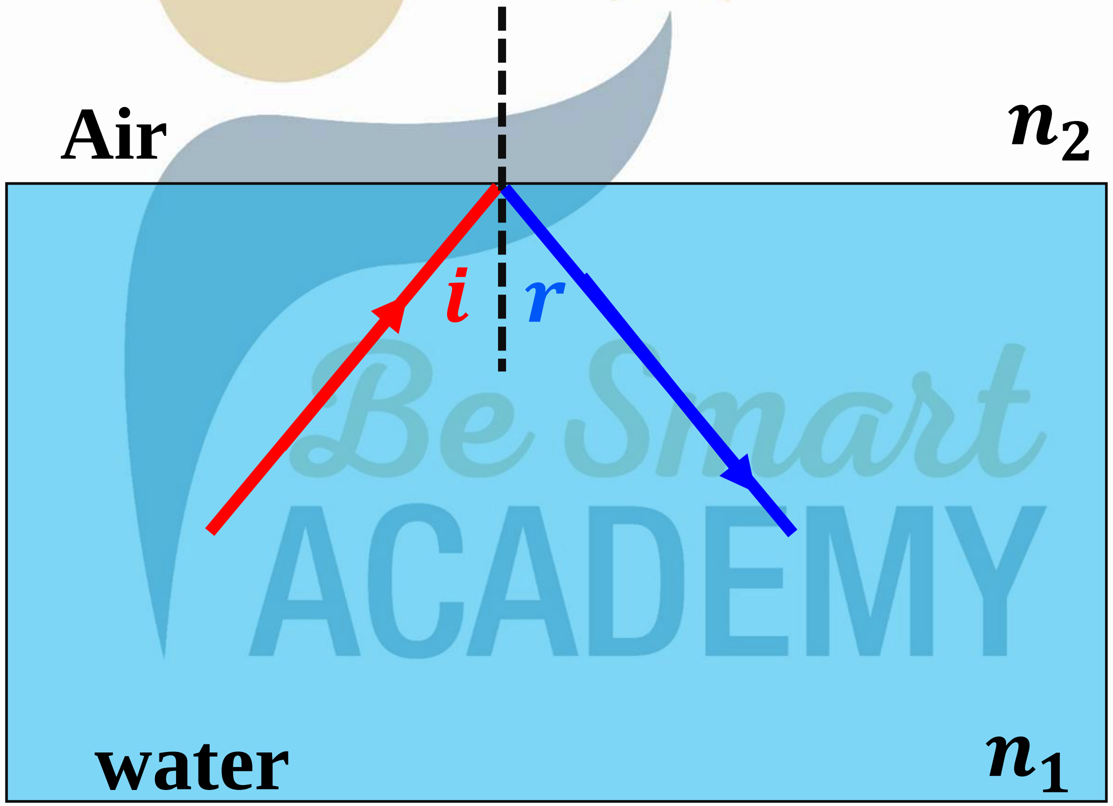
The refracted ray grazes the surface (r = 90).



Cases of Refraction

If $i > i_l$:

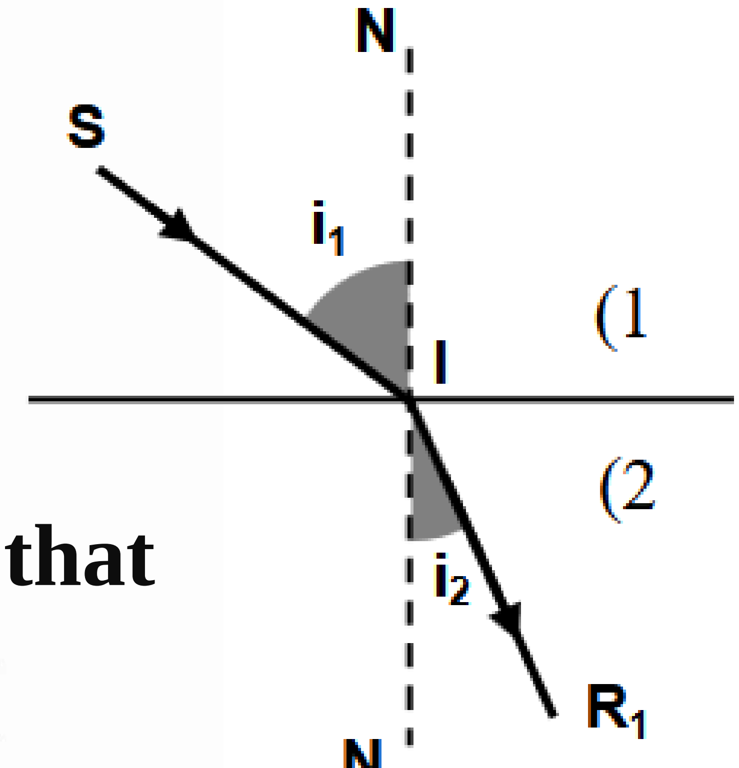
The ray undergoes Total Internal Reflection ($i = r$).



Cases of Refraction

Application 3: We send a luminous ray S_1I in medium (1) at an angle of incidence i_1.

It emerges into medium (2) along the ray IR_1 that forms an angle i_2 with the normal NN'.



1. Give the name of the physical phenomenon that the ray S_1I undergoes at I.

2. S_1I represents the incident ray. What does I R_1 represent?

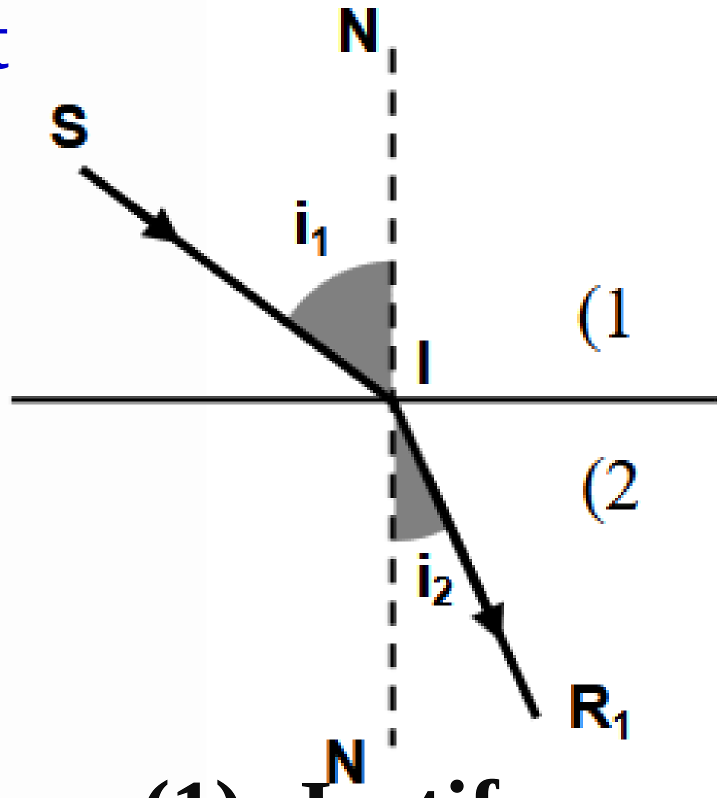
3. Compare i_1 and i_2.

4. The medium (2) is more refractive than medium (1). Justify.

Cases of Refraction

1. Give the name of the physical phenomenon that the ray S_1I undergoes at I.

The physical phenomenon The refraction of light



2. S_1I represents the incident ray. What does I R_1 represent?

I R_1 is the refracted ray.

3. Compare i_1 and i_2.

According to the figure, we find $i_1 > i_2$

4. The medium (2) is more refractive than medium (1). Justify.

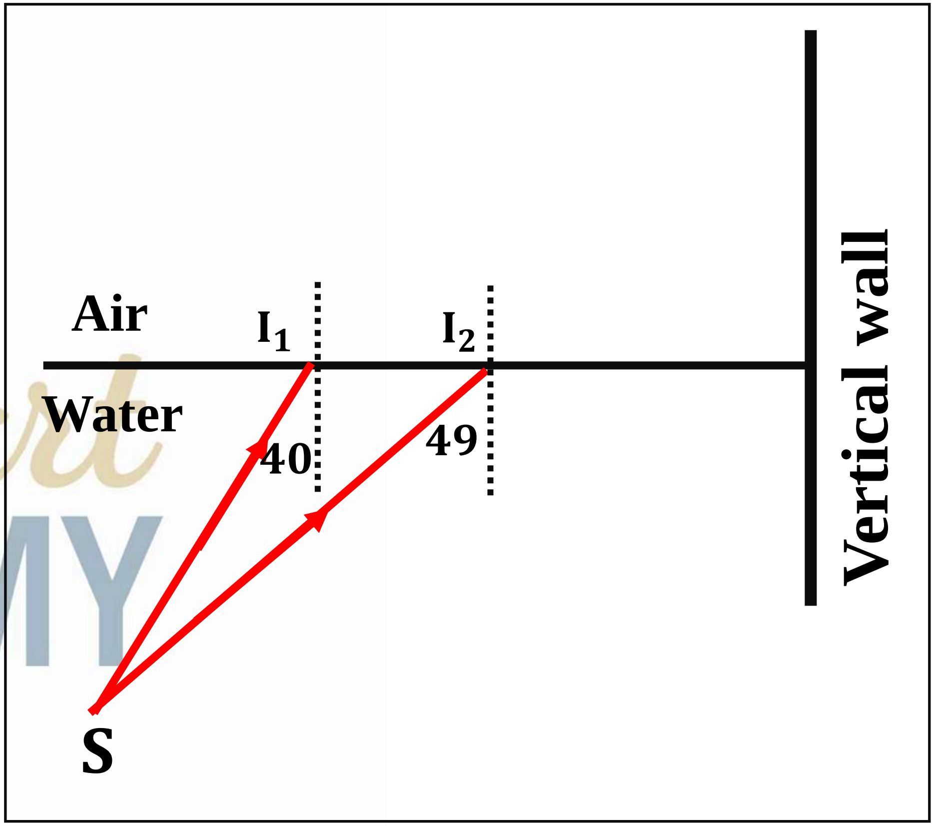
The refracted ray is closer to the normal than the incident ray ($i_2 < i_1$). The medium (2) is then more refractive than the medium (1).

Cases of Refraction

Application 4: A source S of red light placed in water, sending a beam of luminous light rays, on the horizontal surface of separation water-air under an angle of incidence i_1. Given $i_L = 49^{\circ}$

1) Study and complete the path of the ray SI_1.

2) Study and complete the path of the ray SI_2



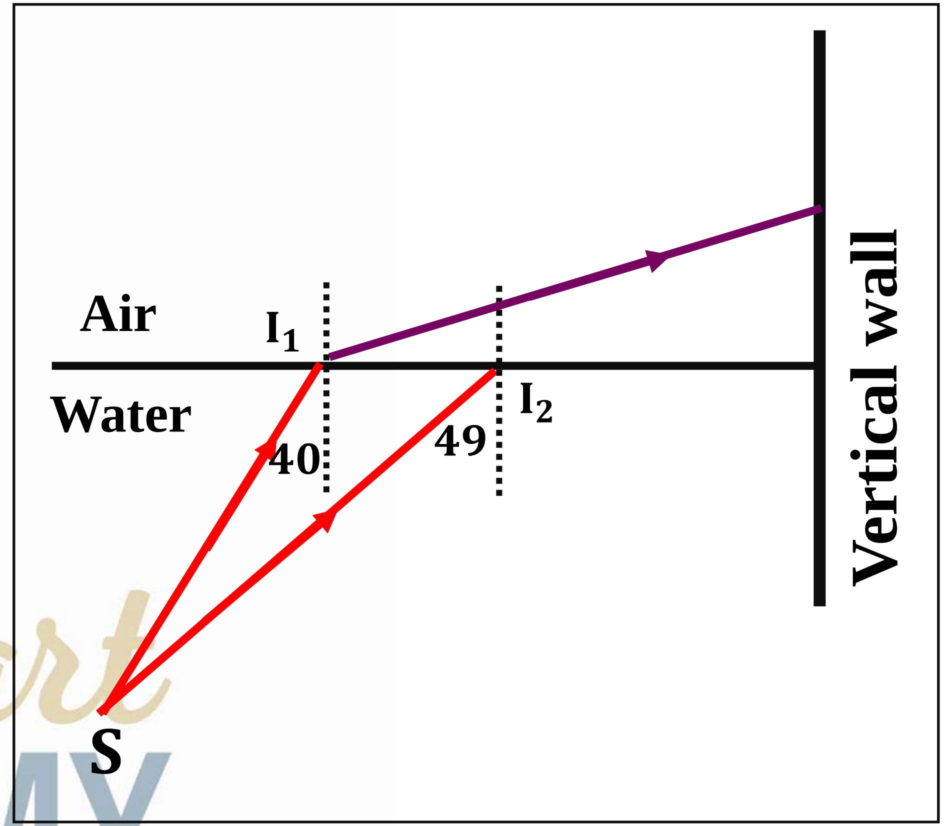
Cases of Refraction

1) Study and complete the path of the ray SI_1.

The ray SI_1 passes from medium of more index to medium of less index ($n_1 > n_2$):

$$i_1 = 40^\circ < i_L = 49^\circ$$

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



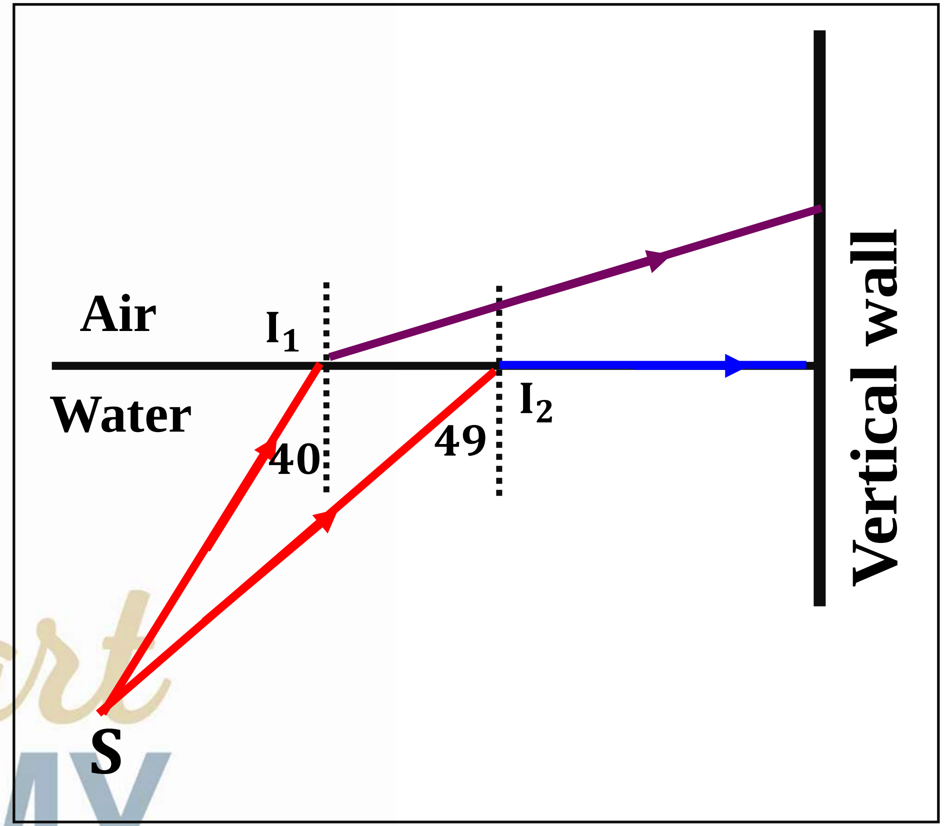
Cases of Refraction

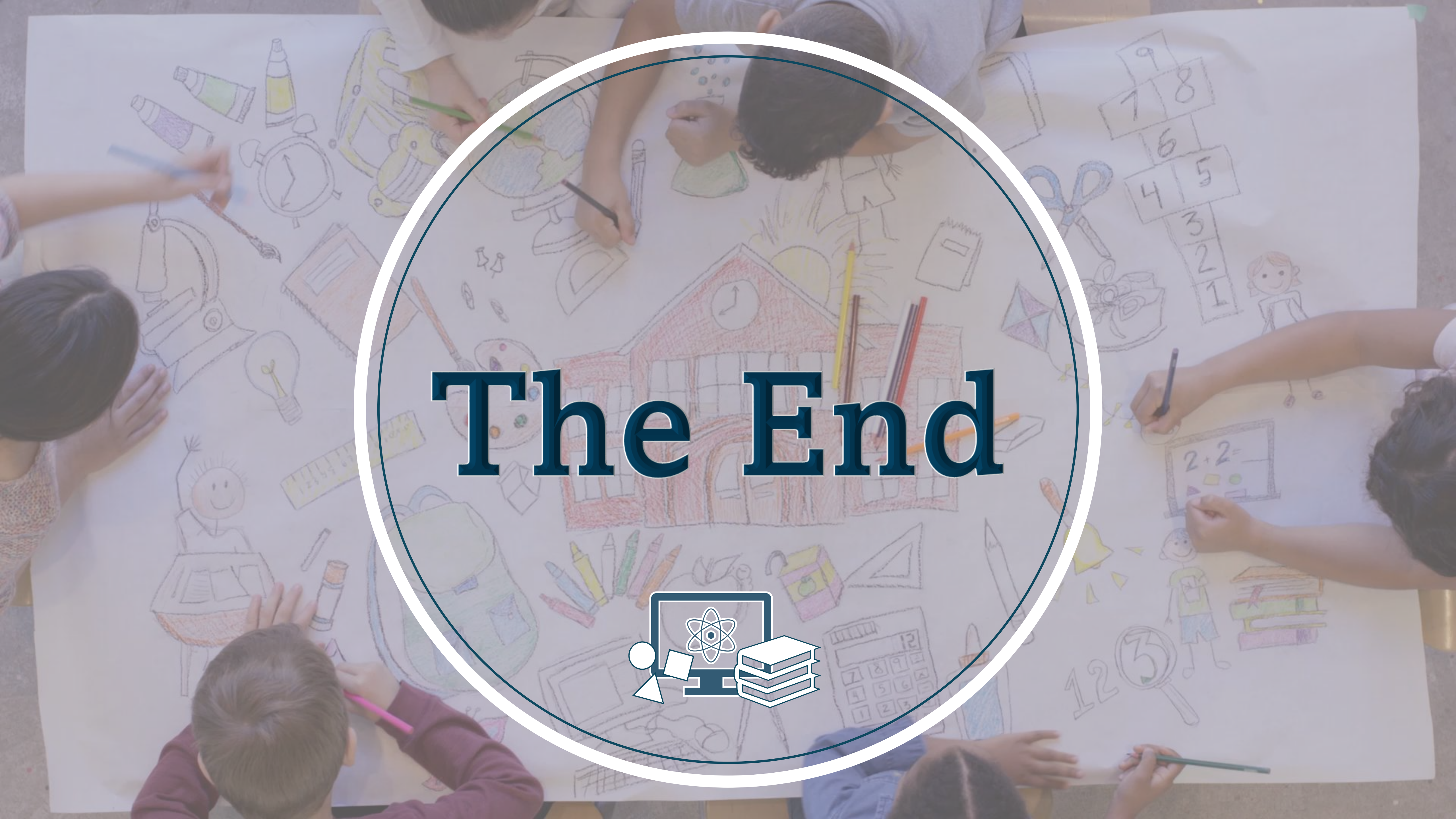
2) Study and complete the path of the ray SI_1.

The ray SI_2 passes from medium of more index to medium of less index ($n_1 > n_2$):

$$i_1 = 49^\circ = i_L = 49^\circ$$

Therefore the ray SI_2 grazing the surface of separation between the two mediums

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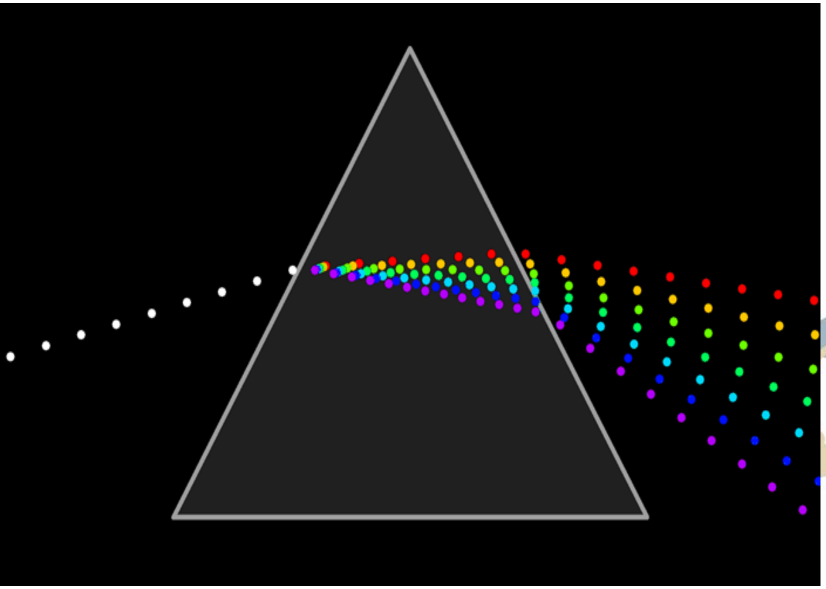


Physics/ Grade 10

Unit Three – Optics

Chapter 11 – Refraction of Light

Prepared Presented by: Mr. Mohamad Seif

OBJECTIVES

4 **Limiting angle**

5 **Dispersion of white Light**

How to calculate limiting angle (i_L)

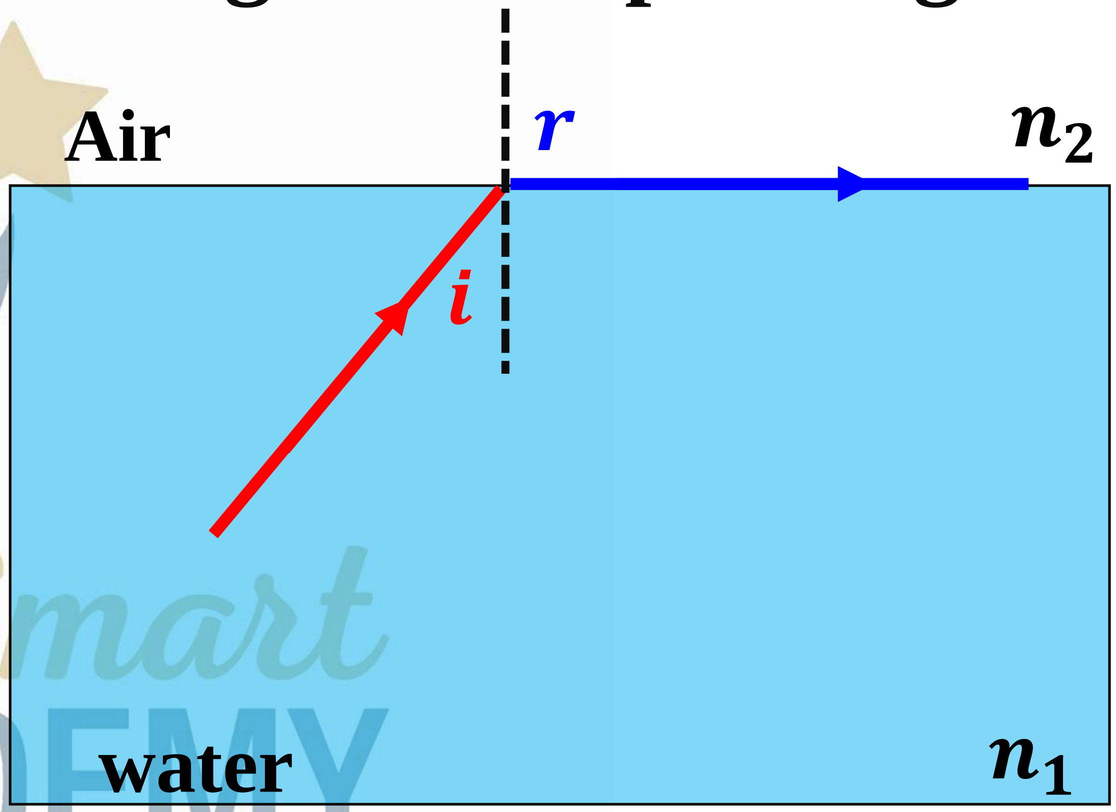
Limiting angle (i_l): is the incident angle corresponding to an angle of refraction of 90°.

Apply Snell's law:

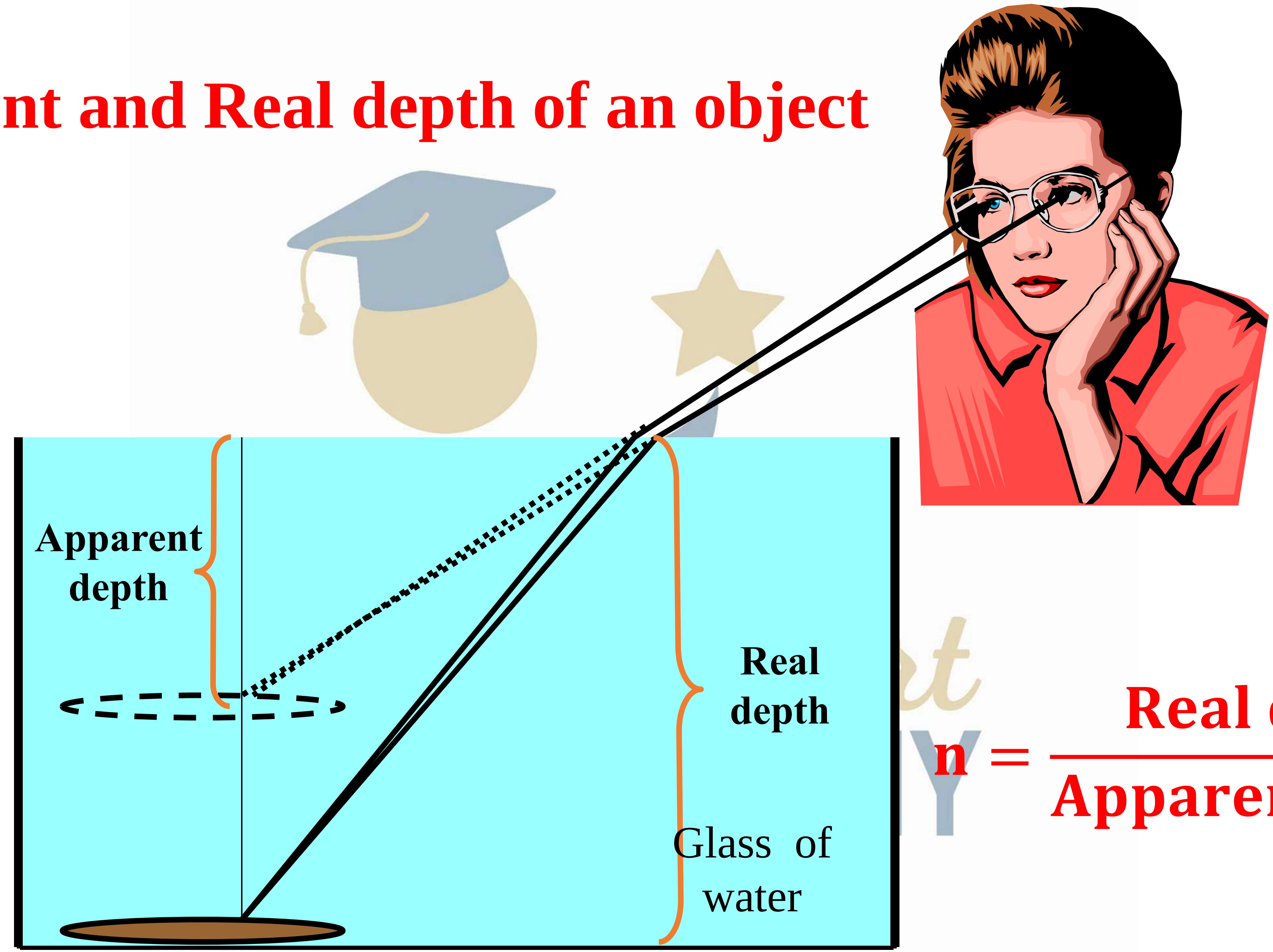
$$n_1 sin(i_l) = n_2 sin(r)$$

$$sin(i_l) = \frac{n_2 sin(90)}{n_1}$$

$$sin(i_l) = \frac{n_2}{n_1}$$



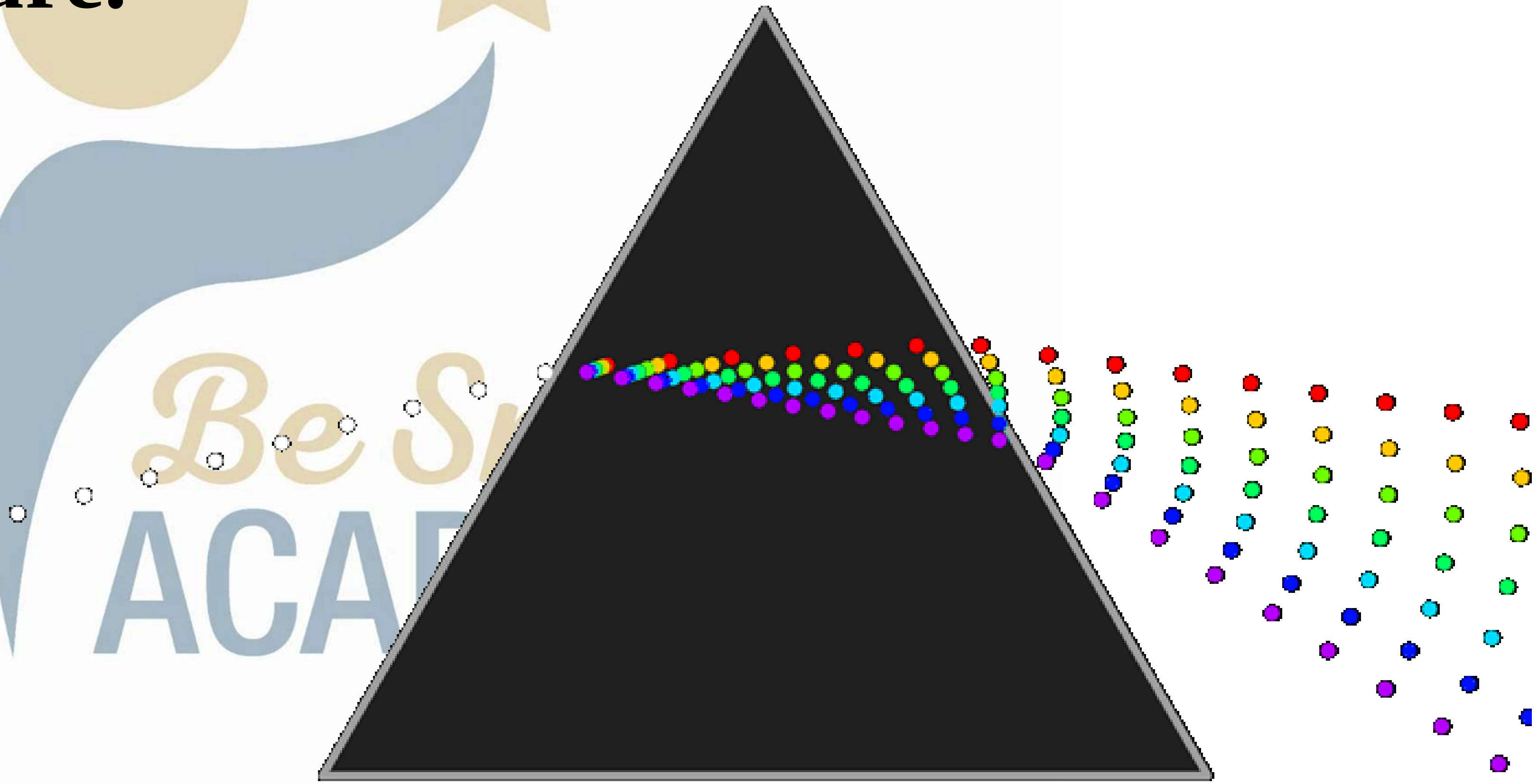
Apparent and Real depth of an object



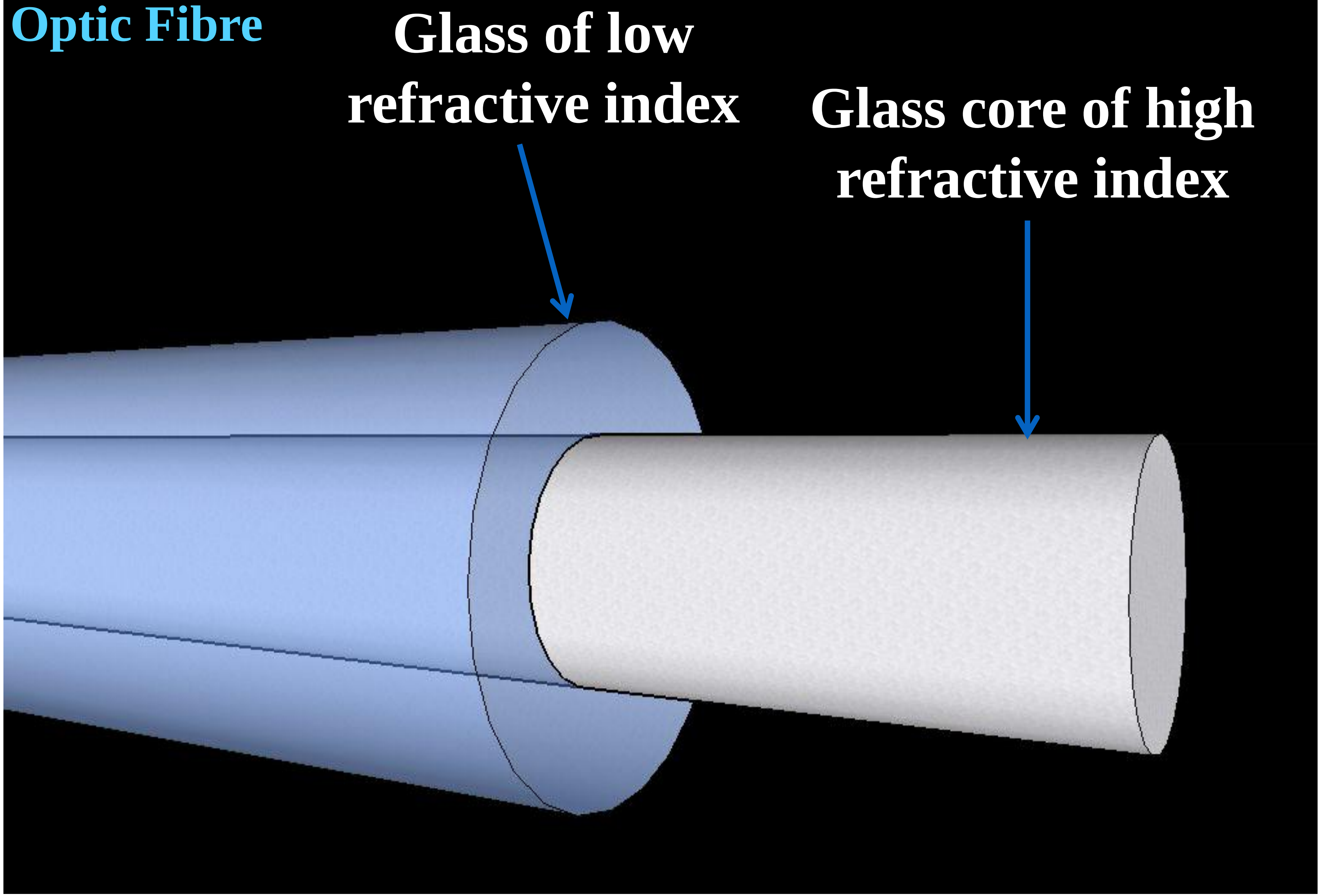
$$n = \frac{\text{Real depth}}{\text{Apparent depth}}$$

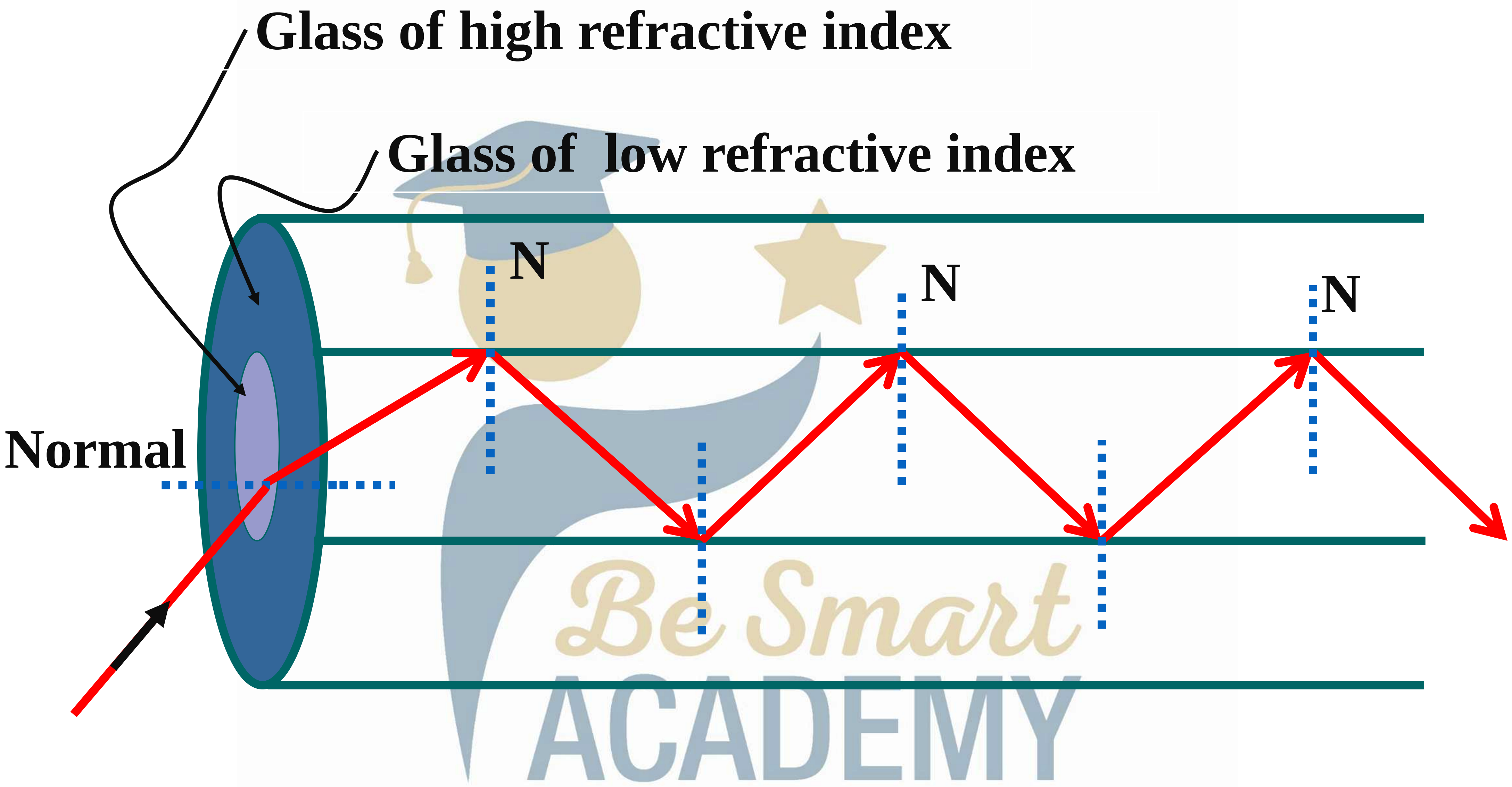
Dispersion of white Light

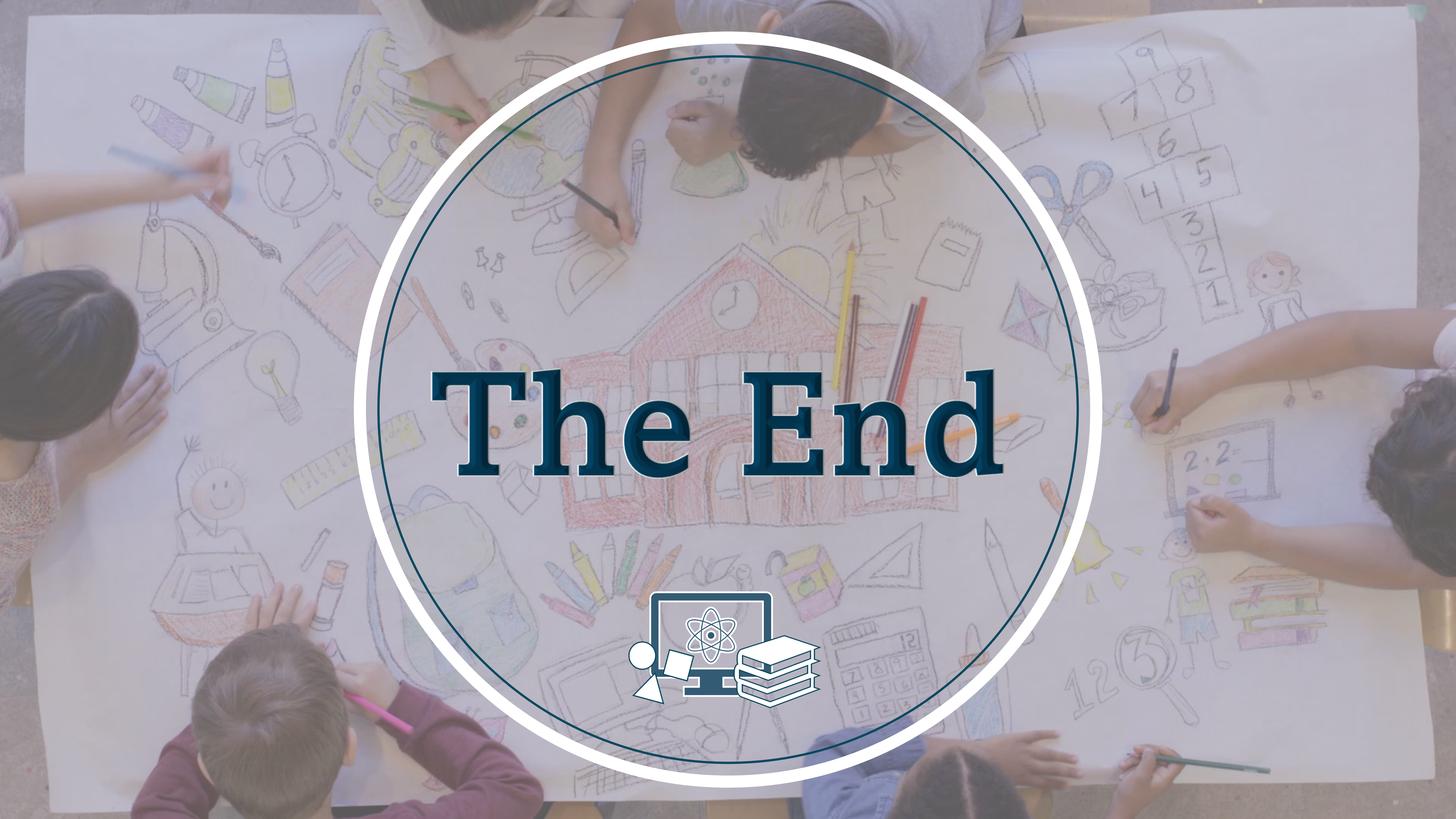
When a beam of while light passes through the surface of a glass prism, we observe on the screen a series of colors as indicated in the figure.



Optic Fibre


Glass of low refractive index
Glass core of high refractive index


Glass of high refractive index
Glass of low refractive index
N
N
N
Normal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