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RELATION BETWEEN THE TOTAL NUMBER OF REFLECTIONS AND THE VALUE OF THE ANGLE OF INCIDENCE (i) WHEN TWO PLANE MIRRORS ARE INCLINED AT AN ANGLE THETA (0) AND THE LIGHT RETRACES ITS PATH AFTER 'n' REFLECTIONS

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Abstract: **The undertaken study is to understand the relation between the total number of reflections and the value of angle of incidence (i) when the mirrors are inclined at an angle theta, and the light retraces its path after 'n' reflections. Pre-existing research has shown a formula to directly derive the value of incidence when the value of 'n' is given, i.e., the number after which the light retraces its path. Using this pre-existing study, two methods can be derived to explain the relationship between the total number of reflections and the value of angle of incidence (i) when the mirrors inclined at an angle theta, and the light retraces its path after 'n' reflections.**

Index Terms **– Angle of incidence**

I. INTRODUCTION

Light is the form of energy that enables us to perceive and see the objects all around us. The branch of Physics that deals with the nature, properties, sources and effects of light is called optics. Optics further diverge into two parts, i.e., physical optics (study of the wave-like nature of light) and the interactions between light and matter. **Ray optics**, also known as **geometrical optics**, is the study of simple properties of light and optical instruments by assuming that light travels in a straight line. The visible light spectrum is absorbed and emitted as tiny packets of energy called photons. These photons have both the properties of a wave and a particle.
Ray optics has become an essential part of life in the present day. The phenomenon illustrating ray optics occurs in our day-to-day life. It is an extensive study and hence includes many concepts and cases. One such case is when light retraces its path after 'n' reflections.

FEW TERMS RELATED TO A MIRROR:

1. *Ray:* It represents the direction of propagation.
2. *Light Beams:* It is a collection of a large number of light rays. It is further divided into a converging beam and diverging beam.
3. *Incident Ray:* It is a light ray from a source falling on a shiny or reflecting surface.

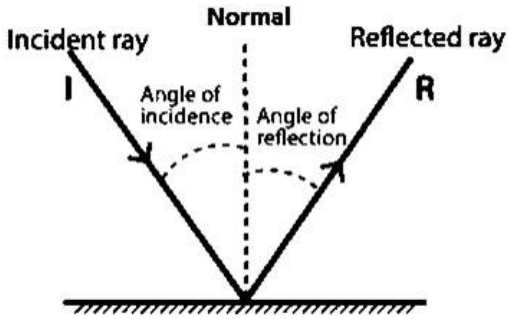
4. *Reflected Ray:* A light ray bounces back in the same medium as the incident ray, after striking the reflecting surface.
5. *Angle of incidence:* The angle formed between the normal and the incident ray at the point of incidence.
6. *Reflected angle:* The angle formed between the normal and the reflected ray at the point of incidence.
7. *Normal:* It is defined as the perpendicular that is drawn to the reflecting surface.

REFLECTION

Reflection is one of the primary properties of light. Reflection is nothing but the images you see in the mirrors. Reflection is defined as the change in the direction of light at an interface in-between two different media so that the wave-front returns to a medium from which it originated. Reflection is further divided into diffused and regular reflection.
Some examples of reflection of light include sound waves and water waves. The light rays will get reflected from the polished surface.

LAWS OF REFLECTION

During reflection, the ray of light follows some laws during its propagation. These laws of reflection are listed below:
1. The incident ray, the reflected ray and the normal to the surface at the point of incidence all lie on the same plane. 2. The angle of incidence will be equal to the angle of reflection.



APPLICATIONS OF OPTICS

As stated, before Ray optics is an essential part of life in the present day. The phenomenon illustrating optics occurs in our day-to-day life and is applied in various fields. The properties of optics in various fields of Physics are as follows-

- The refraction phenomenon is applied in the case of lenses (Convex and concave) for the purpose of forming an image of the object.
- Geometrical optics is used in studies of how the images form in an optical system.
- It is used in the therapeutical and surgeries of human tissues.
- Convex mirrors are used as rear-view mirrors in vehicles.

OBJECTIVE

The purpose of this study was to understand the relationship between the total number of reflections and the value of the angle of incidence (i) when two plane mirrors are inclined at an angle theta and the light retraces its path after ‘n’ reflections.

II. RESEARCH METHODOLOGY

THEORETICAL FRAMEWORK

The undertaken study is to understand the relation between the total number of reflections and the value of angle of incidence (i) when the mirrors are inclined at an angle theta, and the light retraces its path after 'n' reflections.

Pre-existing research has shown a formula to directly derive the value of incidence when the value of 'n' is given, i.e., the number after which the light retraces its path. Using this preexisting study, two methods can be derived to explain the relationship between the total number of reflections and the value of angle of incidence (i) when the mirrors inclined at an angle theta, and the light retraces its path after 'n' reflections.

EQUATIONS USED

There are a total of three equations used in this whole process of deriving a relationship between the total number of reflections and the value of the angle of incidence (i) when the mirrors are inclined at an angle theta (theta is less than or equal to 90 degrees), and the light retraces its path after 'n' reflections.

1) $n + (n-1) = T.R.$ along with $i=(n-1)\theta$
2) $2n+1=T.R.$ along with $i=n\theta$

VARIABLES USED

There are various variables used in the above-stated two equations and they are as follows:

n= an integer dependent on T.R. T.R.= Total Reflection
i = angle of incidence

METHOD

The above-stated relation can be taken in two cases i.e., when the total number of reflections is odd and when the total number of reflections is even.

CASE I: When the total number of reflections is an even number

When we throw an incident ray when two mirrors are inclined at an angle theta and the light retraces its path after n reflections, the total number of reflections is not an even number. If it is an even number then either the total number of reflections is not calculated in a proper manner or the case stated is not a part of it.

CASE II: When the total number of reflections is odd, then two methods can be followed to find the angle of incidence.

Method 2.1

Put the total number of reflections in the formula $n + (n-1) =$ Total reflections where n is the number of reflections after the incident ray retraces its path.
After finding the value of n further put it in the formula $i=(n-1)\ \theta$ where i is the value of angle of incidence ray, n is the number of reflections after the incident ray retraces its path.
Hence you get the value angle of incidence.

Method 2.2

Put the total number of reflections in the formula i.e., $2n+1=$total reflections and directly put the value of n in the formula $i=n\ \theta$.

CONDITIONS

1)The above-stated method is only applicable when the total number of reflections is odd 2) Total reflections are greater than or equal to 3.
3) When in the ray diagram the angle between the two mirrors is less than or equal to 90 degrees.
4) The light must retrace its path.

EXAMPLES AND PROOF

Given below are 3 examples where total reflections are equal to any three random odd numbers greater than or equal to 3 and the angle between the two mirrors is less than or equal to 90 degrees.

EXAMPLE 1: Find the angle of incidence when two mirrors are inclined at an angle less than or equal to 90 degrees and the value of the total number of reflections after which the light retraces its path is 9.

Given, Total Reflection= 9
Method 1) Putting the value of total reflection in the formula n + (n-1) = T.R.
We get the value of n=5
Then the value of the angle of incidence is i=4 θ by simply putting the value of n in the formula i=(n-1) θ .

OR

Method 2) Putting the value of total reflection in the formula 2n+1= T.R.
We get the value of n=4
Then the value of the angle of incidence is i=4 θ by simply putting the value of n in the formula i=n θ .

EXAMPLE 2: Find the angle of incidence when two mirrors are inclined at an angle less than or equal to 90 degrees and the value of the total number of reflections after which the light retraces its path is 57.

Given, Total Reflection= 9
Method 1) Putting the value of total reflection in the formula n + (n-1) = T.R.
We get the value of n=29
Then the value of the angle of incidence is i=28 θ by simply putting the value of n in the formula i=(n-1) θ .

OR

Method 2) Putting the value of total reflection in the formula 2n+1= T.R.
We get the value of n=28
Then the value of the angle of incidence is i=4 θ by simply putting the value of n in the formula i=28 θ .

EXAMPLE 3: Find the angle of incidence when two mirrors are inclined at an angle less than or equal to 90 degrees and the value of the total number of reflections after which the light retraces its path is 63.

Given, Total Reflection= 9
Method 1) Putting the value of total reflection in the formula n + (n-1) = T.R.
We get the value of n=32
Then the value of the angle of incidence is i=31 θ by simply putting the value of n in the formula i=(n-1) θ .

OR

Method 2) Putting the value of total reflection in the formula 2n+1= T.R.
We get the value of n=4
Then the value of the angle of incidence is i=31 θ by simply putting the value of n in the formula i=n θ .

III. CONCLUSION.

The above-stated method helps us establish a better understanding of the topic and the method of calculation by two different methods in two different cases on the basis of even or odd natural numbers.

LIMITATION

Even though this method is not useful in case

i. The mirrors are inclined at an obtuse angle
ii. The total number of reflections after which light retraces its path is even
iii. The total number of reflections after which light retraces its path is 1 or 2
iv. The light ray does not retrace its path

IV. ACKNOWLEDGEMENT

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V. REFERENCES

ONLINE ABSTRACTS

1) Aakash+Byjus website, 2023, Introduction and Definition reflection, accessed on 19 June 2023, https://byjus.com/jee/ray-optics/
2) Aakash+Byjus website, 2023, pictures 1 and 2, accessed on 19 June 2023, https://byjus.com/jee/ray-optics/
3) Aakash+Byjus website, 2023, Introduction and Application of optics, accessed on 19 June 2023, https://byjus.com/physics/optics/