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Effect of Angle of Incident on Angle of Reflection in Reflection of Light in a Plane Mirror

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ABSTRACT

Light reflection is a basic phenomenon in optics that has been explained in depth in the law of light reflection. This law states that the angle of incidence of a light ray is equal to its angle of reflection when it hits a flat surface. Light reflection can occur on various surfaces, both smooth and rough. This study aims to experimentally corroborate the application of the law of light reflection on a flat mirror. The research method used is a quantitative method with an experimental design designed to measure the angle of incidence and angle of reflection of a laser beam directed at a flat mirror. This method allows researchers to collect numerical data that can be analyzed statistically. The results of the data analysis show that there is a linear relationship between the angle of incidence and the angle of reflection, with the values of the two angles always being equal for each measurement. This result is in line with the law of light reflection and provides strong evidence to support the correctness of the law.

Keywords: Reflection; Light; Angle; Plane Mirror.

1. Introduction

Light is one of the fundamental elements in natural science that influences various aspects of life on Earth. The properties of light make it possible to see, understand, and utilize it in many fields, such as biology. Light sources are objects that can emit light. There are two types of light sources: natural light sources (such as the sun), which produce light naturally without human intervention, and artificial light sources [1]. Light is often depicted as a straight line that travels in one direction when depicted. The main characteristics of light include its straight path of propagation, its ability to penetrate transparent objects, as well as its ability to undergo reflection refraction, and its status as an electromagnetic wave. When light hits the surface of an object, some of the light will be transmitted, and some will be reflected, a phenomenon called reflection [2]. Two laws govern this reflection: the first law states that the angle of incidence is the same as the angle of reflection, while the second law states that the incident ray, normal line, and reflected ray are all in the same flat plane.

Objects that can emit light are known as light sources, which are divided into two main categories: natural light sources and artificial light sources. Natural light sources are sources that produce light naturally and are available at all times, such as the sun, which functions as a large star at the center of the solar system [3]. On the other hand, artificial light sources are human creations that emit light but are not always available all the time; examples include flashlights, neon lights, and candles. As a form of wave, light has a number of characteristic properties, including propagating in a straight line, being able to be reflected, and being refracted when passing through different media. These properties allow light to interact with a variety of objects and surfaces, providing the basis for many optical phenomena that can be observed in everyday life, such as shadows, rainbows, and various technological applications that utilize light. The study of light began with the emergence of the era of classical optics, which studied various optical quantities, including intensity, frequency or wavelength, polarization, and phase of light [4].

The reflected light can be observed when in front of a mirror. Light reflection is divided into two types: regular reflection and diffuse reflection [5]. Regular reflection occurs when light is reflected parallel to each other, usually on a flat, shiny surface such as a mirror [6]. This type of reflection produces clear and distinct images because the angle of incidence of the light is the same as the angle of reflection. In contrast, diffuse reflection occurs when light is reflected irregularly, usually on a bumpy, matte, and rough surface. Light in diffuse reflection spreads in various directions so that it does not form a clear image [7]. It is often used to create a soft atmosphere in a room. For example, light hitting a mirror surface will experience repeated reflections, allowing us to see our reflection [6].

When a light beam hits a flat and regular reflecting surface, the light beam will bounce back regularly. Each line of light will reflect according to the applicable law of reflection, with the difference being in the nature of the reflecting field. Diffuse reflections occur in irregular areas, but the basic principles of reflection remain consistent. In general, light reflection has the same angle between the incident and reflected rays. Regular reflection usually occurs on a flat reflecting surface, such as on a mirror. In contrast, diffuse reflection occurs on an uneven reflecting surface, for example, on a dirty or cracked mirror [8].

In light reflection, there is the Law of Light Reflection proposed by Snellius, which states that the incident ray, normal line, and reflected ray lie in one flat plane, and the angle of the incident ray (i) is the same as the angle of the reflected ray (r), so it can be written in the equation i=r [5]. The reflection of light on a mirror causes an image to form, which can occur in various types of mirrors, such as flat mirrors, concave mirrors, and convex mirrors. In a plane mirror, the nature of the image formed is virtual, pseudo, or unreal because the image is behind the mirror, even though it appears clear to the observer. The image has an enlarged size from the original object. Another interesting property is that the distance between the object and the mirror is the same as the distance of the image from the mirror, which indicates symmetry in the position of the two [9].

Based on the description above, this research aims to strengthen understanding of the Law of Reflection of Light, namely applying the Snellius law for light reflection, determining the nature of the image produced by a flat mirror, and determining the number of images that two flat mirrors can form. Although this law is often taught at various levels of education, conducting hands-on experiments can help practitioners understand this concept more clearly. In addition, practitioners must be able to analyze the properties of images produced by plane mirrors, such as the position, nature, and number of images formed when using more than one mirror.

2. Method

This research uses quantitative methods with an experimental design. Quantitative methods aim to measure and explain phenomena objectively using number-based data. The data obtained is analyzed statistically to draw objective conclusions, such as measuring the angle of incidence and reflection, the distance of the image, and the number of images. This research was conducted at the Physics Laboratory of Jember University on Wednesday, October 23, 2024, from 11.50 to 14.10.

This research, entitled Light Reflection Experiments in Plane Mirrors, focuses on the phenomenon of light reflection in plane mirrors. A flat mirror has the property of reflecting light with an angle of incidence equal to the angle of reflection, thus producing an image that is virtual, upright, and the size of the original object. Measurements in research use tools such as laser light sources, flat mirrors, concave mirrors, arcs, rulers, HVS paper, and screens to capture images.

The research procedure consists of three main stages. In proving the law of reflection of light in a plane mirror, a horizontal line was drawn on HVS paper 10 cm from the edge; then, lines were drawn at angles of 20°, 30°, and 40° using a protractor. A flat mirror is placed on a horizontal line; the laser beam is turned on and then directed at the mirror according to the angle created. The point of the reflected ray is marked, then the lines of the incident ray and the reflected ray are connected. The normal line is drawn perpendicular to point O, where the incident ray and the horizontal line meet. The angle between the normal line and the reflected ray is measured using a protractor; then, the resulting data is recorded. This step is repeated for the other corners.

At the stage of measuring the image distance, a horizontal line is drawn in the middle of the HVS paper; then, a flat mirror is placed directly above this line. Point A is created 4 cm in front of the mirror, and the laser beam is directed at the mirror from that point at an angle of 30°. The reflected rays are marked, then the two lines of reflected rays are extended behind the mirror until they meet at a point marked A'. The length of A' is measured, and the data is recorded. This step is repeated with a point distance of 6 cm and 8 cm from the front of the mirror.

To determine the number of images formed, two plane mirrors are arranged side by side at angles of 45°, 60° and 90°. The object is placed between the two mirrors, then the number of images formed is observed and the results are recorded. The data in this research were obtained through direct measurements of the angle of incidence and angle of reflection of light on a plane mirror. The tools used include a flat mirror, arc, ruler, HVS paper, and a laser beam. The measurement process is carried out by placing a flat mirror on HVS paper, which has been given a straight line as a reference. The laser beam is directed at a flat mirror at a predetermined angle of incidence, then the angle of reflection is measured using a protractor. The incident angle and reflection angle data were recorded for further analysis.

Data is analyzed using a quantitative approach to ensure accurate and objective results. In proving Snell's Law, the angle of incidence and angle of reflection are compared to test compliance with the principle that the angle of incidence is the same as the angle of reflection. The difference between the angle of incidence and the angle of reflection is calculated to evaluate the degree of measurement error. In measuring image distance, the experimental results are compared with the theory that the image distance in a flat mirror is equivalent to the distance of the object in front of the mirror. To calculate the number of images in two flat mirrors arranged at a certain angle, the number of images is calculated using the formula $N = \frac{360^{\circ}}{\alpha} - 1$.

3. Result and Discussion

Light reflection is a phenomenon where the light that hits a surface will be reflected in the direction it came from or in another direction, depending on the characteristics of the surface. Based on the type of surface, light reflection is divided into two types, namely reflection on rough surfaces and reflection on smooth surfaces. The reflection of light that occurs on a rough surface is called diffuse reflection, where the light is reflected randomly because the surface is not flat. Meanwhile, the reflection of light on a smooth surface is called regular reflection, where the light is reflected in a more controlled direction, producing a clear image. Snell's law of reflection states that the incident ray, normal line, and reflected ray are in the same plane, and the angle of incidence is the same as the angle of reflection. This principle is the basis for understanding various light reflection phenomena, including image formation in mirrors [10].

A flat mirror is a type of mirror that has a flat surface where the reflection of light produces a characteristic image. Due to the nature of light reflection on a flat and smooth surface, the image of an object looks as if it is behind a mirror. One of the characteristics of a plane mirror is that the distance of the original object from the mirror surface is always the same as the distance of the image from the mirror. In addition, the resulting image is virtual, meaning it cannot be captured on the screen. This is because the image is formed from the extension of the reflected light, which looks like it comes from behind the mirror [11].

In this research, there are three types of variables: independent variables, dependent variables, and control variables. The independent variable is the angle of incidence (i), while the dependent variable is the angle of reflection (r). The control variable used in this research is the type of mirror.

Table 1 shows the comparison between the angle of incidence and the angle of reflection on the mirror by drawing a horizontal line on his paper and placing a flat mirror perpendicular to the horizontal line.

Table 1. Proving the validity of Snelius' law for reflection

No	Angle of incidence (θ)	Angle of reflection (θ’)
1.	20º	20º
2.	30º	30º
3.	40º	40º

The law of reflection states that the angle of incidence is equal to the angle of reflection. It can be seen in Table 1 that the results of observing the angle of incidence and angle of reflection on a plane mirror, with angles of incidence of 20°, 30°, and 40°, produce the same value as the angle of reflection. This shows that the law of reflection always applies. The resulting image is virtual, upright, and enlarged; this is in accordance with the law of reflection, which states that the incident ray, reflected ray, and normal line are in one flat plane.

Table 2 shows the results of research to determine the nature of the image in a flat mirror. This research was carried out by observing the angle of incidence and angle of reflection of the light and measuring the distance of the object and the distance of the image. The research results can be seen in the table below.

Table 2. Determining the properties of the image in a plane mirror

No	Distance A to Mirror (s) (cm)	Distance A’ to Mirror (s) (cm)
1.	4	4
2.	6	6
3.	8	8

The mirror image in a plane mirror has the characteristics of being upright and as big as the object, virtual, and the distance of the image is the same as the distance of the object. In Table 2, it can be seen that the distance between the object (A) and the mirror and the distance of the image (A') formed from the object produce the same results. When A's distance from the mirror is 4 cm, the resulting image distance A' from the mirror is 4 cm, and the same goes for other distances. This shows conformity with the characteristics of the mirror image in a plane mirror, namely upright and magnified.

Table 3 shows the results of research determining the number of images that two flat mirrors can form. The number of images can be calculated using the formula $N = \frac{360^{\circ}}{\alpha}$ - 1, α is the angle between the two mirrors. This research will show that the greater the angle between the mirrors, the smaller the number of shadows formed.

Table 3. Determining the number of images of two mirrors that coincide

No	Mirror (α)	Number of images
1.	45º	8
2.	60º	5
3.	90º	3

The number of images that two mirrors can form depends on the angle formed between the two mirrors. The number of shadows can be calculated using the formula $N = \frac{360^{\circ}}{\alpha}$ -1. It can be seen in the table that the shadow results for a 45˚ angle are 8, for a 60˚ angle, it produces 5 shadows, and a 90˚ angle produces 3 shadows. It can be seen from the results that the larger the angle of the mirror, the smaller the number of images.

Based on the research that has been carried out, the law of light reflection in a flat mirror appears to function well. The angle of incidence will always be the same as the angle of reflection. Apart from that, this research also strengthens the characteristics of the image created in a flat mirror, namely virtual, upright, and magnified. The number of images visible is influenced by the size of the angle between the two mirrors. By using the formula $N = \frac{360^{\circ}}{\alpha}$ - 1, it can be seen that the greater the angle between two mirrors, the smaller the number of images created.

4. Conclusion

Understanding the reflection of light is very important because this concept is often encountered in various aspects of life. Through the research carried out, a conclusion was obtained, namely to prove that Snellius' law applies to the reflection of light. Snell's law, or law of reflection, states that the angle of incidence is equal to the angle of reflection when light bounces off a surface. By carrying out experiments, practitioners can observe the angle of incidence and angle of reflection of light on a flat mirror surface so that it can be proven that Snelius' law is indeed valid in the phenomenon of light reflection.

To determine the nature of the image produced by a plane mirror. The image formed in a plane mirror has certain properties, such as the size of the image being the same as the object, the image being upright, and the distance of the image from the mirror being the same as the distance of the object from the mirror. Through observing a plane mirror, practitioners can understand the properties of the image and how the characteristics of the image in a plane mirror are different from other mirrors.

To determine the number of images that can be formed by two plane mirrors arranged at a certain angle. When two plane mirrors are arranged close together, more than one image will be formed, depending on the angle between the two mirrors. By observing the number of images that appear at various angles, practitioners can understand the relationship between the angle of the mirror and the number of images formed, as well as the phenomenon of repeated reflection between two flat mirrors.

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