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The Influence Of Shape And Angle of Reflection of Flat Mirrors On a Kaleidoscope

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abstrak

Often, we face difficulties in observing objects in challenging positions. For instance, someone inside a submarine may want to see what lies at the bottom of the sea. One tool based on physics principles that can be employed for this purpose is a kaleidoscope. The formation of images produced by a kaleidoscope can be challenging for those who are unfamiliar with its workings. In a kaleidoscope, multiple reflections occur due to the presence of specific shapes and the number of mirrors used. This research aims to analyze the angles of incident shape and reflected rays in kaleidoscopes with three different shapes, determine the number of images in each kaleidoscope shape, and validate the law of reflection in kaleidoscopes. The process involved using a single object and adjusting the angle, specifically 60˚, 90˚, and 120˚. During the data collection process, it was observed that a 60˚ angle resulted in 5 images (reflections), a 90˚ angle resulted in 3 images (reflections), and a 120˚ angle resulted in 2 images (reflections). The results indicate that as the angle between the mirrors increases, the number of visible or produced images decreases. Conversely, when the distance between flat mirrors is reduced, the number of reflected or produced images increases. The findings on the images in the kaleidoscope are confirmed by the data processing using formulas $n = \frac{360}{\theta} - 1$

Keywords: *Kaleidoscope, Reflection, Special Ray*

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INTRODUCTION

Among the many physical phenomena observable in everyday life, light is one of the prominent occurrences. Light, consisting of particles known as photons, propagates in the form of electromagnetic waves. The evidence supporting the theory mentioned earlier is abundant, representing light's ability to travel straight in various conditions. Examples of such evidence include the sun, known as a light source capable of creating shadows, and a flashlight producing rays seen as straight lines. Optics, as a branch of physics, deals with the workings of the eye that convey impressions of color and substance. Optical science is further divided, with one aspect concerning the formation of images produced by systems like the eye, and the other relating to the physical properties of light acting as electromagnetic waves. Optics is commonly applied in daily life through instruments such as the eye (our natural optical tool), microscopes, cameras, and many others (Kanginan, 2013).

Multiple reflections on a submarine are one of the main challenges in underwater navigation. When a submarine emits sonar waves to detect objects in its surroundings, the waves can reflect from various surfaces in the water, including the sea walls, sea floor, and other objects. These multiple reflections can create interference and make it difficult to distinguish the original signal from the reflected signal. A solution to address the issue of multiple reflections on a submarine is the implementation of a kaleidoscope. By using the optical principles of a kaleidoscope, where light is reflected and reflected again by a series of mirrors, this concept can be applied to the development of submarine sonar systems. (Sonar, 2021)

In this mini-research, we address the issue of how reflection results and the number of images produced in a kaleidoscope vary with different angles. Varying the angles is done to determine whether the number of images produced at each angle is the same or different. In the journal titled "Popularizing Geometrical Concepts: the Case of the Kaleidoscope" (Graf & Hodgson, 1990), it is explained that a kaleidoscope is a tool for viewing multiple images of objects placed inside it. Graf & Hodgson conducted experiments using a kaleidoscope to observe the beautiful and varied patterns produced by beads placed inside. While their explanations in the journal are clear, we aim to replicate or innovate their experiment by adding different angles.

According to our perspective, experiments with bead objects are inefficient as determining the incident angle and the resulting reflected ray's origin is challenging due to the scattered and unordered positions of the beads. Hence, we propose and innovate by suggesting that the bead objects be replaced with a single object for easier analysis of the directions of the rays produced by that object. The creation of a demonstrative tool for this mini-research on the topic of kaleidoscope and reflection is carried out with the aim of analyzing the angles of incident and reflected rays in a kaleidoscope with three different shapes, determining the number of images in each kaleidoscope shape, and proving the law of reflection in a kaleidoscope. The mini-research experiment is designed to be interesting as it will demonstrate or implement whether the material on reflection in flat mirrors is indeed true and can be proven using an optical tool like a kaleidoscope. The fabrication process employs simple materials so that everyone can create and experimentally verify the law of reflection with this optical tool, the kaleidoscope.

THEORETICAL STUDY

In the field of physics, there are numerous types of waves that exist or that we can be aware of. Light is one of these many types of waves. Light belongs to the category of electromagnetic waves. Its characteristic feature is that it does not require a medium as a medium for propagation. Every day, humans need light as illumination to see objects around us. Light is defined as a substance that propagates and possesses specific properties (Nisral, 2012).

Light can be perceived differently due to its inherent properties. Firstly, light can reflect, meaning there is a process of re-emission of light originating from a surface or something that has previously been exposed to light. Secondly, light travels in straight lines, and this propagation occurs if only one intermediate medium is traversed by light. Thirdly, light can pass through transparent objects and be refracted. Lastly, what we will discuss further is that light has the ability to bend or undergo refraction (Studi et al., 2018). One of the tools that implements the concept of reflection is a flat mirror. A flat mirror is known for its reflective surface that occurs on a straight or flat surface. On a flat mirror, there is a known concept called the normal line, which is a line passing through or through the point of incidence. This flat mirror creates an image with the following characteristics:

1. If a real object is in front of the mirror, the mirror will have a virtual image resulting from that real object, and its size is the same, meaning the reflected rays are produced from the virtual image.
2. The object and the image are equidistant from the surface.
3. The position of the image is inverted. (Permana Suwarna, 2010)

When there is an object standing in the middle of a flat mirror (two flat mirrors facing each other), an image will be formed on each mirror, and the image from the first mirror will change into an object on the second mirror and so on (Fauziah, 2021). The property of light that can be reflected means that if light falls on a surface, half of it will be reflected, and the other half will be absorbed or transmitted. The amount of light reflected or absorbed depends on the surface of the object to be reflected. On a mirror, almost every ray will reflect off its surface. Reflected light follows the law that states the angle of reflection equals the angle of incidence, with the mathematical equation $i=r$, and the incident, reflected rays, and normal line are in the same plane, intersecting at a point (the intersection point becomes the location of the image) (Nisral, 2012).

One tool that can be used to implement the reflection material is the kaleidoscope. The kaleidoscope is a device that experiences repeated reflection due to the presence of shapes and the number of mirrors used. The kaleidoscope is shaped like a telescope equipped with flat mirrors arranged around it. At one end, an object is placed so that it can show or display various images reflected from the object placed in the middle (Brewster, n.d.). The kaleidoscope works by producing images from the reflection events of two or more flat mirrors arranged parallelly at different angles. These repeatedly reflected images will then be transmitted to the observer's eyes. The reflected light then produces an image, and this image will become an object to reflect on the second mirror and so on (Nadziyah, 2021).

Methods

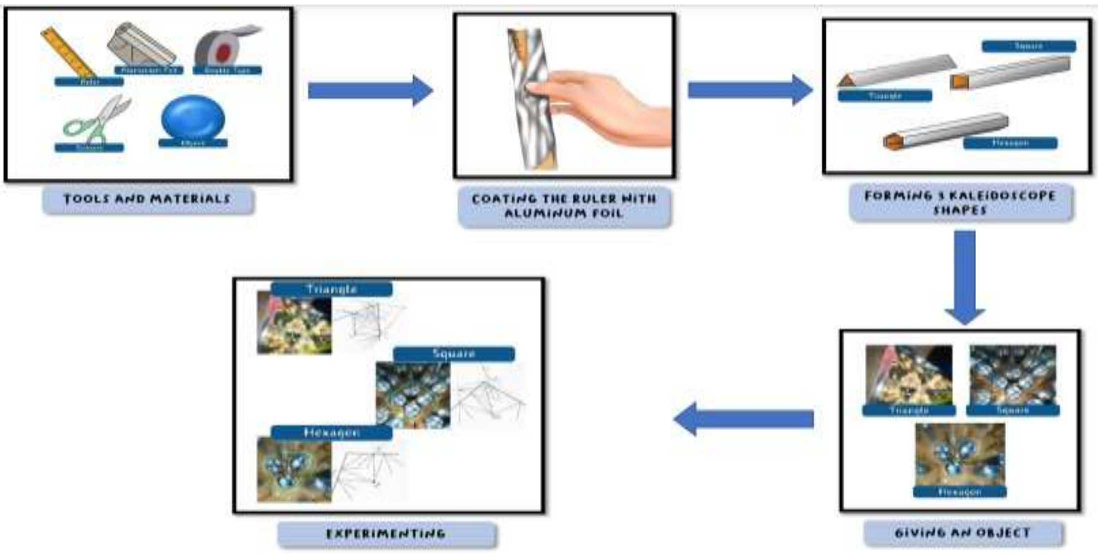


Figure 1. schematic diagram of research methods

1. Tool and Material

From the outlined tool sketch above, the making of this kaleidoscope involves the use of tools and materials such as a ruler, aluminum foil, double-sided tape, one object to serve as the focal point, metallic paper for decoration, and scissors.

2. Manufacturing steps

The creation of a demonstrative tool for the properties of light, specifically the topic of reflection, uses a ruler as a substitute for a flat mirror due to the difficulty and high cost of obtaining a flat mirror of specific dimensions. The ruler will be wrapped or coated with aluminum foil to reflect images of the object. The steps for making it are as follows: first, prepare several rulers to create a kaleidoscope with three specific angles. Wrap the rulers with aluminum foil and join them to form three shapes with specific angles. Close one end of the tool as a base to place the object that will reflect multiple times.

At the other end, it is also closed but has a hole made into a hole for placing the eye as part of the observation. The results of these observations will later be analyzed using the law of reflection, such as determining incident rays, reflected rays, etc. Apart from that, we will also analyze the number of shadows formed in the kaleidoscope and will compare them with the number of shadows in theory.

3. Data Collection Step

Data collection was performed by measuring the angles of each kaleidoscope shape using a protractor. Subsequently, the data was calculated using a specific formula.

a. Formula 1

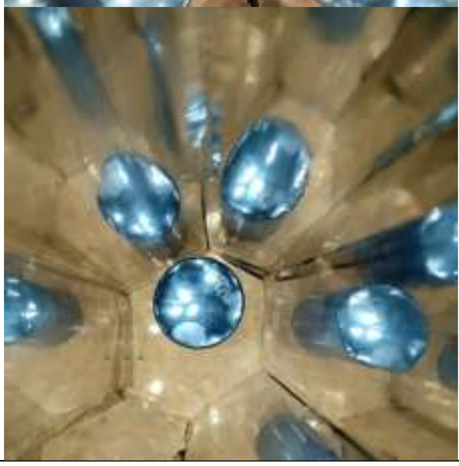
$$n = \frac{360}{\theta} - 1$$

to determine the number of images produced, the results obtained from the calculations using the formula will be compared with the actual conditions in the kaleidoscope tool. (Astuti, 2009)

RESULT

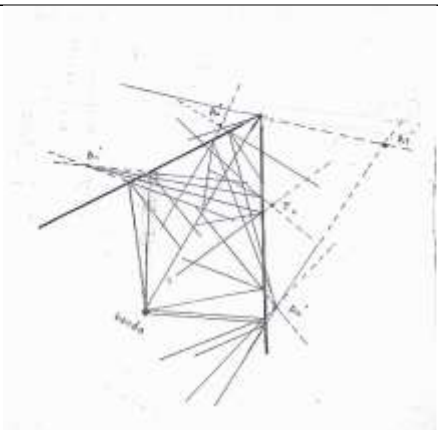
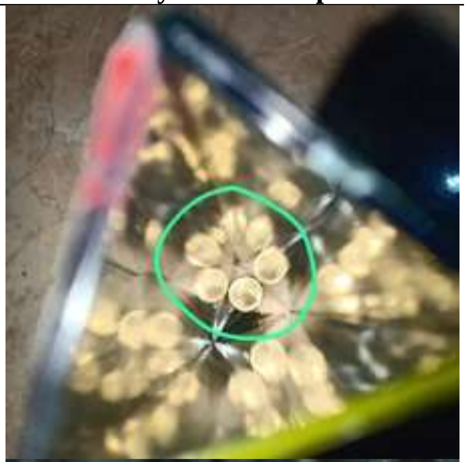
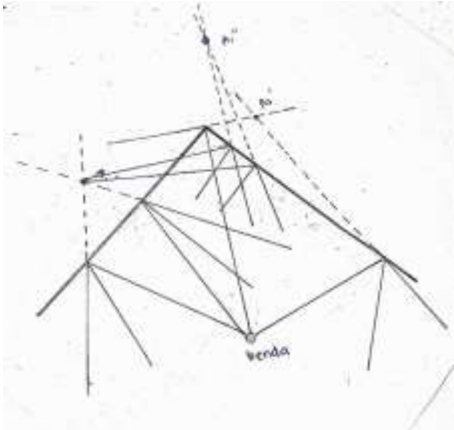
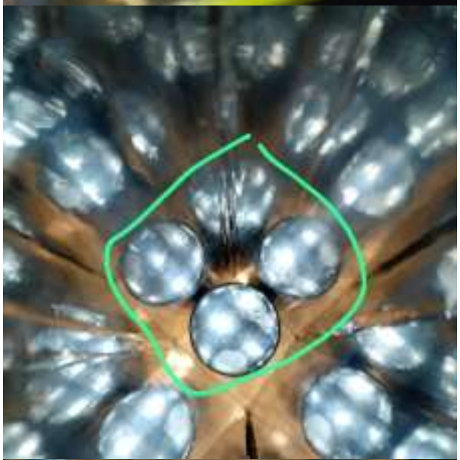
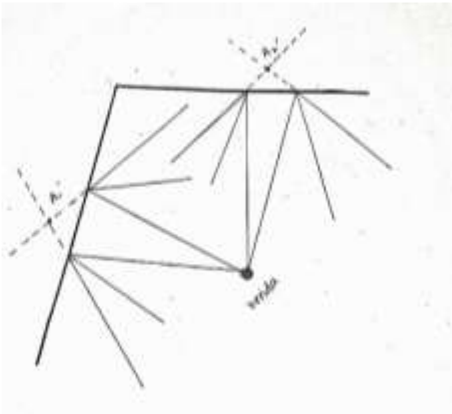
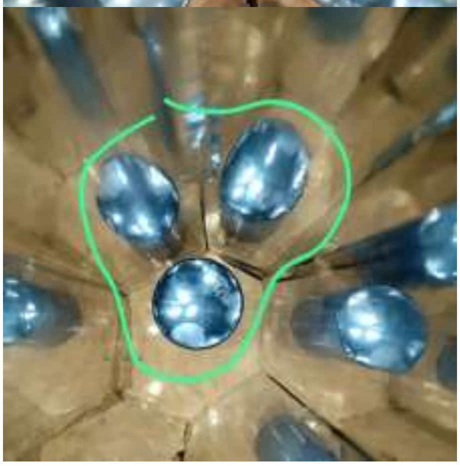
As for the mini research experiment, we conducted the results obtained are:

Table 1. The results of the shadows in the kaleidoscope with angles of 60˚, 90˚, and 120˚ are as follows:

No	Picture	The produced shadows	The resulting angle size
1.		5	Image 1: - Light 1 = 40˚ - Light 2 = 30˚ Image 2: - Light 1 = 28˚ - Light 2 = 20˚ Image 3: - Light 1 = 25˚ - Light 2 = 32˚ Image 4: - Light 1 = 20˚ - Light 2 = 28˚ Image 5: - Light 1 = 35˚ - Light 2 = 40˚
2.		3	Image 1: - Light 1 = 22˚ - Light 2 = 35˚ Image 2: - Light 1 = 40˚ - Light 2 = 45˚ Image 3: - Light 1 = 50˚ - Light 2 = 48˚
3		2	Image 1: - Light 1 = 30˚ - Light 2 = 28˚ Image 2: - Light 1 = 38˚ - Light 2 = 20˚

From the above data, it can be concluded that the larger the angle between the mirrors, the fewer shadows that are visible or produced, and conversely, when the distance between the flat mirrors is made smaller, the shadows reflected or produced will be more numerous. Thus, the relationship between the angle and the shadow results is inversely proportional.

Table 2. Data processing (proving the number of shadows produced at each angle of the kaleidoscope)

No	Picture	n	Conformity with the experiment
1.		$n = \frac{360}{\theta} - 1$ $n = \frac{360}{60} - 1$ $n = 5$	
2.		$n = \frac{360}{\theta} - 1$ $n = \frac{360}{90} - 1$ $n = 3$	
3		$n = \frac{360}{\theta} - 1$ $n = \frac{360}{120} - 1$ $n = 2$	

Click or tap here to enter text.

The purpose of this data processing is to prove whether the number of shadows in the study, based on the theory using the formula, is the same and aligns with the theory.

DISCUSSION

This report is aimed at conducting a small research or mini-experiment on the material of waves and optics with the title "The Influence of Shape and Angle of Reflection of Flat Mirrors on a Kaleidoscope," conceptualized in line with the material of reflection on double mirrors. The research is intended to investigate the impact of shape and angle on the produced shadows and then prove or compare the conformity of the practical results with the calculations through the formula specified in the data processing table. The shapes and angles used in this mini-research are a triangle with a 60˚ angle, a square with a 90˚ angle, and a hexagon with a 120˚ angle.The first experiment was conducted using a kaleidoscope with a triangular shape with a 60˚ angle. Measurement of the angles of each shape was done using a protractor. When placing an object in the center of the kaleidoscope, we photographed the resulting shadows and then calculated the shadows produced from the reflection on two flat mirror surfaces arranged in parallel and positioned obliquely (in the first experiment, the inclination was 60˚ to face the observer; the reflection would then be transmitted to the observer's eye).

After conducting the research, the shadow results from the triangular shape amounted to 5 shadows, resembling a flower when photographed using a smartphone camera. The observed shadow results on the mirror align with the theory or calculations using the formula. The incoming and reflected light lines are drawn according to the rules or laws of regular reflection. This is because the use of flat mirrors in observation is a type of regular reflection. The second experiment used a square shape with a measured angle of 90˚ and produced 3 shadows. The second experiment followed the same steps as the first, only the shape and angle of the combination of flat mirrors were different. The third experiment used a hexagonal shape with a measured angle of 120˚ and produced 2 shadows. The last experiment also followed the same steps as the first and second, only the shape and angle of the combination of flat mirrors were different. From the observations in this mini-research, the practical results and the theoretical results are in line, where in both double mirrors with 60˚, 90˚, and 120˚ angles, they all produce shadow results that correspond between the experiment using the kaleidoscope and the results calculated using the formula. When comparing the practical data with the theory, it can be said that in the reflection on double mirrors, the larger the angle between the mirrors, the fewer shadows that are visible or produced, and conversely, when the distance between the flat mirrors is made smaller, the shadows reflected or produced will be more numerous. Thus, the relationship between the angle and the shadow results is inversely proportional.

CONCLUSION

Based on the activities, it can be concluded that in the reflection on double mirrors, the larger the angle between the mirrors, the fewer shadows that are visible or produced, and conversely, when the distance between the flat mirrors is made smaller, the shadows reflected or produced will be more numerous. Thus, the relationship between the angle and the shadow results is inversely proportional. The incoming and reflected light lines are drawn according to the rules or laws of regular reflection. This is because the use of flat mirrors in observation is a type of regular reflection.

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