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Ethnomathematical analysis of volume constructions in curved-sided solids

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Abstract

Located in Semarang, Sam Poo Kong Temple is a prominent cultural site for the Chinese community, featuring various architectural elements that embody Chinese heritage. This study investigates the ethnomathematical significance of objects at the Sam Poo Kong Temple, particularly focusing on the identification and volume calculation of curved-sided figures. Employing a descriptive qualitative research design with ethnographic methods, the study identifies significant objects, including giant kendil, lanterns, large candles, and spherical ornaments on lion dance statues, as rich sources for teaching analytic geometry. These items illustrate real-world applications of mathematical concepts, particularly in determining volumes through the principles of curved surfaces and integral calculus for rotating bodies. The findings indicate that integrating these culturally relevant objects into geometry education not only enhances students' understanding of mathematical principles but also fosters a deeper appreciation of their cultural context.

Keywords: Analytical geometry; ellipses; ethnomathematics; hyperbolas

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1. Introduction

Mathematics and culture are two aspects of existence that cannot be separated from one another (Iskandar et al., 2022; Pratama & Yelken 2024). Culture emerges in society as a result of the distinctive ways humans adapt to their environment. Every culture in the world uses and develops mathematical ideas, methods, and techniques to interact with the realities of life (Prahmana & D'Ambrosio 2020; Hidayati & Prahmana, 2022; Nicol et al., 2024). While mathematics is manifested as a result of human activity in adapting to the environment (Purniati et al., 2022; Prahmana, 2022). Mathematics is based on human ideas, methods, and techniques for responding to their environment. Mathematical ideas and practices appear in works of art, architectural concepts, activities, and artifacts from various cultures. Therefore, mathematics is a cultural product (Song & Ju 2024). Ethnomathematics is research on the relationship between mathematics and social and cultural backgrounds (Vandendriessche & Pinxten 2022; Zhang & Zhang, 2023; Setiana, 2020; Hidayati & Prahmana, 2022; Iskandar et al., 2022). In learning, it is necessary to connect mathematics with culture. This will make it easier for students to observe and imagine what the lecturer is explaining. Linking mathematics and culture can help students master math better (Rosa et al., 2020). One application of Ethnomathematics can be applied to geometry material.

Geometry offers many basic skills and helps improve deductive reasoning, logical thinking, problem-solving skills, and analytical thinking (Mawarsari et al., 2020; Rahayu et al., 2023). Therefore, the ability to think geometrically plays an active role in developing the ability to think mathematically. One theory in learning geometry that pays attention to students' thinking stages in developing their geometric thinking processes is van Hiele's theory (Siagian & Sinaga, 2019). Research reveals that van Hiele's geometry learning theory has proven to be effective in conclusively learning mathematics (Kandaga et al., 2022). Based on experience and research results, many students still have difficulties in learning geometry. One reason for the difficulty is that geometry is often taught without any real connection to everyday life. Geometry that is taught in universities is not contextual and is not related to everyday life. As a result, learning geometry becomes a transfer of knowledge, and students receive it without any reflection or understanding of how mathematics is used in everyday life. One alternative to improve students' abilities in the geometry course is by connecting material with the culture around students (Massarwe et al., 2010; Küçük, 2013; Sunzuma & Maharaj, 2019; Verner et al., 2019; Fouze & Amit, 2021; Suharta et al., 2021; Hendriyanto et al., 2021).

Increasing ethnic and cultural diversity in education enhances creativity in human growth and development (Hendriyanto et al., 2021). Indonesia's rich cultural heritage, such as Banten batik motifs (Sianturi, 2022), Gringsing batik motifs (Permita et al., 2022), and Yoga batik (Hidayati & Prahmana, 2022; Prahmana & D'Ambrosio, 2020), can be effectively utilized in geometry learning. Ethnomathematics has also been explored in historical sites like Fort Rotterdam (Sulasteri et al., 2020), the Great Mosques of Demak and Bandung (Radiusman et al., 2021; Purniati et al., 2021), the Panjalin traditional house (Sulaiman & Nasir, 2020), and Radakng House in Sahapm Village (Permata et al., 2021), as well as cultural elements like Barong Art (Monalisa et al., 2022) and Barongko Cake (Pathuddin & Nawawi, 2021). Further examples include studies of various tribes: the South American Incas (Gilsdorf, 2016), the Kabihug Tribe in the Philippines (Rubio, 2016), and the Javanese, Sundanese, and Sasak people of Indonesia (Prahmana & D'Ambrosio, 2020; Supriadi, 2019; Sri Supiyati et al., 2019). Additional ethnomathematics research has covered the Muntuk Community (Maryati & Prahmana, 2019), a tribe in the African Sahara (Gerdes, 2004), and Anatolia in Türkiye (Küçük, 2013).

The concept of ethnomathematics is an innovation that can be used in learning mathematics. Through ethnomathematics, the explanation of mathematical values contained in a culture becomes more interesting. Ethnomathematics aims to draw on cultural experiences and the use of mathematics so that it not only makes learning mathematics more meaningful but also provides insight into the social and cultural environment (Suharta et al., 2021). The results of the research show that by using ethnomathematics, mathematics material can be learned more easily (Suharta et al., 2021), increase creativity (Faiziyah et al., 2020), improve the communication ability of geometry material (Farokhah et al., 2017), geometry problem-solving ability (Permita et al., 2022). Based on this, cultural elements can be included in geometry lectures. Learning mathematics related to local culture is a good model because every activity carried out by students always prioritizes cultural values (Sulasteri et al., 2020; Ergene et al., 2020; Prahmana & D'Ambrosio, 2020; Iskandar et al., 2022). One of the cultures that can be used in geometry courses is exploring the Sam Poo Kong pagoda.

1.1. Purpose of study

Sam Poo Kong Temple is a place of worship for the Confucian and Buddhist Chinese community in the city of Semarang (Aisyah et al., 2022), and is a symbol of the multi-cultural, multi-ethnic, and multi-religious people of Semarang (Julianto, 2015). Sam Poo Kong Temple is the oldest Chinese temple in Semarang with an area of 1,020 square meters which has Chinese and Javanese architectural styles from the 14th century (Zaenuri & Dwidayati, 2018). At the Sam Poo Kong pagoda, some buildings and objects are characteristic of the ethnic Tionghoa in Semarang. These buildings and objects can certainly be used as learning resources for students in studying the material. One of them is Analytical Geometry material in Higher Education. Objects in the Sam Poo Kong temple that can be implemented in Analytical Geometry include Giant Kendil, lanterns, and statues containing lion dance balls. The purpose of this study is to identify the ethnomathematics of the objects in the Klenteng Sam Poo Kong which include curved side shapes and examine more deeply in determining the volume of these objects.

2. METHODS AND MATERIALS

This research is qualitative research with an ethnographic approach which aims to get an in-depth description and analysis of the research object. The object of this study is the identification of objects in the form of curved side chambers at the Sam Poo Kong Temple, Semarang. The stages carried out in this study were (1) observing at the Sam Poo Kong Temple Semarang to identify objects in the shape of curved side shapes, (2) measuring the objects that had been identified to obtain diameter, height, length of the major axis, the length of the minor axis and the length of the surface, (3) perform in-depth analysis in determining the volume of these objects, (4) draw conclusions. Data collection techniques were observation and documentation.

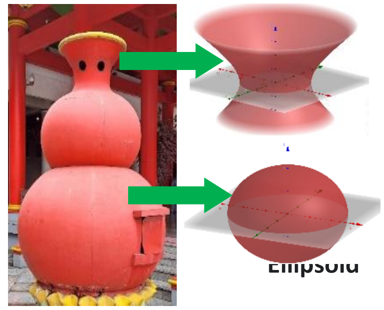
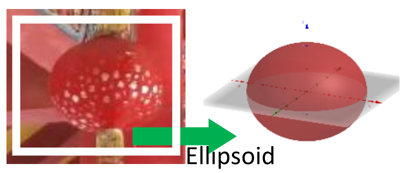
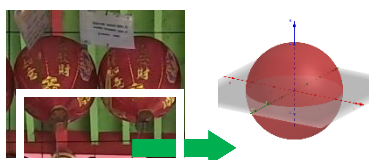
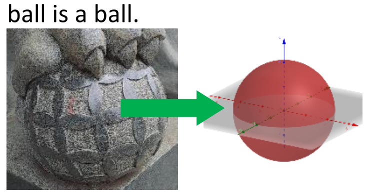
3. RESULTS

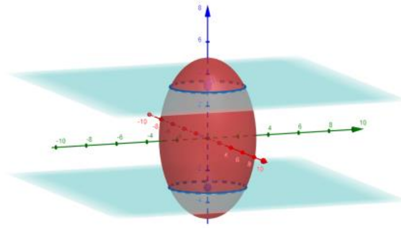
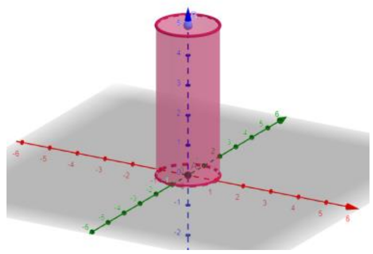
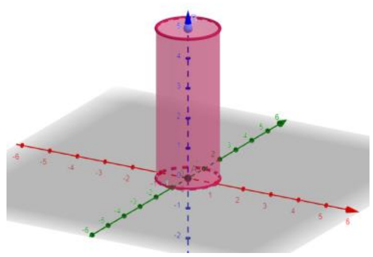
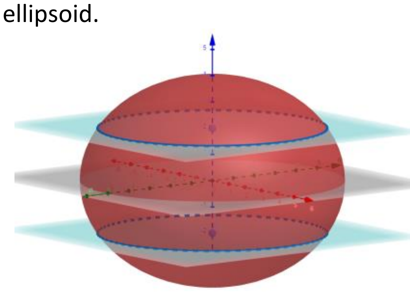
Identification of objects in the shape of curved side chambers at the Sam Poo Kong Temple. The results of observations made at the Sam Poo Kong temple showed that there were several objects in the form of curved side shapes. These objects apart from having cultural values can also be used as the implementation of teaching materials in analytic geometry courses. Following are the results of the identification of objects in the form of curved side chambers in the Sam Poo Kong Semarang pagoda (Table 1).

Table 1

Results of Identification of Objects in the Shape of Curved Side Spaces

Item name and Original Form	Geometry Shape	Culture value
Giant Kendil	The geometric shape of the giant kendil, if analyzed in depth, consists of 3 parts, namely the bottom and the middle in the form of a truncated ellipsoid, but both have different lengths of the major and minor axes. Where the bottom ellipsoid is longer than the middle. And the top is in the form of a truncated hyperbole.	The giant kendil is a place where incense is burned or called hiolo (properly burning incense/incense). Hiolos come in different sizes depending on their placement and function. The hiolo in the Sam Poo Kong pagoda this time has a different size and shape, namely in the form of a giant kendil placed outside the pagoda. At the bottom,

		there is a cavity to put incense while at the top there is also a cavity that functions to cycle out the smoke of the burned incense. This giant pot is red which is a characteristic of the Chinese ethnicity, which symbolizes good luck, happiness, and abundance.
Lanterns 	There are two types of geometric shapes in the lanterns at the Sam Poo Kong temple, namely ellipsoidal and spherical.  Ellipsoid  E all	Lanterns are one of the ornaments that must be in the Temple. The word lantern in Mandarin is called denglong, which means "to illuminate". The red color of the lantern symbolizes prosperity, unity, and sustenance. The tradition of installing lanterns has existed in mainland China since the Xi Han Dynasty, around the 3rd century AD. The appearance of the lanterns coincided with the introduction of paper-making techniques.
Barong Sai Ball Statue 	The geometric shape on the Barong Sai ball is a ball.  Ball	The lion dance is a stone carving in the form of a lion holding a ball. This statue is usually owned by the Chinese community and is placed in a temple, their home, or place of business, this is because the Barong Sai statue is believed to bring good fortune and a mate. The barong sai statue has two types, namely male and female. The barong sai statue at the Sam Poo Kong Temple is placed at the entrance of the temple, as a symbol of blessing for the people who come to the Temple.
Stone Carving	The geometric shape on the stone carving at Sam Poo Kong Temple on the side is a truncated ellipsoid with the major axis parallel to the Y axis.	There are several types of stone carvings at the Sam Poo Kong Temple, namely cubes, blocks, ellipsoids, tubes and wall stone

	 **Truncated Ellipsoid**	carvings. Each carving has its storyline, some telling the story of Admiral Cheng Hoo, carvings of gods, dragon carvings, and various other carvings.
Giant Candle 	The geometric shapes on the giant candle beside are tubes.  **Tube**	Candles by the Chinese ethnicity is a light to live life for the next year. The Chinese people believe that the candle is a hope so that the life they live can run easily and smoothly.
Temple Pillar 	The geometric shapes on the supporting pillars of the buildings in the Sam Poo Kong Temple are in the form of a tube that extends upwards.  **Tube**	The pillars of the Pagoda must have pillars that are in the form of tubes that rise high and are red. There is also a support that has carvings. Ornaments on the pillars are often in the form of gods, warlords, plants, flowers, elephants, kilin, dragons, and others.
Copper Hilo 	The geometric shape on the copper hiolo on the side is a truncated ellipsoid.  **Truncated Ellipsoid**	Copper Hiolo is a place where incense is burned inside the Temple. At every place of worship for the Chinese ethnic, either at home or in the pagoda, there is always copper incense. Copper hiolo have various sizes from small to large.

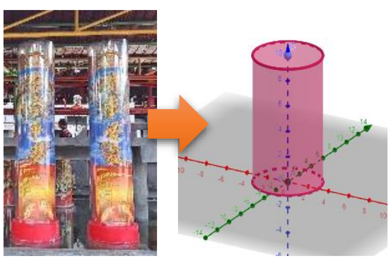
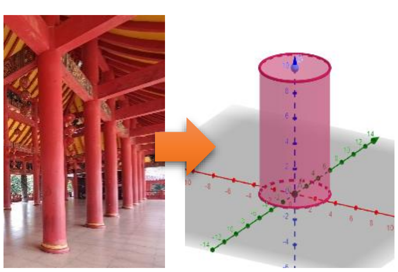
3.1. Volume of curved side spaces using the concept of spatial geometry

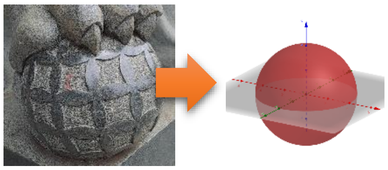
Determining the volume of objects in the Sam Poo Kong Temple which are in the form of curved side shapes, there are objects whose volume can be found simply by using the volume concept of curved side shapes. The following is the identification of the volume of curved side chambers in the Sam Poo Kong Temple which can be calculated using the concept or formula for curved side chambers, including:

Table 2 shows that the giant candle and the supporting pillars of the temple are tubular. The volume of these two objects can be calculated using the volume formula of the cylinder. Meanwhile, the lion dance is in the shape of a ball. The following is the result of the volume of the giant candle, supporting pillars, and lion dance balls based on observations made by measuring the length, diameter, and height of the giant candles, supporting pillars, and lion dance balls.

Table 2

Volume analysis of curved side spaces using the cylinder volume concept

Item Name	Observation Results	Volume Analysis
Giant Candle 	The results of the measurement observations that have been carried out are obtained: Long diameter = 60 cm Height = 2.5 meters	The shape of the giant candle is a tube. This is because the giant candle has a circular base and roof that are parallel to each other and has a rectangular blanket. Based on these characteristics, the giant candle is in the form of a tube. So, the Volume of a giant candle = the volume of a cylinder. Volume of cylinder = area of base x height V = la xt $=\pi r^2 t$ $= 250(3{,}14)(30^2)$ = 706,500cm^3 So, the volume of each giant candle is 706,50cm^3
Pillar of Sam Poo Kong Temple 	The results of the measurement observations that have been carried out are obtained: Long diameter = 60 cm Height = 2.5 meters	The shape of the giant candle is a tube. This is because the giant candle has a circular base and roof that are parallel to each other and has a rectangular blanket. Based on these characteristics, the giant candle is in the form of a tube. So, the Volume of the giant candle is = the volume of a cylinder. Volume of cylinder = area of base x height V = la xt $=\pi r^2 t$ $= 250(3{,}14)(30^2)$ = 706,500cm^3 So, the volume of each giant candle is 706,500cm^3

Barong Sai ball 	The results of the measurement observations that have been carried out are obtained: Long diameter = 28 cm	The shape of the lion dance is a ball. So, to get the volume of the lion dance ball use the ball formula. Ball volume $=\frac{4}{3}\pi r^2$ $=\frac{4}{3} \times \frac{22}{7} \times 14^3$ $= 821.33 cm^3$ So, the volume of the lion dance ball is $821.33 cm^3$

3.2. Volume of curved side spaces using the concept of rotational volume

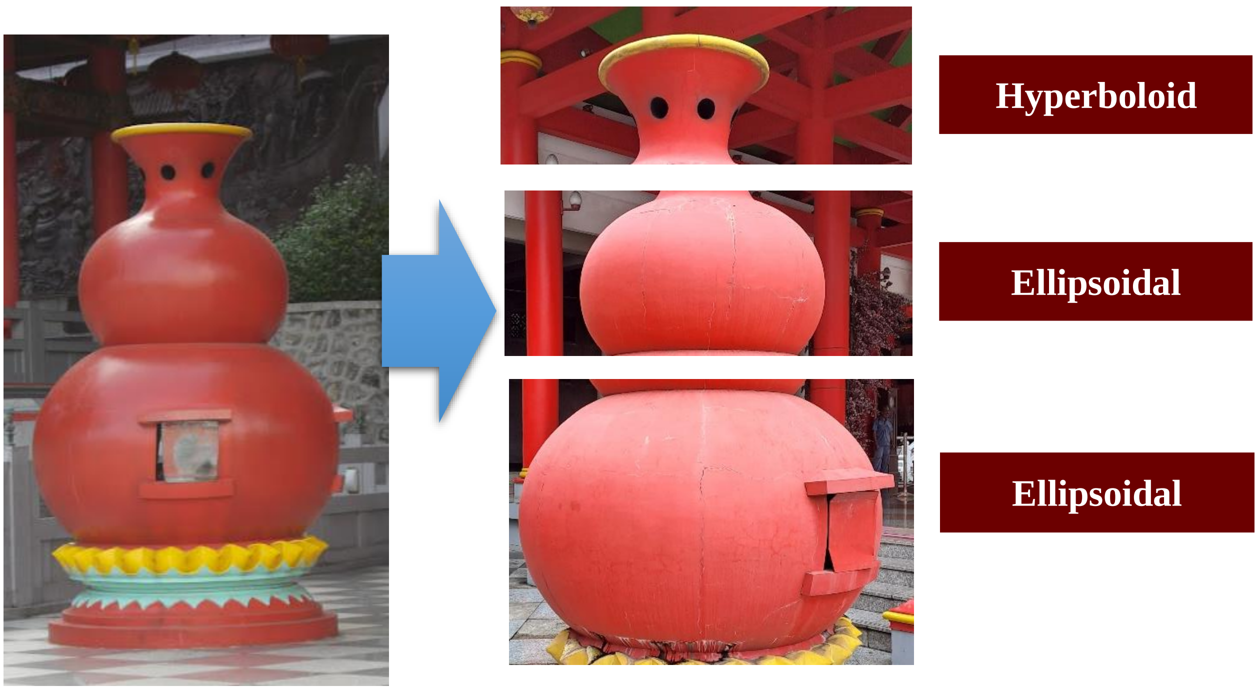
There is an object in the Sam Poo Kong pagoda that has the shape of a curved side shape. In determining its volume, you cannot use the concept or volume formula for curved side shapes. It is necessary to have the concept of the volume of a rotating object in integral calculus and the concept of determining the equation of a conic section in analytical geometry to determine the volume of the object. One of the objects in the Sam Poo Kong Temple whose volume can be calculated using this technique is a giant kendil.

Figure 1
Giant Dwarf

Based on Figure 1, it can be seen that this giant dwarf is a geometric shape with curved sides consisting of 3 parts. The first part is the bottom which is in the shape of an ellipse. In mathematics, the 3D shape of an ellipse is called an ellipsoid. The second part is the middle part which is also ellipsoidal but with a shorter major axis length compared to the first ellipsoidal. The third part is the part of the chimney which is in the form of a hyperbola which is a geometric shape, so that in mathematics the hyperbole in 3D is called a hyperboloid. To find out the volume or surface area of the giant pot can be obtained using the concept of Integral Calculus, namely the volume of a rotating object. But before looking for the volume of the object, of course, you must first know the equation of the large ellipse, small ellipses, and hyperboles using concepts in Analytical Geometry. Based on the length of the major axis and the length of the minor axis that can be obtained from measurements on the giant kendil according to the original size. The following is an illustration of the giant pot broken into geometric shapes (figure 2).

Figure 2

Structure of the Giant Kendil



The first step in determining the volume of a rotating object is the equation of the curve or the equation of the line which forms the boundary of the area to be rotated. In determining the equation of the curve, we first assume that the curve is in the Cartesian coordinate system with the center of the curve being the center of the Cartesian coordinate, namely point O (0,0). We will first look for the equations on the large ellipsoid.

3.3. Large ellipsoidal

3.3.1. Ellipse equation

To determine the equation of the large ellipse, it is necessary to first determine the center of the ellipse, the length of the major axis, and the length of the minor axis. It was assumed earlier that the center of the ellipse is the center of the cartesian coordinate O (0,0). The length of the major axis is the diameter of the lower ellipsoid, which is 100 cm. The length of the minor axis is the height of the lower ellipsoid, which is 80 cm.

Based on this information, it is obtained:
Major axis length = 100 cm
For example: the length of the major axis =$|2a|$, so
Major axis length = 100 cm
$\leftrightarrow |2a| = 100$

$$\leftrightarrow a = \frac{100}{2}$$

$\leftrightarrow a = 50$

So, the peak coordinates on the major axis are (50, 0) and (-50, 0).

Minor axis length = 80 cm
For example: minor axis length =$|2b|$, so
Minor axis length = 80 cm
$\leftrightarrow |2b| = 80$
$\leftrightarrow b = \frac{80}{2}$
$\leftrightarrow b = 40$

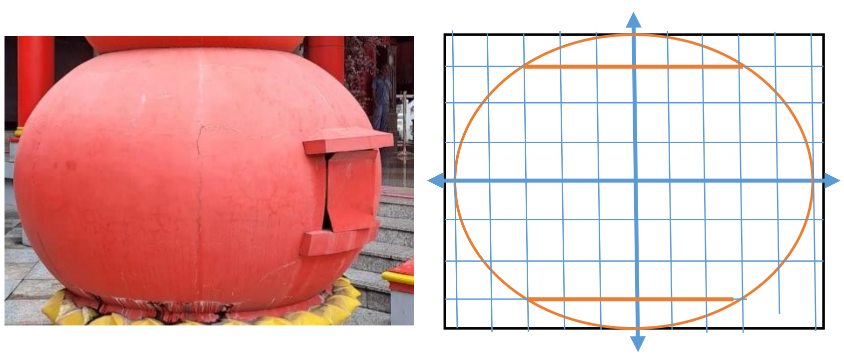
So, the peak coordinates on the minor axis are (0, 40) and (0, -40).

Specifies the focus coordinates
$a^2 = b^2 + c^2$
$\leftrightarrow\ c^2 = a^2 - b^2$
$\leftrightarrow\ c^2 = 50^2 - 40^2$
$\leftrightarrow\ c^2 = 2500 - 1600$
$\leftrightarrow\ c^2 = 900$
$\leftrightarrow\ c = \sqrt{900} = 30\ cm$

So, the focus coordinates are (30, 0) and (-30, 0).

The results of the calculations above can be concluded that:
Elliptical Center Coordinates = (0, 0)
Focal point coordinates = (30, 0) and (-30, 0)$f_1 f_2$
Major axis peak coordinates = (50, 0) and (-50, 0)$A_1 A_2$
Minor axis peak coordinates = (0, 40) and (0, -40)$B_1 B_2$
Based on this information, the large elliptic curve sex can be described in Cartesian coordinates as follows (Figure 3).

Figure 3
Large ellipse



The equation of an ellipse with center O (0, 0) and a major axis on the X axis has the general form, that is,

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

$$\leftrightarrow\ \frac{x^2}{50^2} + \frac{y^2}{40^2} = 1$$

$$\leftrightarrow\ \frac{x^2}{2500} + \frac{y^2}{1600} = 1$$

$\leftrightarrow 1600x^2 + 2500y^2 = 4.000.000$

$\leftrightarrow 1600x^2 + 2500y^2 - 4.000.000 = 0$

So, the elliptical equation formed is $1600x^2 + 2500y^2 - 4.000.000 = 0$

3.3.2. Rotational volume: ellipse

The ellipse is a closed curve at Cartesian coordinates at R2. To determine the volume of the ellipse, it is necessary to rotate it with the Y axis, so a geometric shape will be formed at Cartesian coordinates R3, so that it is an ellipsoidal shape. To find out the volume of a rotating object from an ellipse, the concept of Integral Calculus is used with sub-materials on the use of integrals in the volume of a rotating object.

To get the R3 form according to the Giant Kendil, the elliptical equation is rotated concerning the Y axis. The first thing to do is to change the elliptic equation into the variable y form, so we get:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

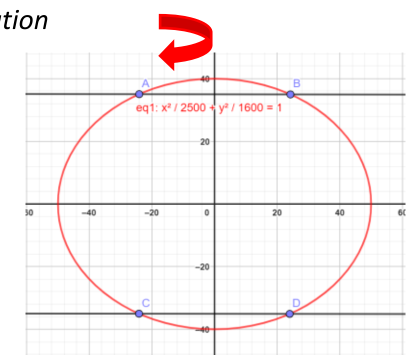
$$\leftrightarrow \frac{x^2}{a^2} = 1 - \frac{y^2}{b^2}$$

$$\leftrightarrow x^2 = a^2\left(1 - \frac{y^2}{b^2}\right)$$

The volume of the rotating object is bounded by the curve and about the Y axis. To make it easier to find the volume of the rotating object, the ellipse is divided into 2 parts, namely the curve above and below the X axis which has the same volume (figure 4). Here is an illustration of the ellipse.$x^2 \ -30 \leq y \leq 30$,

Figure 4

General form of the large ellipse equation



The volume of the rotating body bounded by the curve and about the Y-axis is equivalent to 2 times the volume of the rotating body bounded by the curve and about the Y-axis, that is, $x^2 \ -30 \leq y \leq 30, x^2 \ 0 \leq y \leq 30$

$$V1 = 2\pi \int_0^{30} x^2 \, dy$$

$$\leftrightarrow V1 = 2\pi \int_0^{30} a^2\left(1 - \frac{y^2}{b^2}\right) dy$$

$\leftrightarrow V1 = 2a^2\pi\left[y - \frac{1}{3b^2}y^3\right]_0^{30}$
$\leftrightarrow V1 = 2 * 50^2\pi\left[\left(30 - \frac{1}{3.40^2}(30^2)\right) - (0)\right]$
$\leftrightarrow V1 = 2 * 2500\,\pi\,[30 - 0{,}1875]$
$\leftrightarrow V1 = 5000\,\pi\,[29{,}8125]$
$\leftrightarrow V1 = 149.062{,}5\,\pi\,cm^3$

3.4. Small ellipsoidal

3.4.1. Ellipse equation

To determine the equation of the large ellipse, it is necessary to first determine the center of the ellipse, the length of the major axis, and the length of the minor axis. It was assumed earlier that the center of the ellipse is the center of the cartesian coordinate O (0,0). The length of the major axis is the diameter of the lower ellipsoid, which is 60 cm. The length of the minor axis is the height of the lower ellipsoid, which is 40 cm.

Based on this information, it is obtained:

Major axis length = 60 cm
For example: the length of the major axis =$|2a|$, so
Major axis length = 60 cm
$\leftrightarrow |2a| = 60$
$\leftrightarrow a = \frac{60}{2}$
$\leftrightarrow a = 30$
So, the peak coordinates on the major axis are (30, 0) and (-30, 0).

Minor axis length = 40 cm
For example: minor axis length =$|2b|$, so
Minor axis length = 40 cm
$\leftrightarrow |2b| = 40$
$\leftrightarrow b = \frac{40}{2}$
$\leftrightarrow b = 20$
So, the peak coordinates on the minor axis are (0, 20) and (0, -20).

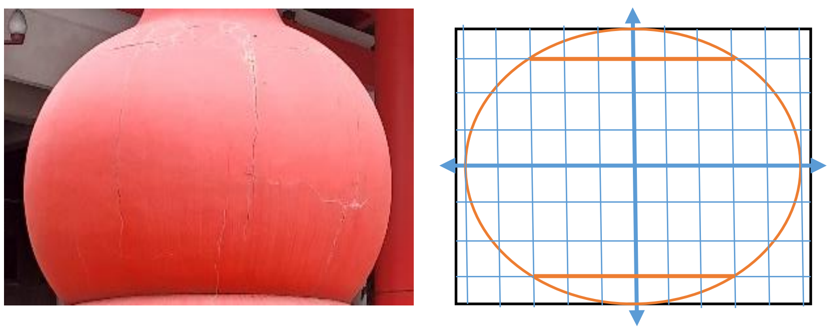
Specifies the focus coordinates
$a^2 = b^2 + c^2$
$\leftrightarrow\ c^2 = a^2 - b^2$
$\leftrightarrow\ c^2 = 30^2 - 20^2$
$\leftrightarrow\ c^2 = 900 - 400$
$\leftrightarrow\ c^2 = 500$
$\leftrightarrow\ c = \sqrt{500} = 10\sqrt{5}\ cm$
So, the focus coordinates are (, 0) and (-, 0).$10\sqrt{5}10\sqrt{5}$

The results of the calculations above can be concluded that:
Elliptical Center Coordinates = (0, 0)
Focal point coordinates = (, 0) and (-, 0)$f_1 10\sqrt{5} f_2 10\sqrt{5}$
Major axis peak coordinates = (30, 0) and (-30, 0)$A_1 A_2$
Minor axis peak coordinates = (0, 20) and (0, -20)$B_1 B_2$

Based on this information, the large elliptic curve sex can be described in Cartesian coordinates as follows (figure 5).

Figure 5

General form of the small ellipse equation



The equation of an ellipse with center O (0, 0) and a major axis on the X axis has the general form, that is,

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$
$$\leftrightarrow \frac{x^2}{30^2}+\frac{y^2}{20^2}=1$$
$$\leftrightarrow \frac{x^2}{900}+\frac{y^2}{400}=1$$
$$\leftrightarrow 400x^2+900y^2=360000$$
$$\leftrightarrow 400x^2+900y^2-360.000=0$$

So, the elliptical equation formed is $400x^2+900y^2-360.000=0$

3.4.2. Rotational volume: ellipse

The ellipse is a closed curve at Cartesian coordinates at R2. To determine the volume of the ellipse, it is necessary to rotate it with the Y axis, so a geometric shape will be formed at Cartesian coordinates R3, so that it is an ellipsoidal shape. To find out the volume of a rotating object from an ellipse, the concept of Integral Calculus is used with sub-materials on the use of integrals in the volume of a rotating object.

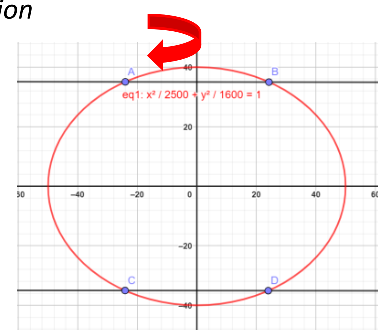
To get the R3 form according to the Giant Kendil, the elliptical equation is rotated concerning the Y axis. The first thing to do is to change the elliptic equation into the variable y form, so we get:

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$
$$\leftrightarrow \frac{x^2}{a^2}=1-\frac{y^2}{b^2}$$
$$\leftrightarrow x^2=a^2\left(1-\frac{y^2}{b^2}\right)$$

The volume of the rotating object is bounded by the curve and about the Y axis. To make it easier to find the volume of the rotating object, the ellipse is divided into 2 parts, namely the curve above and below the X axis which has the same volume. Here is an illustration of the ellipse.$x^2 \ -15 \leq y \leq 15$,

Figure 6

General form of the small ellipse equation



The volume of the rotating body bounded by the curve and about the Y-axis is equivalent to 2 times the volume of the rotating body bounded by the curve and about the Y-axis, that is $x^2 \ -15 \leq y \leq 15, x^2 \ 0 \leq y \leq 50$

$$V2 = 2\pi \int_0^{15} x^2 \, dy$$

$$\leftrightarrow V2 = 2\pi \int_0^{15} a^2 \left(1 - \frac{y^2}{b^2}\right) dy$$

$$\leftrightarrow V2 = 2a^2\pi \left[y - \frac{1}{3b^2} y^3\right]_0^{15}$$

$$\leftrightarrow V2 = 2 * 30^2\pi \left[\left(15 - \frac{1}{3.20^2}(15^2)\right) - (0)\right]$$

$$\leftrightarrow V2 = 2 * 900 \, \pi \, [15 - 0{,}1875]$$

$$\leftrightarrow V2 = 1800 \, \pi \, [14{,}8125]$$

$$\leftrightarrow V2 = 26.662{,}5 \, \pi \, cm^3$$

3.5. Hyperboloid

3.5.1. Hyperbola equations

To determine the hyperbola equation, it is necessary to first determine the center of the hyperbola, the length of the major axis, and the length of the minor axis. It was assumed earlier that the center of the hyperbola is the cartesian coordinate O (0,0). The length between the peaks is 30.

Based on this information, it is obtained:

Length between peaks = 30 cm

For example: the length between peaks =$|2a|$, so
Length between peaks = 30 cm
$\leftrightarrow |2a| = 30$
$\leftrightarrow a = \frac{30}{2}$
$\leftrightarrow a = 15$
So, the top coordinates of the hyperbola are (15, 0) and (-15, 0).

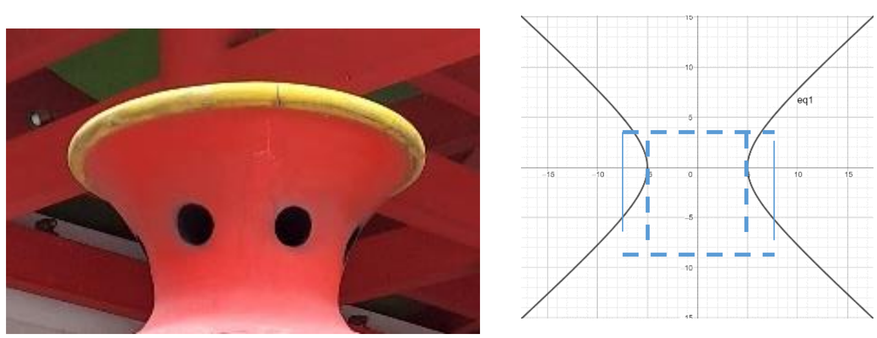
Focal length = 40 cm
For example: focal length =$|2c|$, so
Focal length = 40 cm
$\leftrightarrow |2c| = 40$
$\leftrightarrow c = \frac{40}{2}$
$\leftrightarrow c = 20$
So, the coordinates of the focus of the hyperbola are (20; 0) and (-20, 0).

Determine the value b
$b^2 = c^2 - a^2$
$\leftrightarrow\ b^2 = 20^2 - 15^2$
$\leftrightarrow\ b^2 = 400 - 225$
$\leftrightarrow\ b^2 = 175$
$\leftrightarrow\ b = \sqrt{175} = 16{,}77\ cm$
So, the coordinates of the imaginary axes are () and).$0; 13{,}230; -13{,}23$

The results of the calculations above can be concluded that:
Hyperbola Center Coordinates = (0, 0)
Focus point coordinates =f_1(22.5; 0) Andf_2(-22.5, 0)
The main axis coordinates =A_1(15, 0) and (-15, 0)A_2
Imaginary axis peak coordinates = (0,) and (0, -)$B_1 13{,}23 B_2 13{,}23$

Based on this information, the large hyperbola curve sex can be described in Cartesian coordinates as follows (figure 7).

Figure 7
The general form of the hyperbola equation



The equation of a hyperbola with center O (0, 0) and a principal axis on the X axis has the general form, that is,

$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$

$\leftrightarrow \frac{x^2}{15^2} - \frac{y^2}{13{,}23^2} = 1$

$\leftrightarrow \frac{x^2}{225} - \frac{y^2}{175{,}03} = 1$

$\leftrightarrow 175{,}03x^2 - 225y^2 = 39.381{,}75$

$\leftrightarrow 175{,}03x^2 - 225y^2 - 39.381{,}75 = 0$

So, the hyperbola equation that is formed is $175{,}03x^2 - 225y^2 - 39.381{,}75 = 0$

3.5.2. Volume of Rotate: Hyperbola

The hyperbola is a closed curve at Cartesian coordinates at R2. To determine the volume of the hyperbola, it is necessary to rotate it with the Y axis, so a geometric shape will be formed at cartesian coordinates R3 so that it is in the form of a hyperboloid. To find out the volume of a rotating object from a hyperbola, the concept of Integral Calculus is used with sub-material on the use of integrals in the volume of a rotating object.

To get the R3 form according to the Giant Kendil, the Hyperbola equation is rotated concerning the Y axis. The first thing to do is change the Hyperbola equation into the variable y form so that we get:

$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$

$\leftrightarrow \frac{x^2}{a^2} = 1 + \frac{y^2}{b^2}$

$\leftrightarrow x^2 = a^2\left(1 + \frac{y^2}{b^2}\right)$

The volume of a rotating object is bounded by the curve and about the Y axis. To make it easier to find the volume of the rotating object, the hyperbola is divided into 2 parts, namely the curve above and below the X axis which has the same volume. The following is an illustration of the hyperbola.$x^2 \ -10 \leq y \leq 20$,

The volume of a rotating body bounded by a curve and about the Y axis is equivalent to 2 times the volume of a rotating object bounded by a curve and about the Y axis, that is, $x^2 \ -10 \leq y \leq 20, x^2 \ -10 \leq y \leq 00 \leq y \leq 20$

$V3 = \pi(-\int_{-10}^{0} x^2\, dy) + \pi \int_0^{20} x^2\, dy$

$\leftrightarrow V3 = \pi \int_0^{10} a^2\left(1 + \frac{y^2}{b^2}\right) dy + \pi \int_0^{20} a^2\left(1 + \frac{y^2}{b^2}\right) dy$

$\leftrightarrow V3 = a^2\pi\left[y + \frac{1}{3b^2}y^3\right]_0^{10} + a^2\pi\left[y + \frac{1}{3b^2}y^3\right]_0^{20}$

$\leftrightarrow V3 = 15^2\pi\left[\left(10 + \frac{1}{3.\,13{,}23^2}(10^2)\right) - (0)\right] + 15^2\pi\left[\left(20 + \frac{1}{3.\,13{,}23^2}(20^2)\right) - (0)\right]$

$\leftrightarrow V3 = 225\,\pi\,[10 + 0{,}19044] + 225\,\pi\,[20 + 0{,}76176]$

$\leftrightarrow V3 = 225\, \pi\, [10{,}19044 + 20{,}76176]$

$\leftrightarrow V3 = 6.964{,}245\, \pi\, cm^3$

Total Volumes= V1 + V2 + V3

=$149.062{,}5\ \pi$+ +$26.662{,}5\ \pi 6.964{,}245\ \pi$

=$69.815{,}970\ \pi\ cm^3$

Based on the results of the analysis of large elliptical volume calculations, small elliptical volumes, and hyperbolic volumes, the volume of the giant kendil is $69.815{,}970\ \pi . cm^3$

4. DISCUSSION

The ethnomathematics identification of geometric shapes at the Sam Poo Kong Temple in Semarang can be used as a reference for learning strategies that can be implemented in the lecture process, especially in the courses of spatial geometry, analytic geometry, and integral calculus which are related to the volume of curved geometric shapes. Geometry is a material that is closely related to everyday life, namely the objects around it in the form of curved side shapes, such as tubes, cones, and balls. It will be different if it turns out that the objects found are geometric shapes with curved sides such as ellipsoids, hyperboloids, and paraboloids. The determination of the volume of these objects cannot be calculated using the volume concept of curved side shapes. There needs to be another concept that must be implemented in determining the volume, this concept is the integral volume of a rotating object which is included in the material in integral calculus courses.

In addition, to know the curve and boundary equations that will be used for the volume integral of a rotating object, it is necessary to have the concept of analytic geometry, namely conical slices in the form of ellipses, parabolas, and hyperbolas. Often people think that analytical geometry and integral calculus courses cannot be implemented in everyday life namely the conical slices in the form of ellipses, parabolas, and hyperbolas. Often people think that analytical geometry and integral calculus courses cannot be implemented in everyday life namely the conical slices in the form of ellipses, parabolas, and hyperbolas. Also, there is a perception that analytical geometry and integral calculus courses cannot be implemented in everyday life (Ramlan, 2016; Sucipto & Irpan 2022). The results of this research analysis are of course no longer valid.

The existence of ethnomathematics identification of curved side geometric shapes at the Sam Poo Kong Temple, Semarang, shows that the materials of analytic geometry and integral calculus are very supportive of everyday problems. (Madrazo & Dio, 2020) And can support learning innovation. The identification of ethnomathematics as a learning innovation is expected to support problem-solving abilities (Madrazo & Dio, 2020) and students' geometric thinking abilities (Waluya et al., 2022). These results have excellent potential to be developed into innovations in contextual learning and to introduce Indonesian culture to students so that the ethnomathematics field can be used as a learning tool using a learning method approach (Badruzzaman et al., 2022)

5. CONCLUSION

This study concludes that the objects in the Sam Poo Kong Temple are curved side shapes and can be a learning resource for students to study analytic geometry material about daily life and culture. These objects include giant kendils, lanterns, giant candles, and ball ornaments on the lion dance statue. The material that can be implemented in ethnomathematics identification of curved side geometric objects in the Sam Poo Kong Temple is volume material. The volume of these objects can be determined using volume formulas for curved shapes such as cylinders, spheres, and cones. For more complex curved objects, like ellipsoids, hyperboloids, paraboloids, or even spherical sections, the volume can be calculated using the concept of integral volume for rotating objects. Before using the integral volume concept of a rotating body, it is necessary to determine the equation of the curve first and certain integral limits.

The equation of the curve can be obtained by observing the object first so that the length of the major axis, the length of the minor axis, the length of the imaginary axis, the length of the main axis, and the height of the object in the shape of a curved side shape are obtained. After that, new curve equations will be obtained in the form of ellipses, hyperbolas, parabolas, and circles. The equation of the curve can be obtained by observing the object first so that the length of the major axis, the length of the minor axis, the length of the imaginary axis, the length of the main axis, and the height of the object in the shape of a curved side shape are obtained. After that new curve equations will be obtained in the form of ellipses, hyperbolas, parabolas, and circles. The equation of the curve can be obtained by observing the object first so that the length of the major axis, the length of the minor axis, the length of the imaginary axis, the length of the main axis, and the height of the object in the shape of a curved side shape are obtained. After that, new curve equations will be obtained in the form of ellipses, hyperbolas, parabolas, and circles.

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Ethical Approval: The study adheres to the ethical guidelines for conducting research.

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