Written Report

Pi in Life

Group 08-7

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Introduction

Our project aims to find out the most efficient method to calculate Pi that is closest to the actual value of Pi. (Which means the first discovered value.)

We are also going to find out the most reliable method of calculating Pi amongst all the methods with Google Sheets.

Our Objectives:

1) What methods are there to calculate Pi, and which one is the most reliable? (In terms of the time taken to calculate it, and how close it is to the actual value of Pi)
2) Are there any patterns in the digits of Pi?

Our research problems are:

1. What methods are there to calculate Pi + comparison of the methods?
2. Are there any patterns in the digits of Pi?

Scope of study:

- Rationale
- Objectives
    - Irrationality of Pi
    - Closest method to find Pi
- Literature Review

- Methodology
- Conclusion

Rationale:

- Find the different methods used to calculate Pi
- Compare the methods
- Find out which method is the most reliable at arriving to the value closest to Pi

- Find whether there are any patterns in the digits of Pi

Literature Review

Article 1 (Rod Walton, 2014)

According to Rod Walton, he sees Pi being used in business and everyday life all the time. We agree that people use Pi in their daily lives as a lot of occupations use Pi as a solution, example architectures.

"It figures in a lot of different ways," said Rick Gurley, who is electrical utility AEP-PSO's manager of protection and control engineering. "It holds true every time." We agree with Rick Gurley as Pi has many different uses and never fails the user.

Christian Constanda, the University of Tulsa's C.W. Oliphant professor of mathematical science, sees Pi revealed in pretty much every aspect, from sports to automobiles to the roads they travel on. As said earlier, Pi can be useful in many ways, from solving math problems to building cars.

Conclusion: From the quotes of this article by Rod Walton, we can confirm that people do use Pi in their daily life and even in their occupations. Pi can be used in architecture, solving math problems,and many more. Pi has been useful in many inventions and has helped us advance in technology. People might use Pi in their daily lives, but do they know what Pi actually is and how it was created? Thus, this report will enlighten them about the history and the methods of calculating Pi.

Article 2 (James Vincent, 2016)

In this article, Pi is used by engineers and scientists to maybe create cures for certain diseases, solve some cases, and build more structures in Singapore to improve our lives. Engineers and scientists need pi for all sorts of tasks.

But calculations like these only need between five to 15 digits to be accurate, and we currently know pi to quadrillions of digits.

Conclusion: Since technology in math is advanced, mathematicians have the ability to calculate Pi to millions and million of digits. However, though they have advanced technology, till this very day, they are still unable to identify or spot a pattern in the digits of Pi. Thus, we have it as one of our research questions to allow us to attempt to find small patterns that may appear anywhere in this irrational number.

Article 3 (Unknown Author, 2017)

There are many formulas made by many different people to calculate the value of Pi. However, each formula ends up with a different answer. Pi also crops up in probability. The function $f(x)=e^{-x^2}$, where e=2.71828… is Euler's number, describes the most common probability distribution seen in the real world, governing everything from SAT scores to locations of darts thrown at a target. The area under this curve is exactly the square root of π.

The first formula to calculate Pi was the Archimedes' 96 polygon method. The earliest written approximations of pi are 3.125 in Babylon (1900-1600 B.C.) and 3.1605 in ancient Egypt (1650 B.C.). Both approximations start with 3.1 – pretty close to the actual value, but still relatively far off.

Conclusion: In every formula, like Pi, there will be either a few methods or one specific method to get to the answer. However, for Pi, each different method ends up with a different answer, usually verying by only a small value. Thus, we conclude that the first method to calculate Pi was the most accurate method and we will use the answer as the actual value of Pi.

The ancient Babylonians calculated the area of a circle by taking 3 times the square of its radius, which gave a value of pi = 3.

The first calculation of pi was done by Archimedes of Syracuse (287–212 BC)

Archimedes knew that he had not found the value of pi but only an approximation within those limits.

In this way, Archimedes showed that pi is between 3 1/7 and 3 10/71.

Mathematicians began using the Greek letter π in the 1700s. which was introduced by William Jones in 1706.

Methodology

Methods Of Pi

We are going to use Google Sheets to calculate the different methods of calculating Pi.

Archimedes' 96 polygons method

For Archimedes's 96 polygon method, he used a regular polygon to estimate the shape of a circle. He was trying to find the circumference of a circle by getting the perimeter of a polygon. He used the formula $2\pi r$, and worked backwards from the "circumference". He continued making the regular *n*-gon smaller and smaller, which means '*n*' gets bigger as it goes, as the more sides a polygon has, the closer its value to the value of a circle. Thus, the value gets closer to the actual value of Pi. We have a simpler version

First, we took the length of each side of the polygon as 7. Then, we approximated the radius to be 108. So, "circumference" is 7x96=672, and since circumference=$2\pi r$, $\pi r=672\div 2=336$.

And since r=108, "π"=336÷108=3.111111111. Compared to the original ten digits of Pi, the difference is 0.030481542.

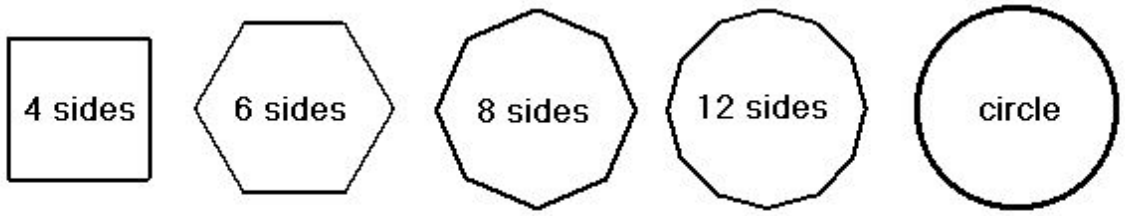
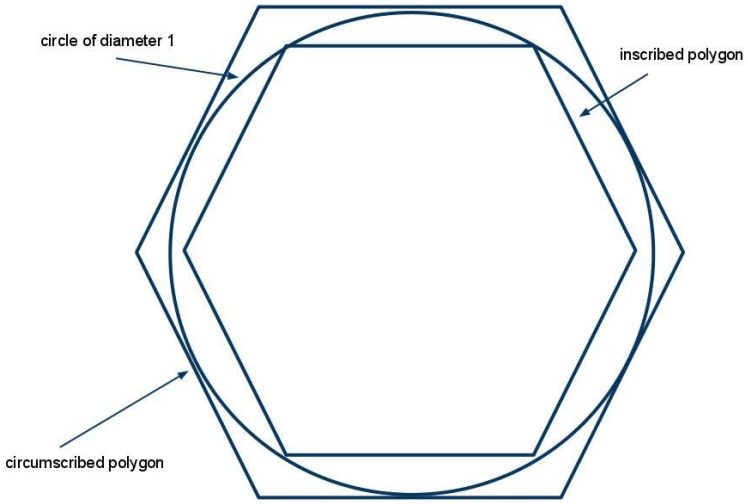


Figure 1. The more sides a regular polygon has, the more closely it approximates a circle.



Leibniz's Method

$$\frac{355}{113} \approx 3.141\,592\,920\,3\ldots$$

For Leibniz's method, it was indefinite, so we calculated the method all the way until $\frac{1}{99}$, taking about ten minutes. The result, which is $\frac{\pi}{4}$, is $\frac{32}{41}$. When multiplied by 4 to get the approximation of Pi, the value, to ten digits, is 3.121951219. Compared to the original ten digits of Pi, the difference is 0.019641434.

Wallis's Method

For Wallis's method, it was indefinite, so we calculated the method to one hundred fractions, from 2/1 to 100/99, taking about twenty to thirty minutes. The final result was 3.157339689. Compared to the original ten digits of Pi, which is 3.141592653, the difference is 0.015747036.

Zu Chongzhi's Method

For Zu Chongzhi's method, $\pi \approx \frac{355}{113}$, the ten-digit result was 3.141592920. It took only about a few seconds to get the answer. This approximation of Pi is the best approximation with the denominator of 4 digits or less, with an accuracy to 6 decimal places. Compared to the original ten digits of Pi, the difference was 0.000000267.

Method	Value of Approximation of Pi (to ten digits)	Difference between Approximation and Value of Pi (to ten digits)	Time taken to get value
Archimedes	3.111111111	0.030481542	15 minutes
Leibniz	3.121951219	0.019641434	10 minutes
Wallis	3.157339689	0.015747036	20 minutes
Zu Chongzhi	3.141592920	0.000000267	1 minute

Comparing the different methods

After looking at the four methods, we can conclude that Zu Chongzhi's approximation is the best method of the four, as its value was the closest to Pi, and it took the shortest time to be calculated.

Irrationality of Pi

Through thorough research and observation, we have come to realise:
Most of digits come in pairs.
E.G. there were many '66' or '33'.
This shows that in the irrational number "π", there are many repeated numbers coming in pairs.
We did not spot any triplets which tells us that although Pi contains repeats, it only goes to the extend of pairs
We also observed that most of the digits are multiples of 3 lesser than 10
E.G. 3, 6, 9

So we have these formulae below to find out about most of the digits in Pi:

x÷3=the digit 3 (if answer has a decimal recurring of 3)

x÷3=the digit 6 (if answer has a decimal recurring of 6)

x÷3=the digit 9 (if whole number, or decimal recurring of 9)

x being the number of digits from the start

Conclusion

In conclusion, we have achieved our objectives - to find out the most efficient method that gives us a value closest to the actual value of Pi, and whether there are patterns in the digits of Pi. It would be better if we included more formulas, but for now this is what we have.

Word Count (excluding acknowledgements and wo): 1500

Acknowledgements:

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