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Proof of errors in the values of π

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ABSTRACT:

The mathematical constant π (pi), is defined as the ratio of a circle's circumference and its diameter, has been approximated in diverse ways in history and in multidisciplines. The ancient approximations such as 22/7 ,√10 to highly accurate rational forms like 355/113, each reflects the mathematical tools and cultural context of its time. Archimedes provided the first rigorous bounds, and further the computational advances extended precision to trillions of decimal places. This paper deals with the comparative analysis of these values, examining their accuracy, historical significance, and practical utility. The comparison underscores π's unique role as both a universal constant and a benchmark for mathematical progress, illustrating how its approximations have shaped scientific understanding to the digital age.

This paper deals with a method to identify the correct value of pi, and that method is **($a^2 - b^2$)**. Using this method, one can determine the correct numerical value of pi among all the approximate values found until now. However, how do we identify which is the exact value? For this purpose, Thus, we present a comparison of the various values of **π** discovered so far.

Keywords: π, exact value, comparison, geometric proof

INTRODUCTION:

The approximate value of π, 3.14159, has been known since antiquity, with early approximations are recorded in Babylonian, Egyptian, and Greek mathematics. Modern computational methods have extended its decimal representation to trillions of digits, yet its exact value remains elusive due to its irrational and transcendental nature. The mathematical constant π is one of the most fundamental and widely recognized numbers in mathematics and science. π is defined as the ratio of a circle's circumference to its diameter, it is an irrational number with a non-repeating, infinite decimal expansion.

Beyond geometry, π appears in diverse areas of science and engineering. It plays a central role in trigonometry, complex analysis, probability theory, and number theory. In physics, π emerges naturally in formulas describing wave motion, quantum mechanics, electromagnetism, and general relativity. Its ubiquity underscores the deep connections between mathematics and the physical world, making π not merely a geometric constant but a universal symbol of mathematical truth.

Let us explore the multidisciplinary utility of π. In physics, π arises naturally in the mathematical description of waves, oscillations, and circular motion. It appears in fundamental equations such as the Schrödinger equation in quantum mechanics, the formulation of electromagnetic waves, and Einstein's field equations in general relativity. In computer science, π is central to algorithms for numerical analysis, cryptography, and computational geometry. In engineering, π is indispensable in the design and analysis of mechanical systems, electrical circuits, and signal processing. In statistics, π emerges in probability distributions and statistical theory.

A circle is a geometric shape. Its visible area shows the measurable interior, and its circumference shows the boundary length. We want to know the exact area (in square units) of this figure and the exact length of its circumference. The diameter of a circle can be measured to any degree of precision. But how do we measure the circumference? It is possible using algebraic methods. Similarly, by practical (experimental) methods, measuring the boundary point by point is also possible. To measure it, attempts have been made to divide the circle into many parts, form regular polygons, unfold them flat, and then join them in a straight line to approximate the circumference. However, even if infinite parts of the circle are taken, three points on the circle's circumference cannot lie exactly on a straight line. Therefore, the exact circumference cannot be obtained this way. And even with polygons having an infinite number of sides, this method does not reach a final, exact result. Because of this, many researchers still believe that the exact value of pi cannot be determined.

No method so far has produced the exact value of pi. Therefore, it is commonly said that the exact value of pi cannot be known. We claim that the exact value of π is *not* a difficult subject if we approach it correctly. We already know that the area of the regular 12-sided polygon (dodecagon) inside a circle is $3r^2$ — this is universally accepted. What we want is to obtain the area of the full circle. For this, a study on the remaining portion of the circle, that is, $(\pi - 3)r^2$. To study this part, the square circumscribing the circle as a base is used. The area of the circumscribing square is $4r^2$, which is also universally accepted. If we subtract the area of the circle from this square, the remaining area is:

$$(4 - \pi)\, r^2$$

Finding this area is also quite difficult. For better understanding, the area of the 12-sided polygon is subtracted from the circle and subtracted the circle from the square. The leftover areas from both methods were then added together:

$$(\pi - 3)\, r^2 + (4 - \pi)\, r^2 = 1\, r^2$$

According to modern accepted values, the approximate value of π is non-terminating: **3.141592653…**, more than 300 trillion digits have been calculated, and even today the search for further digits continues.

In various papers [1-13], using various geometric methods, the exact value of pi is calculated. This is demonstrated through algebraic equations that both quantities $(\pi - 3)\, r^2$ and $(4 - \pi)\, r^2$ can be derived. Furthermore, the paper titled **"Values of Pi: Exact or only approximate? The Exact Value of Pi"** explains how the length corresponding to the value of pi can be obtained and how the exact area of a circle can be derived. Many equations are given whose answers come out incorrect if π is only approximate. There are infinitely many such equations.

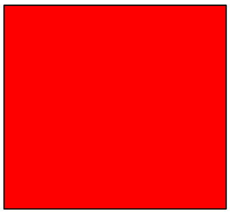
According to the new value of pi, the square area of the circle can be accurately converted, and from any given square area the corresponding circle can also be constructed. This means a circle whose area is an integer can indeed be constructed. If pi were merely approximate, the following equation could **not** give an integer result:

Name	**Value**
Prince jessii	**3.125**
Archimedes pi	**223/71 = 3.140845… < π < 22/7 = 3.142857…**
Aryabhatta	**62832/20000 = 3.1416…**
Ramanujan	**9801/1103√8 = 3.14159273001**
Zu's Ratio / milu	**355/113 = 3.1415929…**
Current value of pi	**= 3.141592653…**
Parker pi	**20612/6561 =3.141594…**
Gogawale pi	**(17 – 8√3) = 3.143593…**
Jain pi	**(4√2)/√(1 + √5) = 3.1446055…**
Reddy pi	**(14 – √2) /4 = 3.146446…**
Heisel pi	**256/81 = 3.16049…**
Halfplex pi	**√10 = 3.162277…**
Goodman pi	**3.2**

Table 1 shows the values of pi worked out by various scholars.

Table 1 shows, various methods have been used to find the value of π. The confusion still exists to which of these values is the exact value? To identify this, a new method **($a^2 – b^2$) is used**. Using this method, by taking the appropriate values of *a* & *b*, and performing simple numerical calculations, the area (or result) obtained matches the value of π given in the above data (or any other value of π). So, let's see how this method works.

Consider a sheet of plain paper and cut out a square from it according to certain given measurements. Then, from that cut-out square sheet, again cut out another square according to the given measurements. After cutting the second square from the first one, the **area** of the remaining portion of the paper is calculated. . For example, as shown in, from a square sheet of size (10 × 10) = 100 cm^2, if we cut out a smaller square of size (7 × 7) = 49, then the two resulting pieces have the following areas, one of (7 × 7) = 49 cm^2, And the remaining part (100 – 49) = 51 cm^2. This method is very useful and simple, to identify the two areas they were colored differently. Now consider two sheets with different colors, red and yellow indicated in the figures below.



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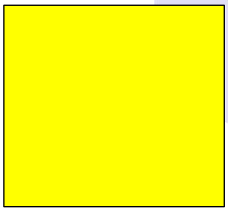


Fig 1 **Fig 2**

Figure 1 indicates a red colored square of side a and having area a^2.
Figure 2: indicates a yellow colored square of side a and having area a^2.

Figure 1 and figure 2 are two sheets with different colors having the same area that is $\mathbf{a^2}$ if we consider each side as 'a'. Since we have to cut out squares of equal size from these two sheets, the two sheets were placed one on top of the other, as shown in the figure below.

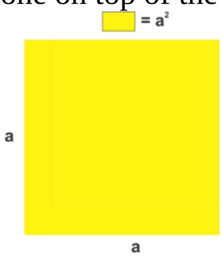


Fig 3: Shows the two sheets with same area placed one above the other.

Then, from both square sheets, another smaller square piece of side **b** is cut and placed one above the other.

This is shown in the figure below.

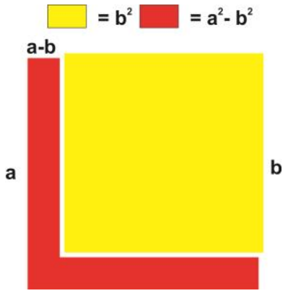


Fig 4: Square of side b is cut and olaced one above the other.

In the above figure 4, the areas of the two different pieces are as follows:
the **yellow square piece** has an area of **b^2**, and the **red frame-shaped piece** has an area of **$(a^2 – b^2)$**. These two pieces were then arranged as shown in the first figure the yellow square was pasted onto the red frame. The shape thus formed was turned upside down so that its back side became the front as shown in the next figure 5 and 6.

Then, the areas of both these figures were measured, and how they were obtained is shown below

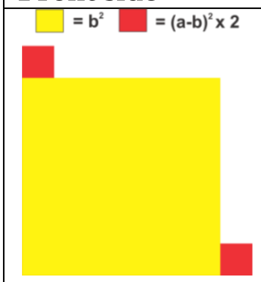
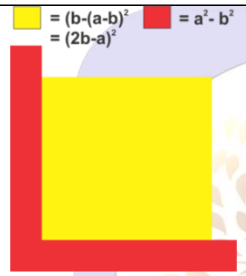
Front side	**Back side**
 **Fig 5**	 **Fig 6**
Area of Front side $b^2 + [(a – b)^2 \times 2]$ $= b^2 + 2(a^2 + b^2 – 2ab)$ $= 2a^2 + 3b^2 – 4ab$	Area of Back side $(a^2 - b^2) + [b – (a – b)^2 = (2b – a)^2]$ $(a^2 - b^2) + (2b – a)^2$ $= (a^2 – b^2) + (4b^2 + a^2 – 4ab)$ $= 2a^2 + 3b^2 – 4ab$

Figure 5 and figure 6 indicate the front and back sides respectively.

By both above methods, the areas of the front and back sides come out to be **equal** this was already observed earlier.Using both these methods, the area of the front and back sides is found to be equal to:**$2a^2 + 3b^2 – 4ab$.** This formula was verified using various examples with different values of *a* & *b*.

For example, by using graph paper and measuring square areas geometrically, the values were checked. Here, *b* is taken such that **$a/2 < b$**, meaning *b* is greater than half of *a*.

In the first numerical example, let's assume **$a = 30$**.
Then, *b* should be greater than 15 that is, we can take values like b = 16, 17, 18, … and so on.

By substituting these values into the above formula, the resulting area values gradually increase.

For instance, if **$b = 20$**, then according to the formula
$(2a^2 + 3b^2 – 4ab)$**,**
the resulting area is as follows

$(2a^2 + 3b^2) - 4ab$

$= 2(30^2) + 3(20^2) - 4(30 \times 20)$

$= 1800 + 1200 - 4(600)$

$= 3000 - 2400$

= 600

Then, when **b = 25** was taken, the values were substituted into the formula
$(2a^2 + 3b^2 - 4ab)$**,**
and the corresponding **area (or result)** was calculated.

$(2a^2 + 3b^2) - 4ab$

$= 2(30^2) + 3(25^2) - 4(30 \times 25)$

$= 1800 + 1875 - 4(750)$

$= 3675 - 3000$

$= 675$

Another example: when **b = 26** is taken, then according to the formula
$(2a^2 + 3b^2 - 4ab)$,
the resulting **area (or value)** is calculated as follows.

$(2a^2 + 3b^2) - 4ab$

$= 2(30^2) + 3(26^2) - 4(30 \times 26)$

$= 1800 + 2028 - 4(780)$

$= 3828 - 3120$

$= 708$

Among the three examples above:

- In the first case, when **b = 20**, the area obtained was **600**.
- In the second case, when **b = 25**, the area obtained was **675**.
- In the third case, when **b = 26**, the area obtained was **708**.

By analyzing these examples, we can see that:

- When the side of the smaller square is **20/30 = 2/3** of the larger square,
  the area is also **600/900 = 2/3** times that of the larger square.
- When the side is **25/30 = 5/6**,
  the area is **675/900 = 3/4** times that of the larger square.
- When the side is **26/30 = 13/15**,
  the area is **708/900 = 59/75** times that of the larger square.

From these examples, we observe that when the side of the smaller square **b = 25/30 = 5/6** of the larger square, the area of the resulting figure becomes **675/900 = 3/4** of the original square's area.

That means, when a square of side **5/6** of the original side is cut and arranged as shown earlier, the area of the new figure formed is **3/4** of the original square's area.

Now, let's see **why** this happens.

$(a/2)^2 \times 3$

$= (30/2)^2 \times 3$

$= (15^2 \times 3)$

= 675

If **a = 30** is taken as the **diameter** of the circle,
then the **radius** of that circle will be **15**.

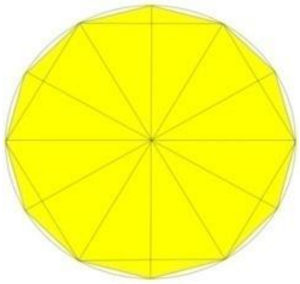


Fig 7: Shows a dodecagon with the radius of 15.

In the figure 7 , the circle has a radius of 15. Inside it, a regular dodecagon (12-sided polygon) has been drawn. The area of that polygon is found to be:

Area = $(15^2 \times 3)r^2 = 675r^2$

From this example, it was observed that the side of the original square was taken as the diameter of the circle. Hence, half of that side becomes the radius of the circle.

When a circle of that radius is drawn on the same square sheet,
the area of the regular 12-sided polygon inscribed in that circle is approximately $3r^2$, according to the above formula.

Similarly, in the third example above, the ratio of the sides was 26/30 = 13/15,
and the area obtained was 708.

Now, dividing this value **708** by the square of the radius (**$15^2 = 225$**):

708 ÷ 225 = 3.1466666…

This value is slightly greater than the true value of π.

From this observation, it became clear that in order to get a value exactly equal to the real π by this method, the side **b** of the inner square must be taken slightly smaller than 26.

To find out how much smaller, the ratio 26 ÷ 15 = 1.7333… was calculated.
That means, the side length should be a little less than 1.7333… times the radius.

Using this reasoning, if we now take the side of the main square as 2 units,
we can determine what the exact side length **b** should be in order for the result to match the true value of π.
Let's see how that is found.

Example No. 1

Side of square paper a = 2 then, Measurement of cutting piece b = 1.6		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.6)^2 + (2 - 1.6)^2 \times 2$ $= 2.56 + (0.4)^2 \times 2$ $= 2.56 + 0.32$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.6 \times 2) - 2]^2 + (2^2 - 1.6^2)$ $= (3.2 - 2)^2 + (4 - 2.56)$ $(1.2)^2 + 1.44$ $= 1.44 + 1.44$	= 2.88

Example No. 2

Side of square paper a = 2 then, Measurement of cutting piece b = 1.7		
Front side formula	Back side formula	Each sides total
[b²+ (a –= 2.89 + (0.3)² × 2 $= 2.89 + 0.18$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.7 \times 2) - 2]^2 + (2^2 - 1.7^2)$ $= (3.4 - 2)^2 + (4 - 2.89)$ $(1.4)^2 + 1.11$ $= 1.96 + 1.11$	= 3.07

Example No. 3

Side of square paper a = 2 then, Measurement of cutting piece b = 1.8		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.8)^2 + (2 - 1.8)^2 \times 2$ $= 3.24 + (0.2)^2 \times 2$ $= 3.24 + 0.08$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.8 \times 2) - 2]^2 + (2^2 - 1.8^2)$ $= (3.6 - 2)^2 + (4 - 3.24)$ $(1.6)^2 + 0.76$ $= 256 + 0.76$	= 3.32

Among the three examples above, it seems that the value of **b** should be slightly more than 1.7 times and less than 1.8 times.

Example No. 1

Side of square paper a = 2 then, Measurement of cutting piece b = 1.72		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.72)^2 + (2 - 1.72)^2 \times 2$ $= 2.9584 + (0.28)^2 \times 2$ $= 2.9584 + 0.1568$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.72 \times 2) - 2]^2 + (2^2 - 1.72^2)$ $= (3.44 - 2)^2 + (4 - 2.9584)$ $(1.44)^2 + 1.0416$ $= 2.0736 + 1.0416$	= 3.1152

Example No. 2

Side of square paper a = 2 then, Measurement of cutting piece b = 1.73		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.73)^2 + (2 - 1.73)^2 \times 2$ $= 2.9929 + (0.27)^2 \times 2$ $= 2.9929 + 0.1458$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.73 \times 2) - 2]^2 + (2^2 - 1.73^2)$ $= (3.46 - 2)^2 + (4 - 2.9929)$ $(1.46)^2 + 1.0071$ $= 2.1316 + 1.0071$	= 3.1387

Example No. 3

Side of square paper a = 2 then, Measurement of cutting piece b = 1.74		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.74)^2 + (2 - 1.74)^2 \times 2$ $= 3.0276 + (0.26)^2 \times 2$ $= 2.9929 + 0.1352$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.74 \times 2) - 2]^2 + (2^2 - 1.74^2)$ $= (3.48 - 2)^2 + (4 - 3.0276)$ $(1.48)^2 + 0.9724$ $= 2.1904 + 0.9724$	= 3.1628

From the three examples above, it becomes clear that the value of b should be greater than 1.72 times but less than 1.74 times.

Example No. 1

Side of square paper a = 2 then, Measurement of cutting piece b = 1.731		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.731)^2 + (2 - 1.731)^2 \times 2$ $= 2.996361 + (0.269)^2 \times 2$ $= 2.996361 + 0.144722$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.731 \times 2) - 2]^2 + (2^2 - 1.731^2)$ $= (3.462 - 2)^2 + (4 - 2.996361)$ $(1.464)^2 + 1.003639$ $= 2.137444 + 1.003639$	= 3.141083

Example No. 2

Side of square paper a = 2 then, Measurement of cutting piece b = 1.732		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.732)^2 + (2 - 1.732)^2 \times 2$ $= 2.999824 + (0.268)^2 \times 2$ $= 2.999824 + 0.143648$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.732 \times 2) - 2]^2 + (2^2 - 1.732^2)$ $= (3.464 - 2)^2 + (4 - 2.999824)$ $(1.464)^2 + 1.000176$ $= 2.143296 + 1.000176$	= 3.143472

From the above two examples, it is observed that the value of **b** should **be** greater than 1.731 times but less than 1.732 times**.** From this, it is clear that the value of **b** is approximately equal to √3**.**

Side of square paper a = 2 then, Measurement of cutting piece b = 1.7312		
Front side formula	Back side formula	Each sides total
$[b^2 + (a - b)^2 \times 2]$ $= (1.7312)^2 + (2 - 1.7312)^2 \times 2$ $= 2.99705344 + (0.2688)^2 \times 2$ $= 2.99705344 + 0.14450688$	$= [(2b - a)^2 + (a^2 - b^2)]$ $[(1.7312 \times 2) - 2]^2 + (2^2 - 1.7312^2)$ $= (3.4624 - 2)^2 + (4 - 2.99705344)$ $(1.4624)^2 + 1.00294656$ $= 2.13861376 + 1.00294656$	= 3.14156032

From the above example, it is seen that the value of **b** should be taken as slightly greater than 1.7312**.** After continued experimentation, when the side **b** was taken as 1.7312135443361**…**, and calculations were carried out accordingly, The result obtained matched the true, globally accepted value of π**,** accurate to twelve decimal places**.**

Now, let's see how this happens.

Front side	Back side
$b^2 + [(a - b)^2 \times 2]$ $= 1.73121354434\ldots^2 + (2 - 1.731213544336\ldots)^2 \times 2$ $= 2.997100336092\ldots + [(0.2687864556639\ldots)^2 \times 2]$ $= (2.997100336093\ldots + 0.144492317496\ldots)$ $= 3.141592653589\ldots$	$(a^2 - b^2) + (2b - a)^2$ $[(a^2 - b^2)$ $= (2^2 - 1.7312135443361\ldots^2)$ $= (4 - 2.9971003360927\ldots)$ $= 1.0028996639073\ldots$ $+ (2b - a)^2$ $= [2(1.73121354434\ldots) - 2]^2$ $= (3.462427088690722\ldots - 2)^2$ $= 2.13869298966822\ldots]$ $(1.002899663907\ldots + 2.138692989682\ldots)$ $= 3.141592653589\ldots$

Table 2: Indicates the values of a and b used to find the value of pi

So, based on this method, a detailed study was done to find out **what exact value of b** gives a result equal to the true value of π.

Several values were tested for b to determine this relationship,
and a few of those calculated examples are shown below.

(a = 2r) Method (a^2 - b^2)

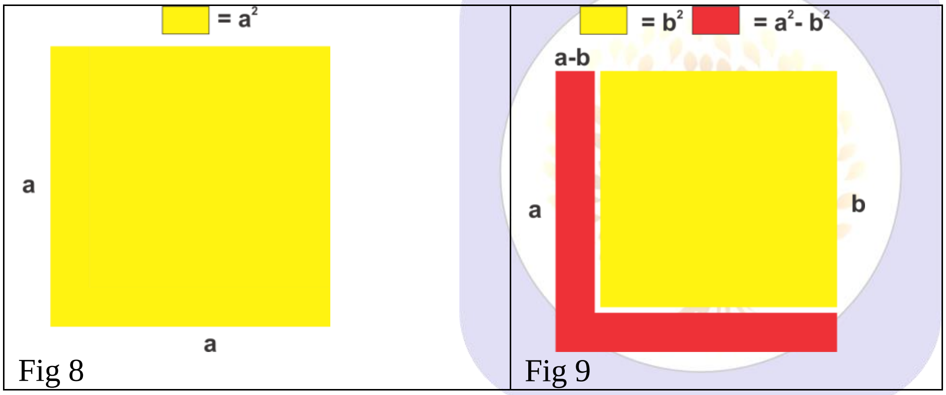


Figure 8: shows the area of the yellow square is a^2 and
Figure 9: shows that the area of the red strip is a^2-b^2 if the area of b^2 is cut from it

Here are some examples from the values of π mentioned earlier.

When **a = 2**, find what the value of **b** will be. According to the above method, the values of **b** have been calculated and are shown in the following table.

Value of π	Side of square paper a = 2 then Measurement of cutting piece b = …
3.125	1.7242015…
3.1415926…	1.731213544…
3.142857… 22/7	1.7317428…
(17 – 8√3) 3.1435935…	√3 1.732050807…
3.144605…	1.732474…
3.146446	1.733242…
√10 3.16227766…	1.739786…

Table 3: Shows the appropriate value of b to calculate pi when a=2

By examining the values of **b** in the above table, it is observed that the **measurement of the cutting piece b** is approximately equal to **√3 times** the side, though for some values it is slightly less and for some values slightly more.

If the side **b** is adjusted (cut) according to the method given in the above table and as explained earlier, then for each value of **π**, the corresponding **area (result)** obtained is accurate.

B^2 & ($a^2 – b^2$)

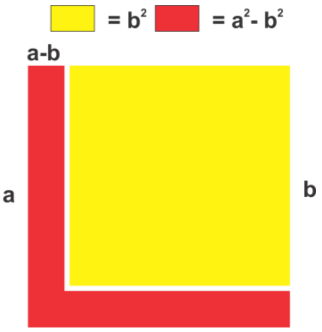


Fig 10: The combination of various values of a and b is shown in the table 4 below

According to the above figure, the values of b^2 and ($a^2 – b^2$) corresponding to each value have been given in the following table.
The sum of these is **4 = (2 × 2)**.

Value of π	b^2	($a^2 – b^2$)
3.125	= (2.9728708…	+ 1.027129…)
3.141592…	= (2.997100…	+ 1.002899…)
3.142857… = 22/7	= (2.998933…	+ 1.001067…)
(17 – 8√3) 3.1435935…	= (3	+ 1)
3.144605…	= (3.001466…	+ 0.998534…)
3.146446…	= (3.004127…	+ 0.995873…)
√10	= (3.0268553…	+ 0.9731446…)

Table 4: The table indicates the variable values of b^2 and a^2-b^2 In finding the value of π

From the above table, the values of **b^2** are slightly greater than 3 for some measurements and slightly less than 3 for others. Similarly, the values of **($a^2 – b^2$)** are slightly greater than 1 for some measurements and slightly less than 1 for others. When the square **b^2** is placed adjacent to the strip **($a^2 – b^2$)**, the figure that is formed represents the area of that shape.

Front side

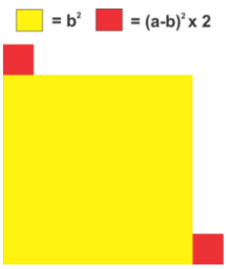


Fig 11: On inverting the squares other way round, area of the yellow aquare is b^2 and area of the red squares is $(a-b)^2$ each.

In the above figure, the values of $\mathbf{b^2}$ and $\mathbf{[(a – b)^2 \times 2]}$ for each measurement are given in the following table. **Analyze** (observe/examine) these values.

Value of π	b^2	$(a – b)^2 \times 2$
3.125	= (2.9728708	+ 0.15212962…)
3.141592…	= (2.997100…	+ 0.1444923…)
3.142857…	= (2.998933…	+ 0.1439238…)
(17 – 8√3) 3.1435935…	= (3	+ 14 – 8√3) + 0.1435935…)
3.144605…	= (3.001466…	+ 0.1431938…)
3.146446…	= (3.004127…	+ 0.1423196…)
√10	= (3.02685532…	+ 0.13542265…)

Table 5: The table indicates the variable values of b^2 and $(a^2$-b^2) x 2 In finding the value of pi

From the above table, the **sum of b^2 and $[(a – b)^2 \times 2]$** appears according to the corresponding value of π. Observe (analyze) the values of $\mathbf{b^2}$ in the above table, and also observe the digits that come after **0.14…** in the value of $\mathbf{[(a – b)^2 \times 2]}$.
The back side of the above figure is shown in the following diagram.

Back side

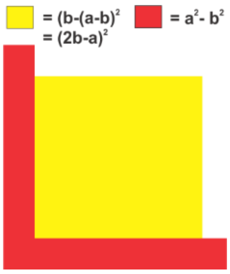


Fig 12: Indicates the area of the red strip to be $(a^2 – b^2)$ and that of the yellow square is $(2b – a)^2$

In the above figure, the values of $\mathbf{(a^2 – b^2)}$ and $\mathbf{(2b – a)^2}$ corresponding to each value of π (pi) are given in the following table.

Value of π	$(a^2 – b^2)$	$(2b – a)^2$
3.125	= (1.0271291…	+ 2.0978712…)
3.1415926…	= (1.0028996…	+ 2.1386929…)
3.142857…	= (1.001067…	+ 2.141790…)
(17 – 8√3) Exact Approximate 3.1435935…	= (1 = (1	+ 16 – 8√3) = (2 + 14 – 8√3) + 2.1435935…)
3.144605…	= (0.998534…	+ 2.1460726…)
3.146446	= (0.995873…	+ 2.1505753…)
√10	= (0.9731446…	+ 2.1891333…)

Table 6: The table indicates the variable values of $(a^2$-$b^2)$ and $(2b$-$a)^2$ In finding the value of pi

The sums of $(a^2 − b^2)$ and $(2b − a)^2$ in the figure above correspond to the value of π\piπ shown earlier.The value of $(a^2 − b^2)$ is sometimes slightly more than 1 and sometimes slightly less than 1 The value of $(2b − a)^2$ comes out as 2 +… (i.e., a little more than 2). Analyze these. This method can produce numerical values for any given value of π\piπ. However, attempting to derive this method exactly (i.e., give a rigorous algebraic proof) becomes a nontrivial mathematical task — if someone succeeds in providing formal proof, that would be excellent.

First, a 4×4 square was taken and then a circle was drawn around (circumscribing) that square. The resulting figure is as shown.

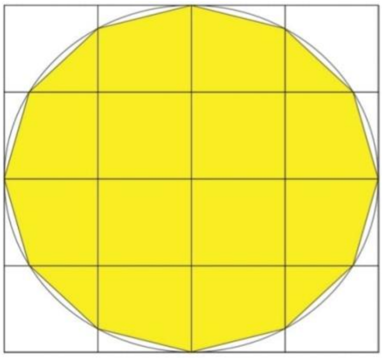


Fig 13: A Dodecagon inscribed in a circle

The radius of the circle shown above is **2r**, and the area of the circle is $4\pi r^2$**.**
Then, if we join the points on the circumference of this circle that coincide with the corners of a square, we obtain **a** regular dodecagon (12-sided polygon) inside the circle.

The area of a regular dodecagon inscribed in a circle of radius **r** is $\mathbf{3r^2}$, which we already know.
Therefore, for a circle of radius **2r**, the area of the inscribed regular dodecagon will be
$(2 \times 2 \times 3r^2) = 12r^2$

The area of the circle having radius **2r** is
$(2 \times 2 \times \pi r^2) = 4\pi r^2$

The figure above is divided into **four equal parts**, and if we take one of those parts, its area will be $\mathbf{(2 \times 2) = 4r^2}$, while the area of the yellow region within it will be
$(12r^2 \div 4 = 3r^2)$

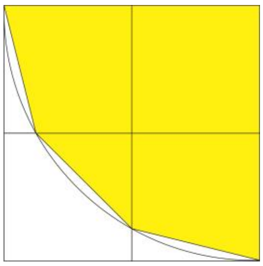


Fig 14: Consider ¼ th part of the figure 13.

In the above figure, the yellow region has an area of $\mathbf{3r^2}$, and the remaining (pink) region has an area of$(4r^2 – 3r^2) = 1r^2$ If this $1r^2$ region is colored red, then the figure will appear as shown below.

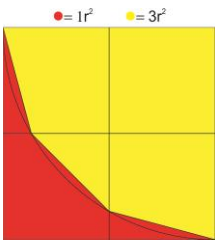


Fig 15: The red region area is $1r^2$ and the yellow region area is $3r^2$

In the above figure, regions with areas of $\mathbf{1r^2}$ and $\mathbf{3r^2}$ can be seen.
Within this $\mathbf{1r^2}$ **region**, the part of the circle that is included is shown in the figure below.

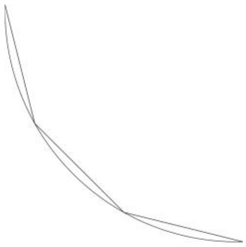


Fig 16: indicates the part of the circle that has been cut out.

The figure above shows the part of the circle that was cut out. So what is the area of that part; how should we calculate it? This is a question about the area inside the circle.

To solve it using the method above, take a square on the same sheet whose side length is √3r. Then form the required shape as follows: on that square draw a quarter of a circle of radius 2r. From this construction we obtain the length √3r. Thus the square on the sheet has side √3r.

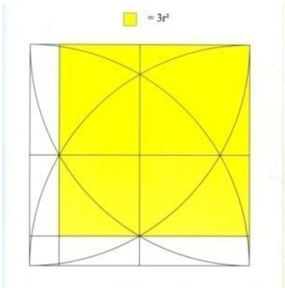


Fig 17: Each side of the yellow portion is √3r and the remaining white portion is $1r^2$

In the figure above, the side of the yellow square is √3r, which means its area is $3r^2$.
The remaining white portion is $(4r^2 - 3r^2) = 1r^2$.
If this remaining white portion is colored red, the figure appears as shown below.

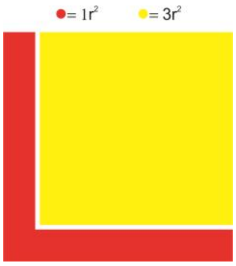


Fig 18: The area of yellow portion is $3r^2$ and that of the red portion is $1r^2$

In the above figure, areas of $1r^2$ and $3r^2$ can be seen.
Out of these, the $3r^2$ part belongs to the circle**,** and within the $1r^2$ portion lies the part of the circle's segment.
To find how much that segment measures, the yellow square was placed over the red strip, and the resulting figure appeared as shown below.

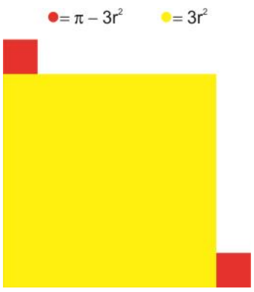


Fig 19: Obtained by flipping the figure 18, thus the yellow region has an area of $3r^2$ and the red region has an area of π-$3r^2$

The area of the figure thus formed is obtained by the formula **$b^2 + [(a - b)^2 \times 2]$**.

In the figure above, the yellow part has an area
$b^2 = (\sqrt{3}r \times \sqrt{3}r) = 3r^2$.

Adding to this, the area of the two small red squares on both sides is calculated using the formula $[(a - b)^2 \times 2]$.

Here, the side of the yellow square is **$\sqrt{3}r$**, therefore the remaining width of the red strip is $(2 - \sqrt{3})r$.

Hence, the area of the two small red squares is:

$(2r - \sqrt{3}r)^2 \times 2 = 2(7 - 4\sqrt{3})r^2 = (14 - 8\sqrt{3})r^2$

Thus, the total area of the entire figure is:

$3r^2 + (14 - 8\sqrt{3})r^2 = (17 - 8\sqrt{3})r^2$

The portion **$(14 - 8\sqrt{3})r^2$** represents the shaded (red) part inside the circle. Why is this so?

Because, in the above method, the square was placed upon the red strip, and when the figure's opposite side was flipped, it appeared as shown in the following diagram.

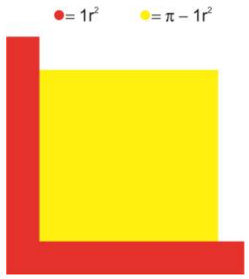


Fig 20: obtained on placing the yellow square on the red strip where the area of each red portion is $1r^2$ and that of the yellow square is π-$3r^2$

The area of the figure above, by the other formula, is

$(a^2 - b^2) + (2b - a)^2$

In the above figure the area of that red strip is

$(2^2 - \sqrt{3}^2)\, r^2 = 1r^2$.

And the area of the remaining part is

$(2b - a)^2 = (2\sqrt{3} - 2)^2 \times r^2 = (16 - 8\sqrt{3})\, r^2$

Thus the total area of the figure above is

$1r^2 + (16 - 8\sqrt{3})\, r^2 = (17 - 8\sqrt{3})\, r^2$

Therefore, the area of the shaded part in the figure above equals $(16 - 8\sqrt{3})\, r^2$

How does that happen? (i.e., explain/justify this result.)

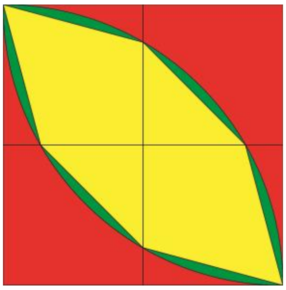


Fig 21: The total area of the figure is πr^2

By combining the red and green parts in the figure above we get an area of $(1r^2 + 1r^2) = 2r^2$ and the remaining part of the circle is $(4 - 2)r^2 = 2r^2$ The total area of this figure equals πr^2

So if we remove (cut out) the red-coloured regions shown in the earlier figure, what will be the area of the remaining figure?

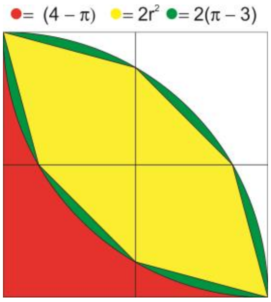


Fig 22: The area of the red portion is 4-π, yellow portion is 2 r^2 and green part is 2(π-3)

The area of the above figure is πr^2. If the left-side green part of this figure is added to the red part, the total area becomes $1r^2$. The green part is then coloured red. Similarly, if the right-side green part is added to the yellow part, and that part is coloured yellow, the resulting figure appears as shown below. Both the green parts on either side are equal in area**.**

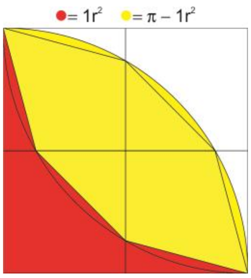


Fig 23: Area of the red part is $1r^2$ and that of the yellow part is π-$1r^2$

The area of the above figure is $\boldsymbol{\pi r^2}$. The area of the red part **is** $1r^2$**,** and the area of the yellow part, along with the shaded portion of the circle, together is
$(2 + 14 – 8\sqrt{3})\ r^2 = (16 – 8\sqrt{3})\ r^2$**,**
which we have already seen in Figure 20. Thus, in Figure 20, the red strip corresponds to the same portion of the circle that appears in Figure 15, and that same portion appears again in the yellow part of Figure 23. Therefore, the shaded portion inside the circle on both sides is equal to $(14 – 8\sqrt{3})\ r^2$**.**

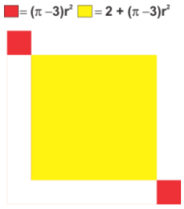


Fig 24: On flipping the figure 23 we obtain the area of the red strip is π-3r² and yellow strip is 2+ (π-3r²)

In the above method, the red strip **o**f 1r² contains the same portion of the circle as the yellow part **o**f 2r² in this figure**.** Therefore, the equal areas obtained on both sides represent one and the same value**.** Even if we say that there cannot be another such value, it would still be acceptable — because, when the above method is applied precisely with numerical accuracy, no other value gives the same result. For some values, the outer portion turns out to be larger and the inner portion smaller, while for others, the outer portion becomes smaller and the inner portion larger. Many examples are checked using exact numerical calculations and have never found any second value that produces equal results on both sides.

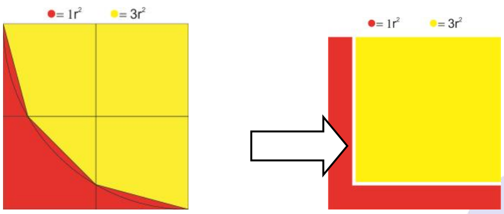


Fig 25, 26: The red part has an area of 1r² and yellow part has an area of 3r²

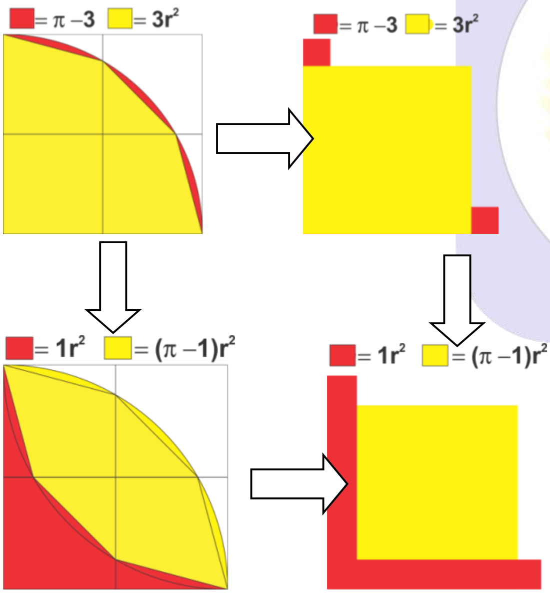


Fig 27, 28: Yellow part has an area of 3r² and the red part has an area of π-3

Fig 29, 30: Yellow part has an area of (π-1)r² and the red part has an area of 1r²

Among the above figures, on the front side, the part of the circle enclosed within lies within 3r² + 1r² area. That same portion has been added on the back side within the yellow region.Hence, the equal result obtained on both sides corresponds to one value**.**

That same value is shown in the above front side and back side figures**.**

CONCLUSION:

Till date the presently used value of π and the one derived in this paper shows a difference. The value of π as per this paper is $\pi = 17 - 8\sqrt{3}$ and approximate value of $\pi = 3.1435935394$ ... Thus this paper discusses the comparison between the values of π and claims that there is an error in the present value of π. The value of pi found in this paper can also be used in proving squaring the circle, which was an unsolvable problem.

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