The Great Pyramid of Giza: Pi and the Golden Ratio

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1 - Introduction

When you think about the Great Pyramid of Giza, what's the first thing that comes to mind? Perhaps you think about how they managed to build such a massive structure without the aid of modern technology. Perhaps you wonder how they managed to align the pyramid to true north. Or, just maybe, you have already heard something about what the main body of this essay will focus on: how they managed to hide pi and the golden ratio within the Great Pyramid of Giza.

2 - Pi in the papyri

Before we consider pi within the pyramid, we must first consider the ancient Egyptians' understanding of pi outside of it. They primarily documented their knowledge on papyrus (a writing material similar to thick paper), and their mathematics can largely be found in their mathematical papyri.

The most famous, and arguably earliest use of pi in any papyrus was in the Rhind Mathematical Papyrus (RMP) which dates to around 1550 BCE, but was transcribed from a now-lost text originally dated to the 19th century BCE. Here, we can see it was used in a number of problems. To begin, let's consider problem 41:

This problem consists of trying to find the volume of a cylindrical grain silo with a given diameter of 9 cubits and height of 10 cubits, giving the answer in terms of cubic cubits, using the formula [1]:

$$V = \left(d - \frac{1}{9}d\right)^2 h$$

$$V = \left(\frac{8}{9}d\right)^2 h$$

$V = \frac{64}{81}d^2h$

From here we can substitute in $d = 2r$ to get our equation in the form $V = \pi r^2 h$, from which we can obtain the value that's used in place of π:

$V = \frac{64}{81}(2r)^2 h$

$V = \frac{64}{81}(4r^2)h$

$V = \frac{256}{81}r^2 h$

Here, we can see that despite not referencing the value directly in their equation, they are using a value for pi approximated as $\frac{256}{81}$, which is roughly equal to 3.16049, and differs from the actual value of pi by around 0.601643%.

While this approximation of pi is implicitly used throughout the RMP, this value of $\frac{64}{81}$, as found in the volume formula $V = \frac{64}{81}d^2h$ in problem 41, is consistently mentioned throughout the papyrus (if we ignore problem 43 where a mistake was made, see (appendix 1)):

Problem 42 is a similar question to problem 41, reusing the same volume formula $V = \frac{64}{81}d^2h$ to calculate the volume of a cylindrical grain silo with a different height and diameter.

Problem 48 asks for the ratio of the area of a circle with diameter 9 to the area of its circumscribing square of side length 9, with the answer being $\frac{64}{81}$.

Problem 50 reinforces problem 48, where a circle with diameter 9 khet is found to have an area of 64 setat (where one square khet is equal to one setat).

If you are wondering how they may have reached the value of $\frac{64}{81}$, see (appendix 2).

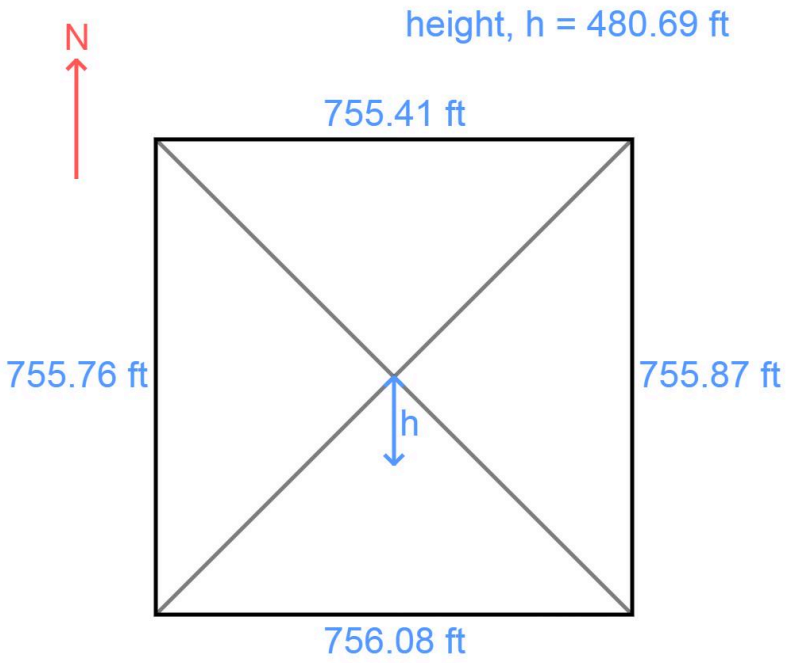
So in the RMP, it seems that rather than using the approximation for pi $\frac{256}{81}$ itself, this value of $\frac{64}{81}$ was used (this is also the case in the Moscow Mathematical Papyrus [2], see (appendix 3)). This was mainly because the equations were in terms of diameter rather than

in terms of the radius as we use for our modern equations involving pi. While this would have been sufficient for the ancient Egyptians' practical engineering uses of pi, namely in calculating the volume of grain silos or the area of circular fields, it does go to show that they were seemingly unaware of the mathematical significance of pi itself. This brings to question how, and perhaps why, they hid pi within the dimensions of the Great Pyramid of Giza.

3 - Pi in the Great Pyramid of Giza

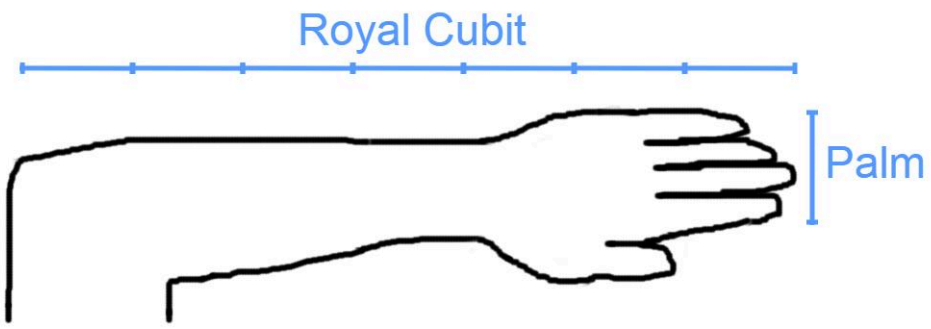
Now, it's finally time to get to the fun part, where we explore the maths behind the Great Pyramid of Giza. Pi can be found within the dimensions of the pyramid to a degree so accurate where it differs from the actual value by less than 0.1%... Crazy!

First, let's establish the dimensions [3] of the four sided pyramid (appendix 4):

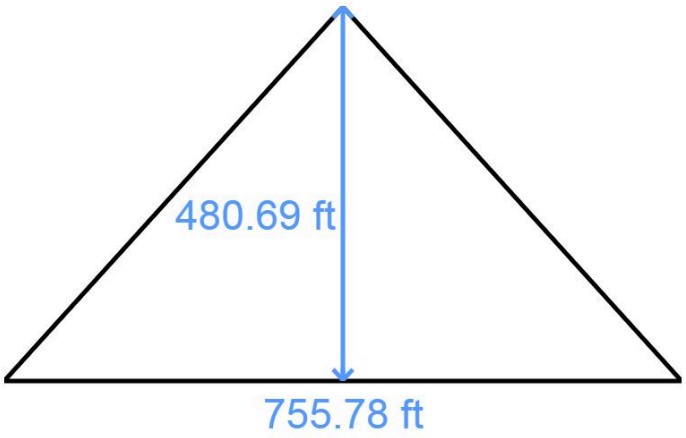


When finding pi within the Great Pyramid, we must consider its seked. The seked (or seqed) describes the inclination of the triangular faces of the pyramid to the horizontal plane of its base. Unlike the gradient which we commonly use, $\frac{\Delta y}{\Delta x}$, the seked is the reciprocal of this, $\frac{\Delta x}{\Delta y}$ [5]. In other words, the seked is the run (Δx) per one royal cubit in rise (Δy), where a royal cubit is around 52.4cm.

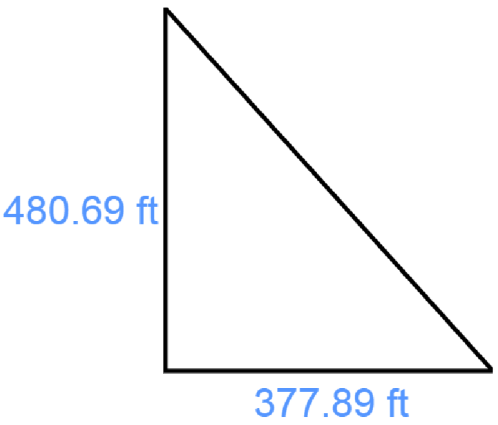
1 royal cubit is equal to 7 palms, and 1 palm is equal to 4 fingers:



So, we can calculate the seked of the pyramid by first using the measurements themselves. If we take the average base length to be 755.78ft, and we use the height of 480.69ft, we can construct a triangle from a cross section of the pyramid:



Then we can construct a right angled triangle with a base length of $\frac{755.78}{2} = 377.89ft$:



From this, we can calculate the seked of the pyramid:

$\frac{377.89}{480.69} = 0.786140756$

And this value is extremely close to $\frac{1}{4}\pi$:

$0.786140756 \times 4 = 3.144563024$

This approximation is roughly 0.0945% away from the true value of pi.

However, you may be thinking that while we have calculated the seked from the measured dimensions of the pyramid, these dimensions have changed over time as the pyramid has eroded. So, how do we go about calculating the intended seked of the pyramid? Well, one method is by using continued fractions.

Continued fractions are used to give a pleasant, rational approximation to numbers, by essentially writing a number as a fraction, whose denominator contains a sum involving another fraction, whose denominator contains a sum involving another fraction and so on…

Simple continued fractions are given by the general formula:

$$a_0 + \cfrac{1}{a_1 + \cfrac{1}{a_2 + \cfrac{1}{\ddots + \cfrac{1}{a_n}}}}$$ [6]

Where the more values of a that you use, the more accurate your approximation will be.

When we calculate [7] the continued fractions for our calculated seked of 0.786140756 we get:

[0; 1, 3, 1, 2, 11, 1, 1, …]

And when we approximate this using values of a up to a_4:

$$0 + \cfrac{1}{1 + \cfrac{1}{3 + \cfrac{1}{1 + \cfrac{1}{2}}}}$$

$$= \frac{11}{14}$$

To find the intended seked, we must try to put this in terms of the royal cubit. $\frac{11}{14}$ can also be written as $\frac{5.5}{7}$, and from our understanding of the royal cubit, this is equal to $\frac{5\ palms\ 2\ fingers}{1\ royal\ cubit}$, giving it a seked of 5 palms 2 fingers.

And since we know the seked is roughly equal to $\frac{1}{4}\pi$:

$$\frac{5.5}{7} \times 4 = \frac{22}{7}$$

From this, you may recognise that $\frac{22}{7}$ is a famous approximation for pi, having a value of around 3.1428857143 and being roughly 0.0402499% away from the actual value of pi. [4]

Another way to phrase this is that when we divide the perimeter (4 times the length) by the height of the pyramid, this is roughly equal to 2π, in the same way that it can be obtained if we divide the circumference of a circle ($2\pi r$) by its radius (r).

Now, the Great Pyramid of Giza was built over 500 years before the mathematical papyri, and they had no known documentation of pi up until this point. So, how is it that they managed to approximate pi in the pyramid to a better degree of accuracy than used hundreds of years later? Surely it must be a coincidence? Well, you may be right.

But what if I told you that the golden ratio could also be found within the pyramid?

4 - The Golden Ratio in Giza

In case you are unaware of the golden ratio, I will give a brief explanation of it:

Phi (written as ϕ, φ or Φ) is used to denote the golden ratio, which is where the ratio between two quantities is the same as the ratio of their sum to the larger of the two quantities such that [8]:

$$\frac{a+b}{a} = \frac{a}{b} = \phi$$

From this equation, we can solve to calculate a value for ϕ:

$$\frac{a+b}{a} = \frac{a}{b}$$

$$\frac{a}{a} + \frac{b}{a} = \frac{a}{b}$$

$$1 + \frac{1}{\frac{a}{b}} = \frac{a}{b}$$

Substitute in $\phi = \frac{a}{b}$:

$$1 + \frac{1}{\phi} = \phi$$

Multiply both sides by ϕ:

$$\phi + 1 = \phi^2$$

Now we can put this into a quadratic form and solve for ϕ:

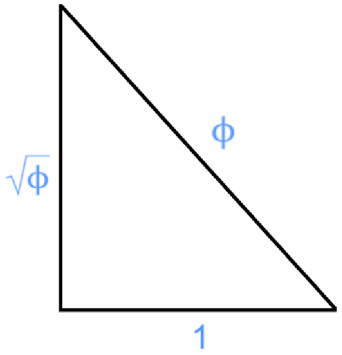
$$\phi^2 - \phi - 1 = 0$$

Using the quadratic formula we obtain the values for phi as:

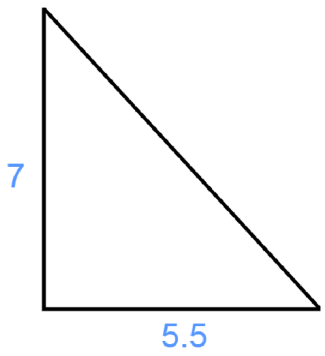
$$\phi = \frac{1 \pm \sqrt{5}}{2}$$

From this we take the positive value $\frac{1+\sqrt{5}}{2} \approx 1.618033989$ to be the golden ratio (the negative root is its negative inverse, $-\frac{1}{\phi}$).

So, how does this relate to the Great Pyramid of Giza? Well, to understand that, we can look back to our equation $\phi + 1 = \phi^2$. Notice how we can use this in the form $a^2+b^2=c^2$ to create a right angled triangle where $(\sqrt{\phi})^2 + (1)^2 = (\phi)^2$:



This is called the Kepler triangle, and we can relate this to the Pyramid of Giza by considering its seked. We have said the seked of the pyramid is 5 palms 2 fingers per royal cubit, and can be written as $\frac{5.5}{7}$. This can be represented by a triangle:



If this triangle behaves like a Kepler triangle, we could say that the ratios of its sides are equal to that of the Kepler triangle, such that $\frac{5.5}{7} = \frac{1}{\sqrt{\phi}}$. We can rearrange this to find an approximation for ϕ:

$$\frac{5.5}{7} = \frac{1}{\sqrt{\phi}}$$

$$\frac{7}{5.5} = \sqrt{\phi}$$

$$\phi = \left(\frac{7}{5.5}\right)^2$$

$$\phi = \frac{196}{121} \approx 1.619834711$$

This estimate for the golden ratio is only around 0.1112907% away from the true value.

This may have been deliberate, however, the ancient Egyptians never mentioned the golden ratio in any of their mathematical papyri.

5 - Evaluation

As you may have noticed, both the relationship with pi and the golden ratio rely on this fraction $\frac{5.5}{7}$, such that:

$$\frac{5.5}{7} \approx \frac{1}{\sqrt{\phi}} \approx \frac{\pi}{4}$$

The seked is acting as a kind of rational intermediate between phi and pi where $\frac{1}{\sqrt{\phi}} \approx \frac{\pi}{4}$. Therefore, the appearance of both of these famous mathematical constants within the dimensions of the pyramid are single handedly due to this fraction $\frac{5.5}{7}$, and suddenly their appearance is beginning to seem rather coincidental. This is also supported by the fact that they did not mention the golden ratio or directly mention pi in any of their mathematical papyri.

One way that they could have achieved this seked is by simply choosing it randomly. The seked achieves a steepness that is high enough to achieve the great height of the pyramid while not sacrificing its stability. Furthermore, you can quite easily construct a pyramid with the same dimensions as the Great Pyramid of Giza by using cords and a pole. (appendix 5)

6 - Conclusion

At this point, I may have convinced you that the dimensions of the pyramid were purely coincidental, and that we shouldn’t be impressed by the appearance of pi and the golden

ratio within the Great Pyramid of Giza. However, I think that such a conclusion would be rather pessimistic.

When we consider that they took the care to align the pyramid to true north to a very high degree of accuracy, and it took an estimated 20 years to build, it would make sense for them to consider the dimensions of the pyramid carefully before building it. And since they chose a seked that involved both pi and the golden ratio for their largest, most renowned pyramid, it is perhaps possible that behind the design of the pyramid, there was a great mathematician who has since been lost to time.

References

[1] Wikipedia (2026) Rhind Mathematical Papyrus. Available at: https://en.wikipedia.org/wiki/Rhind_Mathematical_Papyrus (Accessed 08/04/2026)

[2] Wikipedia (2026) Moscow Mathematical Papyrus. Available at: https://en.wikipedia.org/wiki/Moscow_Mathematical_Papyrus (Accessed 08/04/2026)

[3] McKenty. R (2000) Dimensions and Mathematics of The Great Pyramid. Available at: https://www.theglobaleducationproject.org/egypt/studyguide/gpmath.php (Accessed 08/04/2026)

[4] Wildberger. N (2025) The mathematics of the Great Pyramid | Math History (ancient to modern) 35. Available at: https://www.youtube.com/watch?v=qOkPgo8Rkbw (Accessed 08/04/2026)

[5] Wikipedia (2025) Seked. Available at: https://en.wikipedia.org/wiki/Seked (Accessed 08/04/2026)

[6] Wikipedia (2026) Simple continued fraction. Available at: https://en.wikipedia.org/wiki/Simple_continued_fraction (Accessed 08/04/2026)

[7] WolframAlpha (2026) Continued fraction. Available at: https://www.wolframalpha.com/input?i=0.786140756 (Accessed 08/04/2026)

[8] Wikipedia (2026) Golden ratio. Available at: https://en.wikipedia.org/wiki/Golden_ratio (Accessed 09/04/2026)

[9] Hollenback. G (2002) The Myth of Egyptian Pi. Available at: https://www.hallofmaat.com/numerology/the-myth-of-egyptian-pi/ (Accessed 08/04/2026)

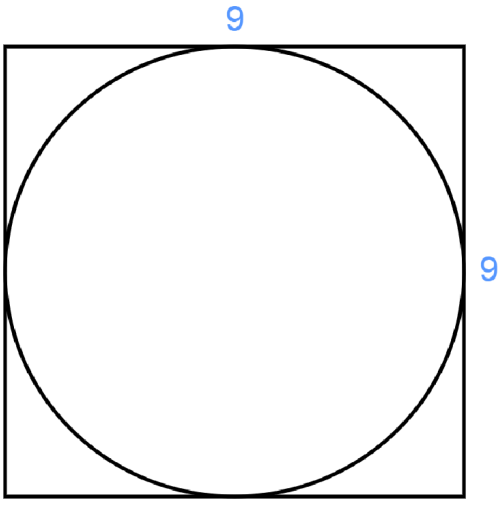
Appendices

Appendix 1

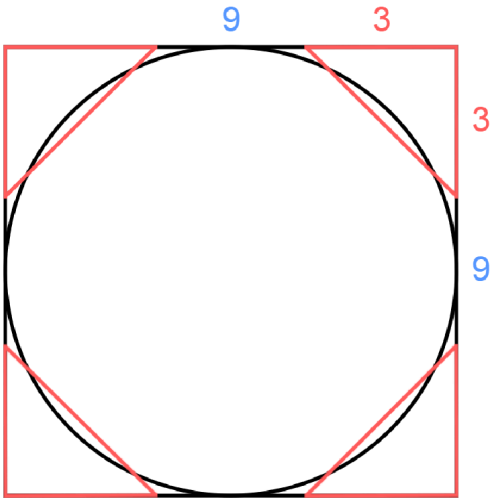
Problem 43 of the Moscow Mathematical Papyrus obtains an approximation of pi as $\frac{8192}{2187}$, which is roughly equal to 3.746 and is a considerably worse approximation than used throughout the rest of the papyrus. However, this is due to a mistake in the calculation made when trying to do the volume equation and a unit conversion in one step. The question was likely trying to use the same process as problems 41 and 42, but the mistake resulted in a different, less accurate volume equation, and subsequently a less accurate obtained value for pi.

Appendix 2

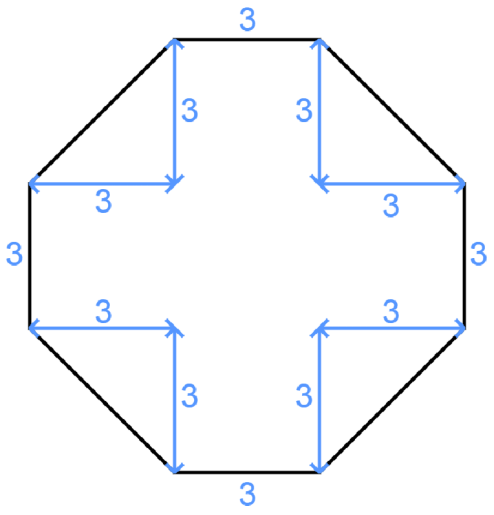
Well, one way is by considering problem 48 of the RMP. Let's say we have a square with side length of 9 units with a circle of diameter 9 units inscribed within it.



To approximate the area of the circle, you can cut the corners off the square using right angled triangles each with legs measuring 3 units:



This forms a semiregular octagon with the following dimensions:



This has a total area of 63 units², which is approximately the same as a square with a side length of 8 units and an area of 64 units². From this, they could have concluded that a circle with a diameter of 9 units has approximately the same area as a square of 8 units. Therefore we can approximate the ratio of the area of the circle to the area of its circumscribing square to be $\frac{64}{81}$, so the area of the circle can be given by $A = \frac{64}{81}d^2$, since d is equal to the length of the square, and d^2 is the area of the square. [9]

Appendix 3

In problem 10 of the Moscow Mathematical Papyrus, the curved surface area of a basket is to be found. They describe the equation:

$$A = (((2d) \times \frac{8}{9}) \times \frac{8}{9}) \times d)$$

Which can be written as:

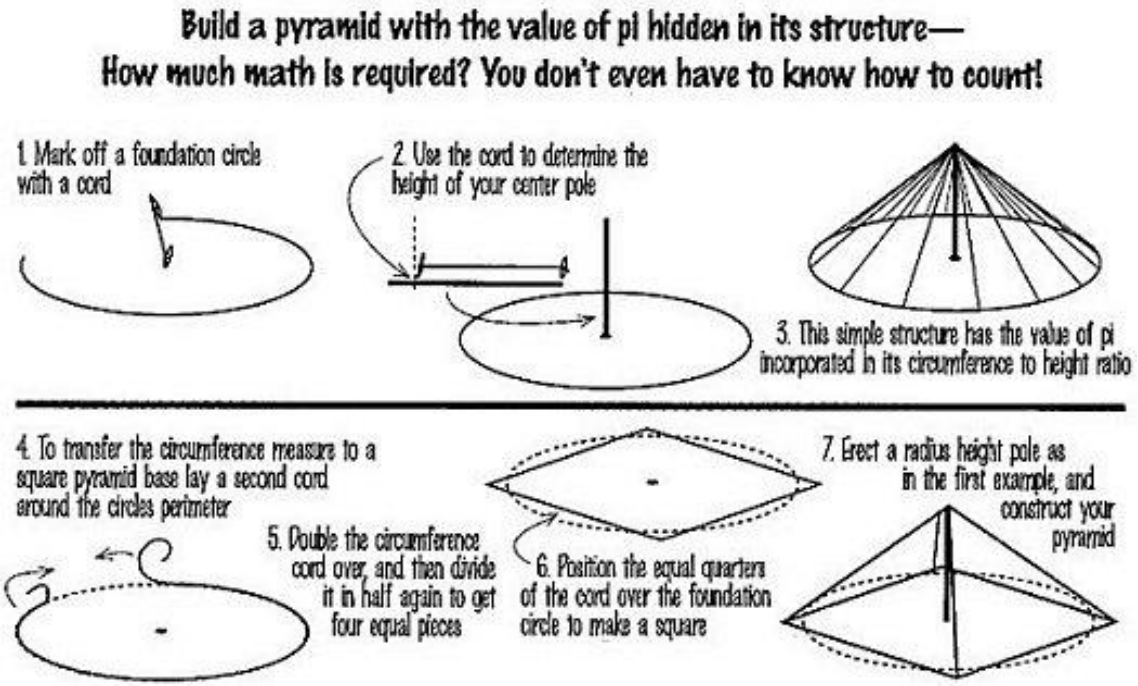
$$A = 2(\frac{64}{81}d^2)$$

Which is consistent with the Rhind Mathematical Papyrus, with this value of $\frac{64}{81}$ being used again.

Appendix 4

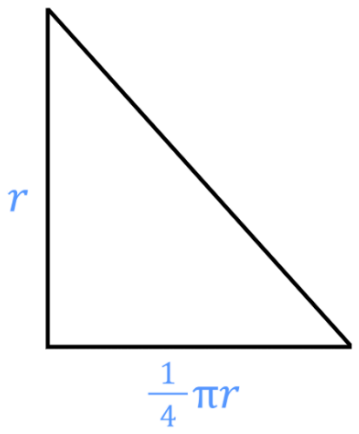
Despite the Great Pyramid of Giza allegedly being eight-sided, with each of the faces having a groove running down the centre, this was very likely due to the erosion of the centres of the faces due to rocks falling from the top of the pyramid, and the removal of the outer casing. The pyramid was very likely to have been intended to have 4 sides (not including the bottom of course!), so we will not be considering the 8-sidedness in our calculations.

Appendix 5



[9]

We know the perimeter of the base of this pyramid is $2\pi r$. Therefore, the length of one side of the base can be given by $\frac{2\pi r}{4} = \frac{1}{2}\pi r$. To calculate the seked, we can halve this value to create a right angled triangle with base $\frac{1}{4}\pi r$ and height r.



This gives us a value of the seked to be $\frac{\frac{1}{4}\pi r}{r} = \frac{1}{4}\pi$, which is approximately equal to the seked of the Great Pyramid of Giza, which is also approximately equal to $\frac{1}{\sqrt{\phi}}$.