The King's Chamber Floor, decoded
The not-so-crazy paving

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Version 1.0.0
DOI: https://doi.org/10.5281/zenodo.6866852

Unqid: 9ea1ef62973252167de9c4cfe0988ec5
Please check via DOI for latest version.

20 July 2022

Abstract

The King's Chamber floor appears to be randomly-sized blocks, perhaps the forerunner for the "crazy paving" décor style. Like everything else about Giza, it is actually mathematically designed, incorporating almost all the favourite irrationals used extensively elsewhere around the site. The floor includes π, φ, φ^2, e^2, $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, $\sqrt{7}$, $\sqrt{\pi}$, $\sqrt{\varphi}$, $\sqrt{\mathrm{e}}$, as well as c^2, g_0 and α. References to the speed of light allow us to potentially also model Einstein's famous equation, using stone lengths.

Keywords: Egyptology, Giza, Great Pyramid, History of Mathematics, History of Science, π, φ

Contents

1 Introduction

The Great Pyramid's King's Chamber is notable for its apparent blandness. Nothing could be further from the truth. As I showed in *The Writing is on the Wall* [1], the walls, floor and ceiling are used to spell out the decimal digits of π, φ, φ^2, e, assorted square roots, the Fibonacci and Lucas sequences, primes, squares, and more.

The mathematics continues on the floor. The floor tiles are laid in six broad strips, with no obvious pattern within each strip, or overall.

Once we apply our minds to the problem, the secrets behind the design appear. It is not crazy paving, but testimony to what they knew about mathematics and physics. Those who have read my other papers [2] will not be surprised by the usual suspects (π, φ, φ^2, e, assorted square roots, etc.) but may be perplexed when c^2, g_0 and α put in an appearance. Adding Einstein's equation to the mix, albeit in a debatable or borderline tongue-in-cheek way, could potentially force a rethink of just how advanced the Giza builders were. It could not have been the 4th Dynasty as we know them.

"The language of Giza is mathematics."

Robert Bauval

"You will believe."

The architects of Giza

Best viewed and printed in colour.

2 Symbols and values

Giza is a construction site. Construction is a practical art, so we need to use practical values for certain irrationals, as shown in Table 1.

Symbol	Name	Practical value	% Accuracy	Date
π	Archimedes' constant	3.1416	99.9998	3.1416 < 150 BCE
e	Euler's number	2.72 or 2.7183	99.9368 or 99.9993	1683 CE
φ	Golden ratio	1.618 $\varphi + 1 = \varphi^2 = 2.618$	99.9979	500 BCE ?
ρ	Plastic number / ratio	1.3247 ρ+1 = ρ^3 = 2.3247	99.9986	1924, 1928 CE
$\sqrt{2}$	Root 2	1.414 or 1.4142	99.9849 or 99.999	
$\sqrt{3}$	Root 3	1.732	99.9971	
$\sqrt{5}$	Root 5	2.236	99.9970	
$\sqrt{7}$	Root 7	2.646	99.9906	
$\sqrt{\pi}$	Root π	1.772	99.9743	
$\sqrt{\varphi}$	Root φ	1.272	99.9995	
$\sqrt{e}$	Root e	1.649	99.9834	
c	Speed of light	2.99792×10^8	99.9998	1926 CE
α	Fine structure constant	7.2974×10^{-3}	99.9994	1969+ CE
g_0	Standard acceleration due to gravity	9.81	99.9658	1901 CE
₵	Royal cubit aka cubit	0.5236m ($\pi/6$)		
Ṗ	Petrie inch	2.5399977 cm		

Table 1: Symbols, names and values

I use "cubit" for the Royal cubit (₵).

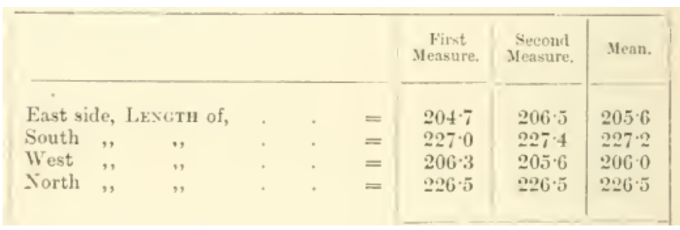
We should remember that we are dealing with a different culture, which may have had a different approach to accuracy and precision, compared to our modern scientific mindset. My Giza analysis suggests they typically worked to 3 or 4 decimal places, and occasionally 2 places, like 2.72 for e. This may indicate that they used abacuses or counting tables, or possibly slide rules or logarithms, to calculate. Alternatively, they may just have used four decimals as anything more did not make sense in construction. 0.0001 ₵ is 5.236×10^{-5} m, which is about 50 microns, half the smallest distance that can be seen with the naked eye, and approaching the length of a human liver cell.

The analysis that follows includes various ratios that approximate some of the irrationals or values in Table 1. Irrationals can not be expressed accurately as fractions. We are further constrained by working with physical lengths. I have generally limited accuracy to 3 decimal places, as I do not think that manufacturing stone blocks to tolerances of 0.0001 ₵ is viable.

We also need to deal with scaling. Some results shown need to be scaled by the appropriate powers of ten, this is inherent in the constraints of a chamber 20 by 10 cubits, or vice versa because the desired number is so small.

3 Dimensions

The only measurements of the slabs on the floor of the King's Chamber that I have access to, are those by Charles Piazzi Smyth [3]. This is a problematic set of measurements. Smyth took them by candlelight, and had a rather slapdash approach to measurement. For example, Figure 1 is an extract of his measurements in the Queen's Chamber.



	First Measure.	Second Measure.	Mean.
East side, Length of, . . =	204·7	206·5	205·6
South ,, ,, . . =	227·0	227·4	227·2
West ,, ,, . . =	206·3	205·6	206·0
North ,, ,, . . =	226·5	226·5	226·5

Figure 1: Smyth's measurements in Queen's Chamber

His measurements along the east side differed by 1.8 inches (over 4.5 cm), and he simply averaged them. Petrie [4], in contrast, measured each distance nine times, being three times each on three different days.

The other problem that Smyth had was the state of the floor. Figure 2 shows a distorted scan of his drawing of the floor, showing all the damaged areas where measuring would have been a challenge. As far as I know the split block on the south edge is a repair and was likely originally a single block so that the floor would have 18 blocks, a multiple of nine, like the walls and ceiling.

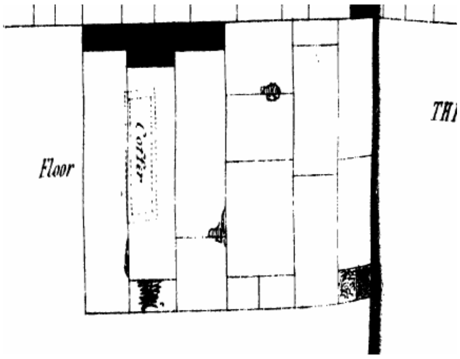


Figure 2: Smyth's diagram of the King's Chamber floor

Figure 3 shows the floor with block labels and three sets of measurements. First are Smyth's measurements in his inches, in black. The figures in blue are a direct conversion to cubits. Lastly, the figures in red are the adjusted "probable" values that make all the relationships work, as well as having a length of twenty cubits and a width of ten cubits.

The column widths are along the top, while Smyth's matching measurements along the south side are at the bottom right of each column. The column totals are along the bottom, with the north and south edge totals on the right.

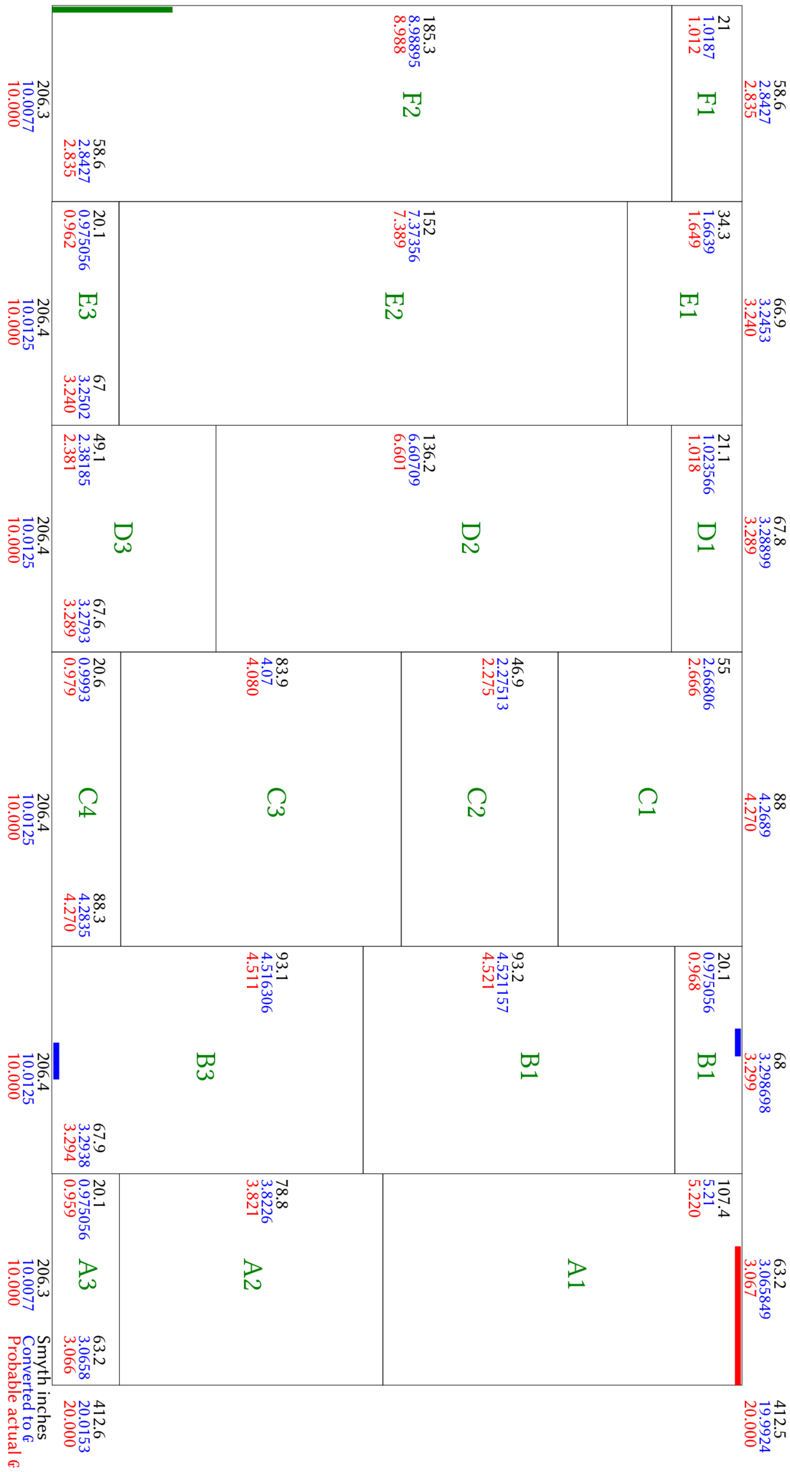


Figure 3: Floor with block labels and dimensions

I am using decimal cubits, as it is clear that this, and not palms, digits, etc., was the tool of choice. Petrie (§139) recorded seeing evidence that such a cubit rod was used.

Fig. 4 shows how part of such a decimal cubit rod might look, compared to a metric ruler. For some reason, it shrinks from true size when printed.

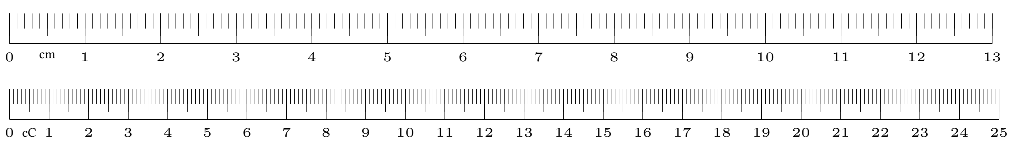


Figure 4: Centimetres and millimetres compared to decimal centicubit and millicubit divisions.

Table 2 shows Smyth’s measurements along the north edge, together with direct conversion to cubits, my estimate of the probable original value that makes things work, the back conversion to inches, and the absolute and percentage difference.

Column	Smyth	Converted	Probable	BackConvert	Absolute Δ ₢	Δ %
A	63.2	3.065849	3.067	63.224	0.001151	0.0375
B	68.0	3.298698	3.299	68.006	0.000302	0.0091
C	88.0	4.268904	4.270	88.023	0.001096	0.0257
D	67.8	3.288996	3.289	67.800	0.000004	0.0001
E	66.9	3.245337	3.240	66.790	-0.005337	-0.1645
F	58.6	2.842702	2.835	58.441	-0.007702	-0.2709
Totals	412.500	20.010486	20.000	412.284		
Averages					-0.001748	-0.0605

Table 2: Column widths, north side

Table 3 shows the same for Smyth’s measurements along the south edge. Note the variations, particularly in columns C and D.

Column	Smyth	Converted	Probable	BackConvert	Absolute Δ ₢	Δ %
A	63.2	3.065849	3.067	63.224	0.001151	0.0375
B	67.9	3.293847	3.299	68.006	0.005153	0.1564
C	88.3	4.283457	4.270	88.023	-0.013457	-0.3142
D	67.6	3.279294	3.289	67.800	0.009706	0.2960
E	67.0	3.250188	3.240	66.790	-0.010188	-0.3135
F	58.6	2.842702	2.835	58.441	-0.007702	-0.2709
Totals	412.600	20.015337	20.000	412.284		
Averages					-0.002556	-0.0681

Table 3: Column widths, south side

Table 4 shows the blocks and their lengths from the diagram, as well as a re-conversion of the probable value back to Smyth-era inches..

Block	Smyth	Col tot	Converted	Col tot	Probable	Col tot	BackConvert
A1	107.4		5.210003		5.220		107.606
A2	78.8		3.822609		3.821		78.767
A3	20.1	206.3	0.975056	10.008	0.959	10.000	19.769
B1	20.1		0.975056		0.968		19.955
B2	93.2		4.521157		4.521		93.197
B3	93.1	206.4	4.516306	10.013	4.511	10.000	92.991
C1	55.0		2.668065		2.666		54.957
C2	46.9		2.275132		2.275		46.897
C3	83.9		4.070012		4.080		84.106
C4	20.6	206.4	0.999312	10.013	0.979	10.000	20.181
D1	21.1		1.023567		1.018		20.985
D2	136.2		6.607099		6.601		136.074
D3	49.1	206.4	2.381854	10.013	2.381	10.000	49.082
E1	34.3		1.663902		1.649		33.993
E2	152.0		7.373561		7.389		152.318
E3	20.1	206.4	0.975056	10.013	0.962	10.000	19.831
F1	21.0		1.018716		1.012		20.862
F2	185.3	206.3	8.988953	10.008	8.988	10.000	185.280

Table 4: Blocks and lengths in inches and cubits

Table 5 shows the blocks and the various dimensions, and the accuracy of the probable value to Smyth’s measurements, as both absolute delta cubits, and percentage difference.

Block	Smyth	Converted	Probable	BackConvert	Absolute Δ ₢	Δ %
A1	107.4	5.210003	5.220	107.606	0.009997	0.1919
A2	78.8	3.822609	3.821	78.767	-0.001609	-0.0421
A3	20.1	0.975056	0.959	19.769	-0.016056	-1.6467
B1	20.1	0.975056	0.968	19.955	-0.007056	-0.7237
B2	93.2	4.521157	4.521	93.197	-0.000157	-0.0035
B3	93.1	4.516306	4.511	92.991	-0.005306	-0.1175
C1	55.0	2.668065	2.666	54.957	-0.002065	-0.0774
C2	46.9	2.275132	2.275	46.897	-0.000132	-0.0058
C3	83.9	4.070012	4.080	84.106	0.009988	0.2454
C4	20.6	0.999312	0.979	20.181	-0.020312	-2.0326
D1	21.1	1.023567	1.018	20.985	-0.005567	-0.5439
D2	136.2	6.607099	6.601	136.074	-0.006099	-0.0923
D3	49.1	2.381854	2.381	49.082	-0.000854	-0.0359
E1	34.3	1.663902	1.649	33.993	-0.014902	-0.8956
E2	152.0	7.373561	7.389	152.318	0.015439	0.2094
E3	20.1	0.975056	0.962	19.831	-0.013056	-1.3390
F1	21.0	1.018716	1.012	20.862	-0.006716	-0.6592
F2	185.3	8.988953	8.988	185.280	-0.000953	-0.0106
Averages					-0.003634	-0.4211

Table 5: Blocks cubit accuracies

4 The columns

There are five numbers using the column widths, of which two take two columns at a time, one uses five columns, and two are column differences. First is π, using columns A and B, shown in Figure 5.

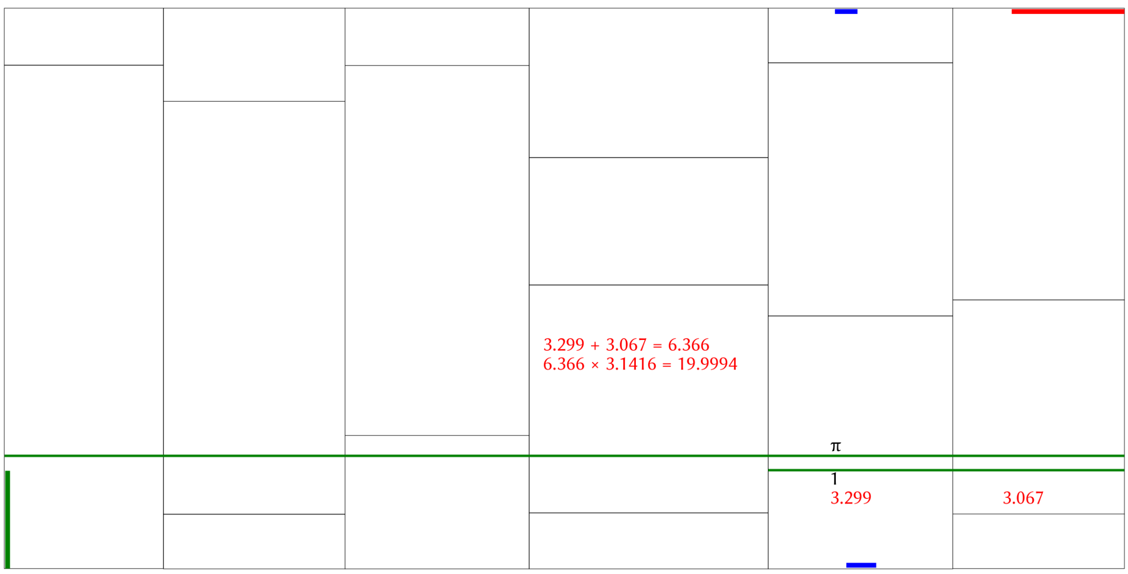


Figure 5: Pi ratio

Also curiously, 6.366 ₢ is 3.333 metres. The number 3 often pops up at Giza.

The square root of 7 uses the middle two columns, shown in Figure 6.

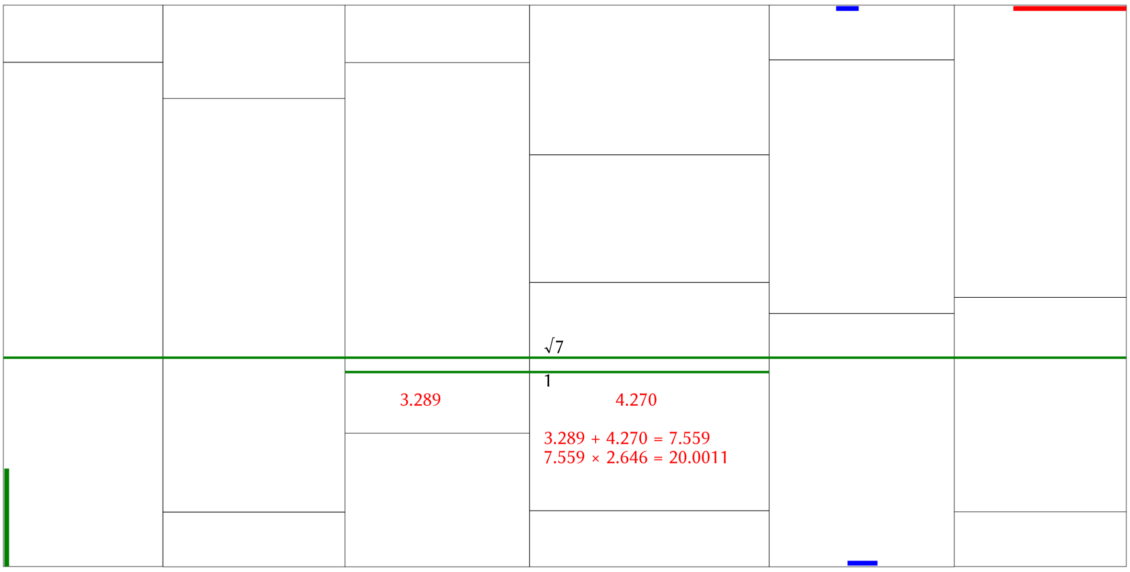


Figure 6: $\sqrt{7}$

The difference between the eastern half and western half gives us $\sqrt{\varphi}$, shown in Figure 7.

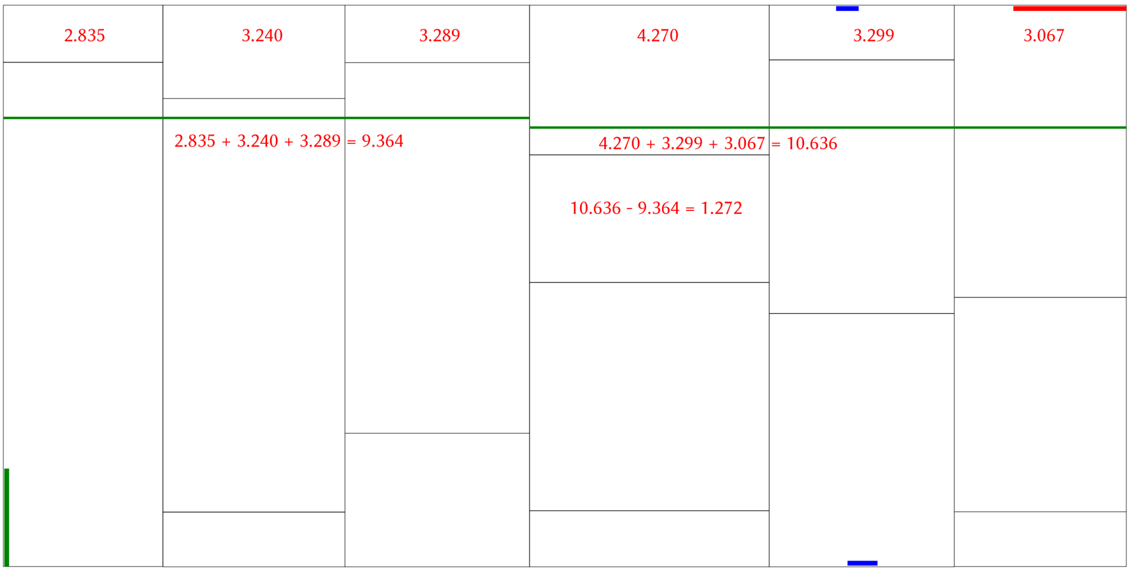


Figure 7: $\sqrt{\varphi}$

Switching from mathematics to physics, columns E to A give us the speed of light squared, in metres (apart from scaling by 10^8), shown in Figure 8.

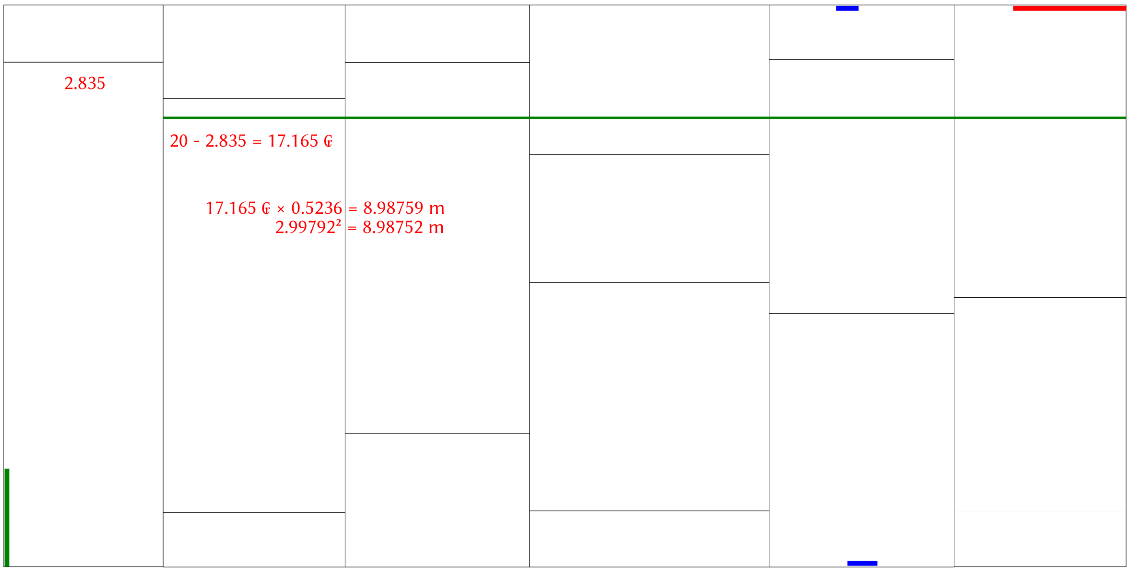


Figure 8: Speed of light squared

The difference between columns C and D gives us a good estimate for the gravitational constant on earth, divided by 10. $g_0/10$ is shown in Figure 9.

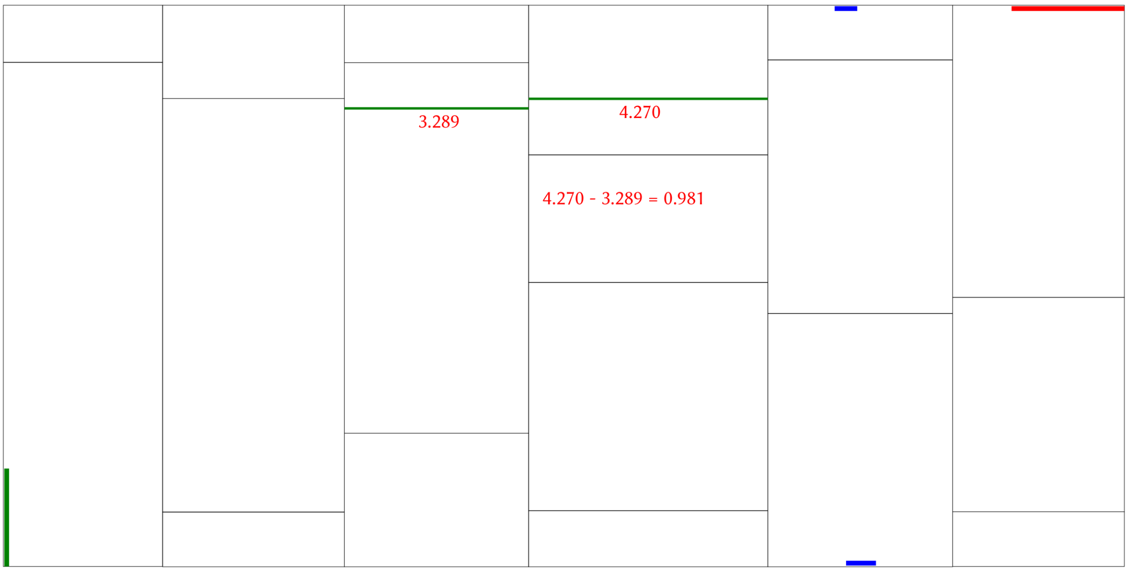


Figure 9: Standard acceleration due to gravity

5 Block lengths

I differentiate between two classes of blocks: significant blocks, which are the larger blocks, and filler blocks, which are typically close to a cubit high, and fill up the columns. The relationships use the significant blocks, shown in Figure 10.

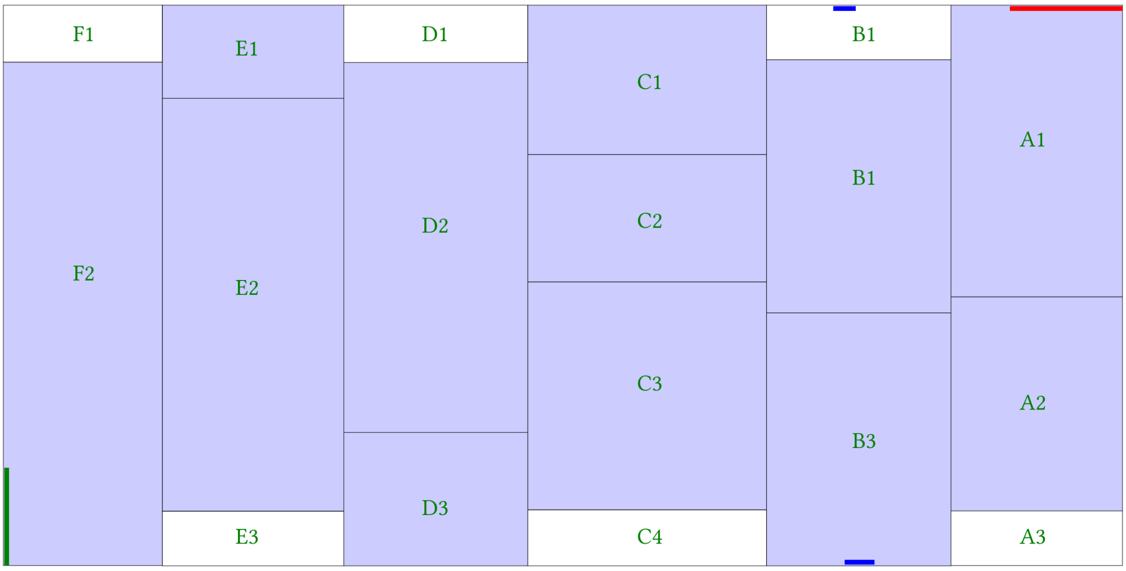


Figure 10: Significant blocks

We start with column A, which has φ^2 as shown in Figure 11.

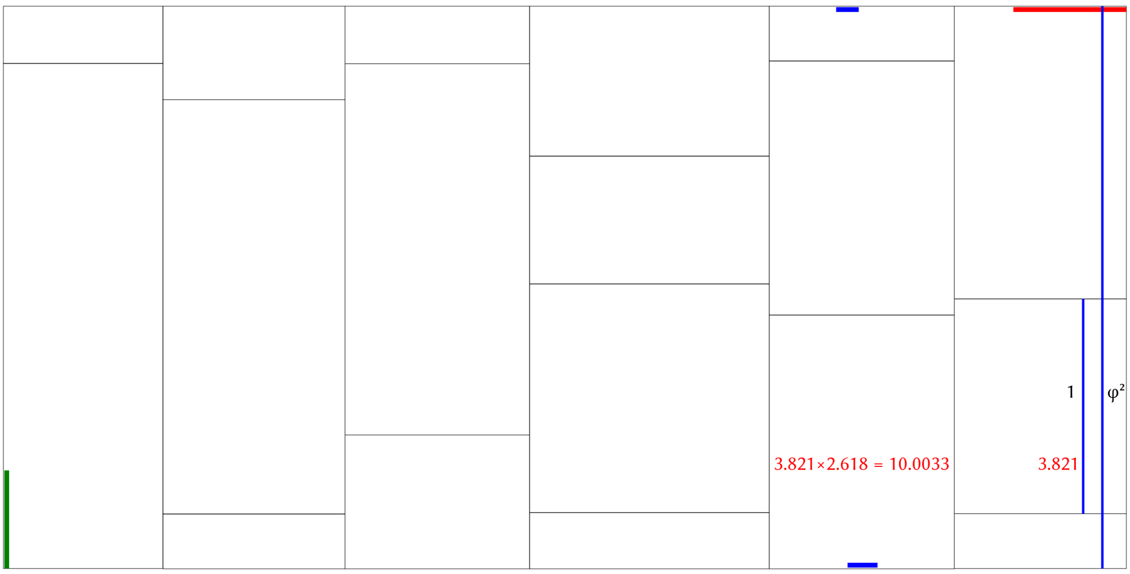


Figure 11: φ^2

The first column also has $\sqrt{3}$, in Figure 12.

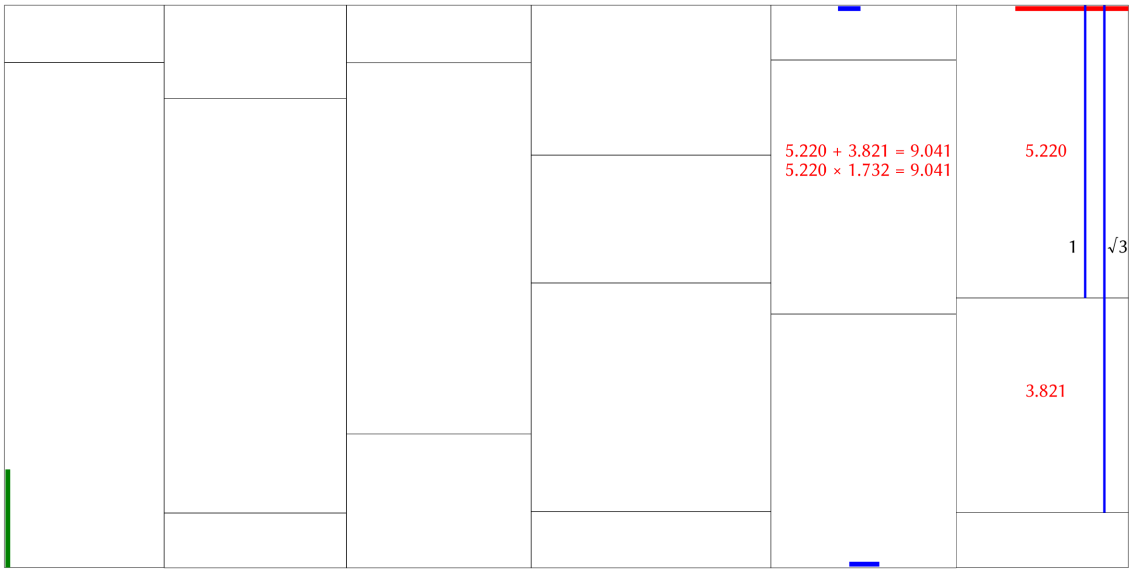


Figure 12: $\sqrt{3}$

We shall return to column B shortly, and now jump to column C for the rest of the integer square roots. Block C3 - C1 gives $\sqrt{2}$, shown in Figure 13.

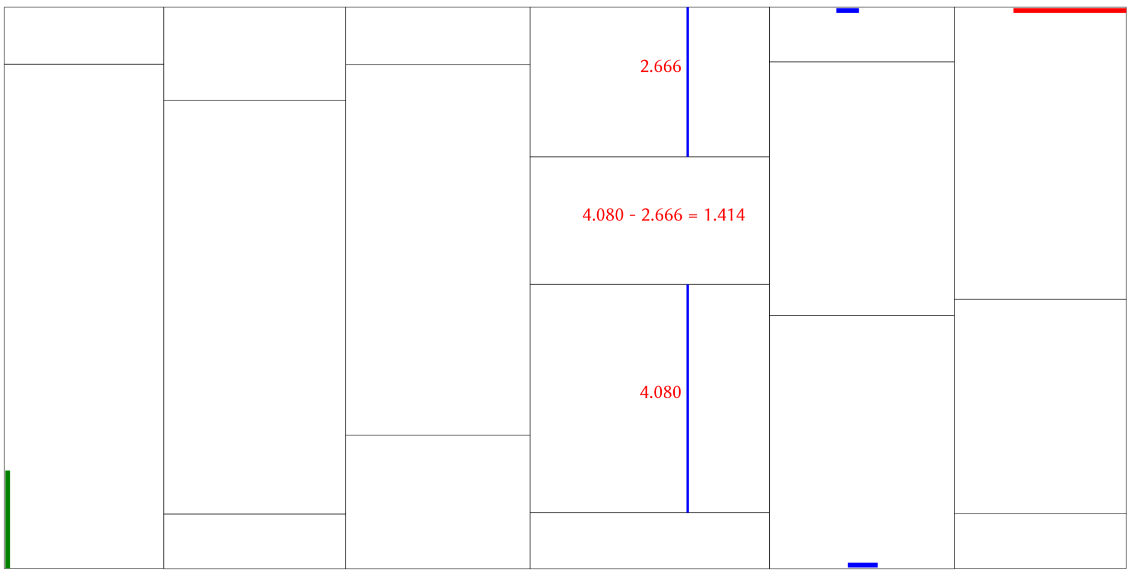


Figure 13: $\sqrt{2}$

Block B3 - C2 gives $\sqrt{5}$, shown in Figure 14.

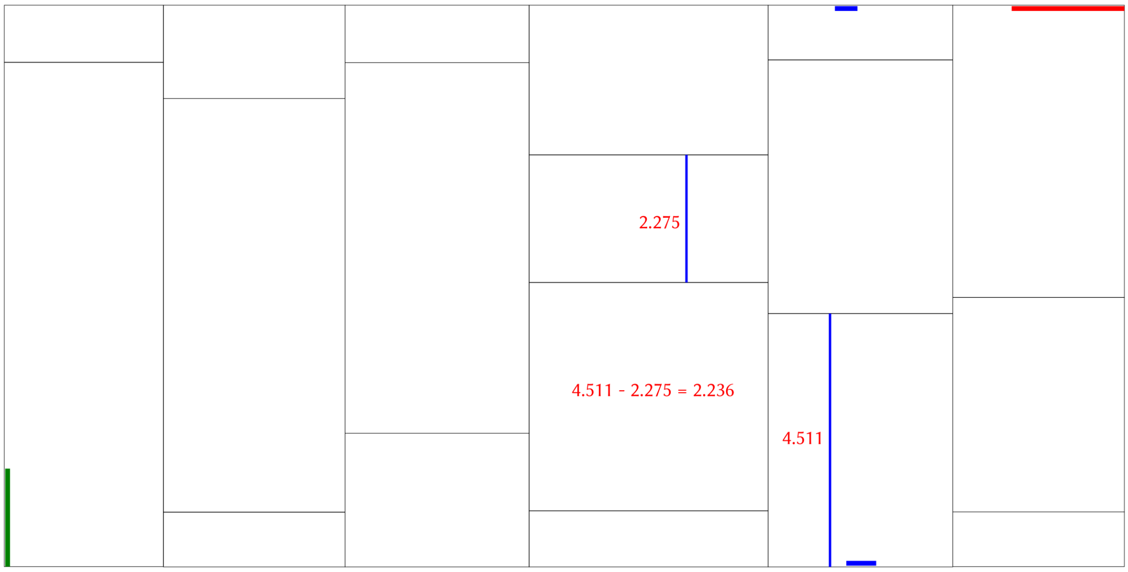


Figure 14: $\sqrt{5}$

Phi is between blocks C3 and D2, shown in Figure 15.

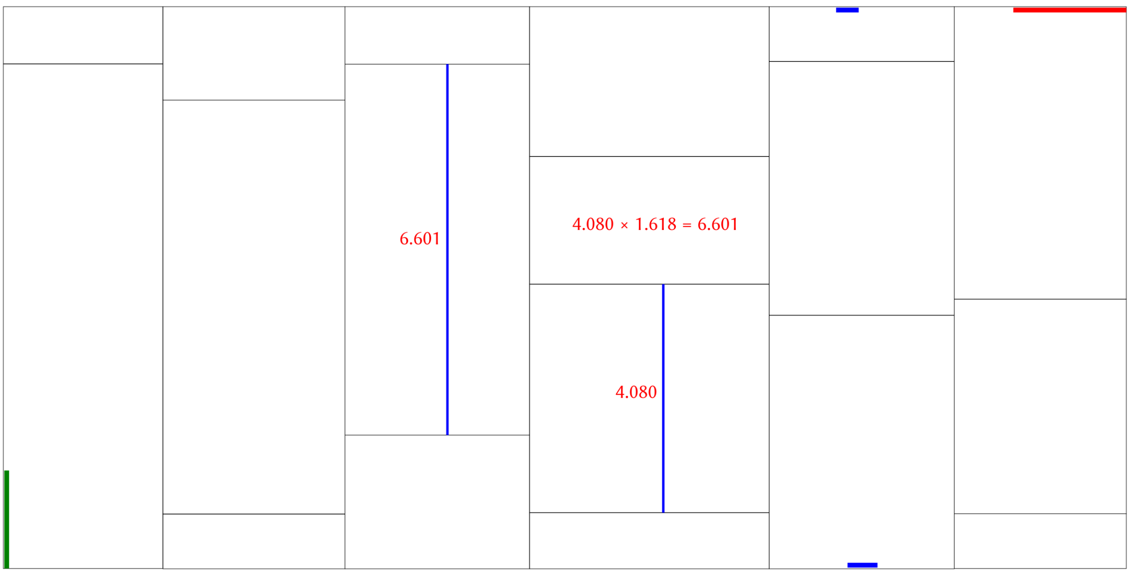


Figure 15: φ

We come now to the more challenging examples. First up is $\sqrt{\pi}$, which is challenging not because of what it is, but because the calculation is not as straight-forward as what we have seen so far. The formula is given by

$$\frac{\text{D2} - \text{D3}}{\text{D3}} = \sqrt{\pi}$$

and is shown in Figure 16.

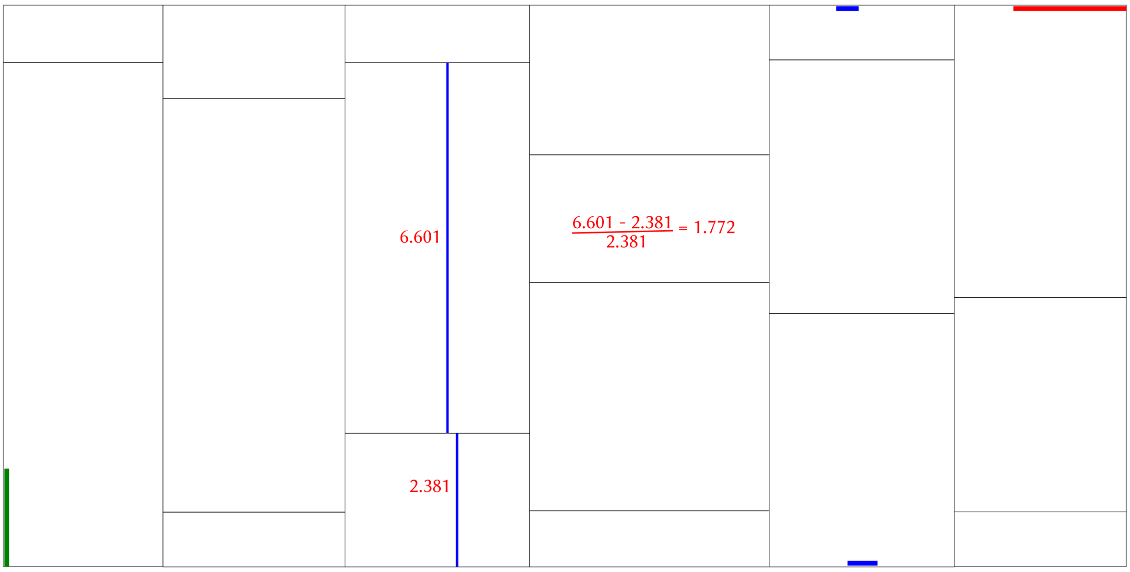


Figure 16: $\sqrt{\pi}$

Next are $\sqrt{e}$ and e^2, both in column E, shown in Figure 17.

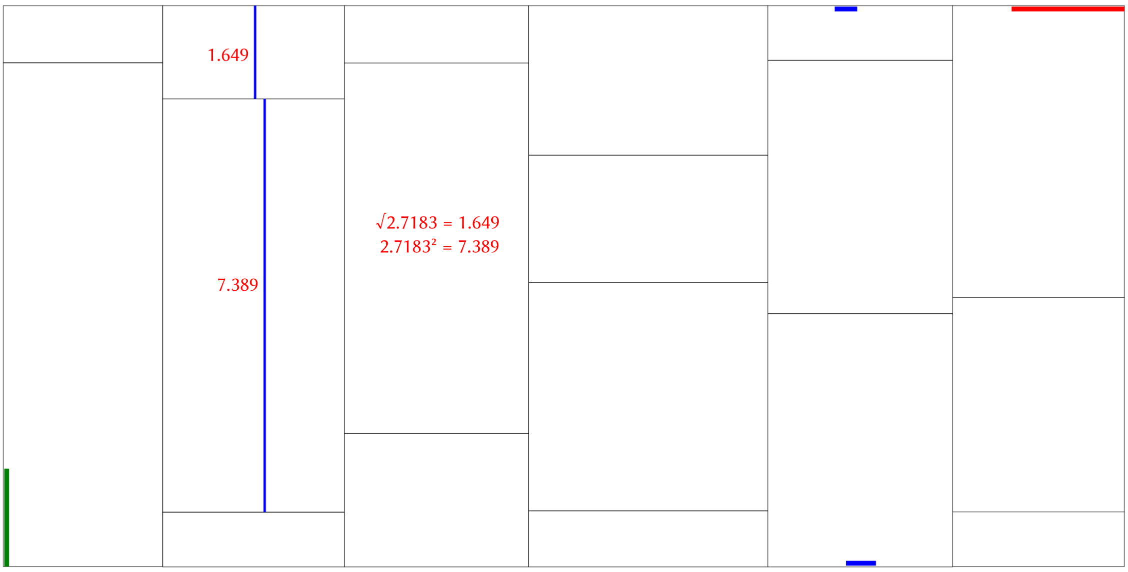


Figure 17: $\sqrt{e}$ and e^2

Moving from mathematics to physics, we have the speed of light squared, again. The designers often did things more than once, either to make a point, or improve the odds of someone noticing. Block F2 is c^2, shown in Figure 18. The designers used a cubit length numerically the same as what the metre length should be.

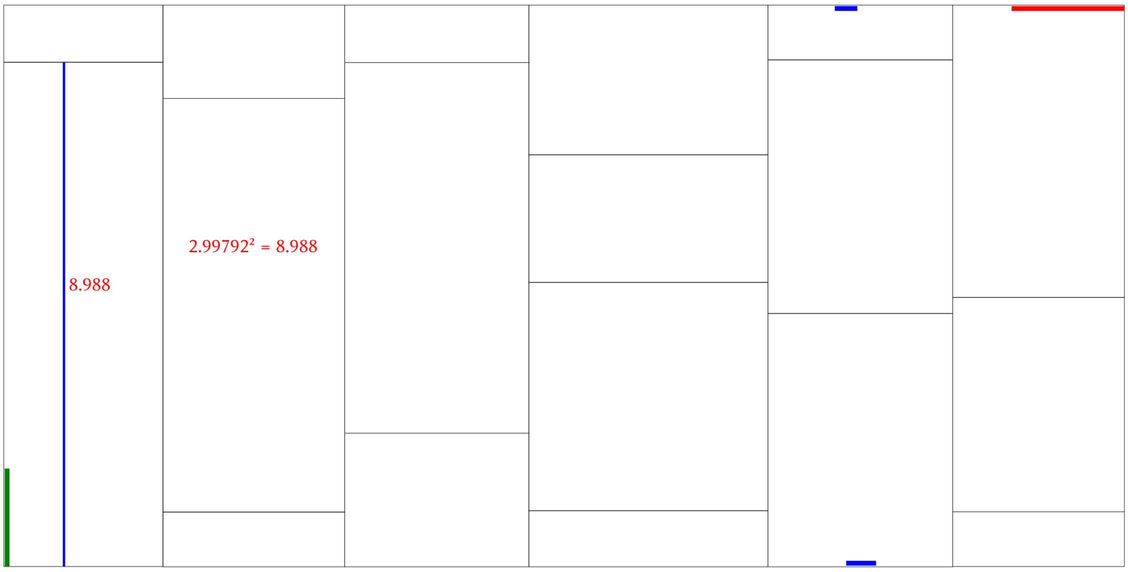


Figure 18: c^2

Lastly, what is arguably the most annoying of all. The only unused significant block is B2, and it contains alpha. The fine structure constant keeps popping up at Giza, and it really should not. Alpha × 100 is shown in Figure 19.

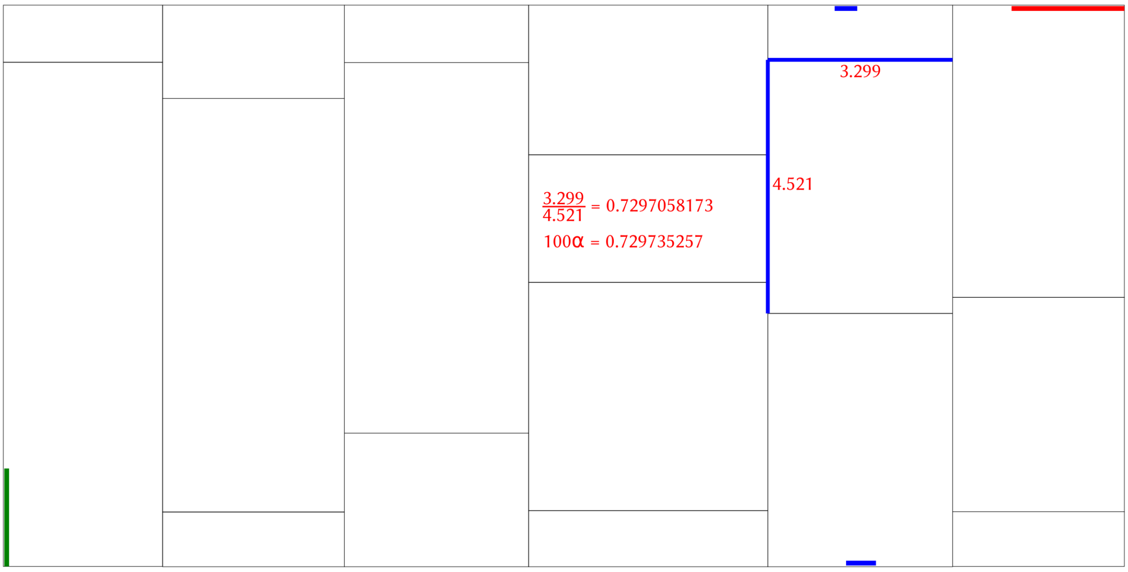


Figure 19: α

6 The most famous equation of all time

"And Joseph, here's the punchline, it's really gonna blow your mind, flip your lid."

Pharoah in *Joseph and the Amazing Technicolor Dreamcoat*, lyrics by Tim Rice

If the fine structure constant was problematic, things are about to get a lot worse.

Albert Einstein (or his clever wife) showed us that $E = mc^2$. This is often cited as The Most Famous Equation of All Time, due to its simplicity and profundity. If you were a pyramid designer, and wanted to illustrate this formula, how would you do it?

We have seen c^2 twice above, as lengths. We use the metre version, from the width of columns E to A, converted to cubits at 17.165 ₵.

We can also use a length to represent Energy. The potential energy of an object is related to its height above ground, so perhaps we can use a high point, say the top of the tallest building on earth, to represent this potential energy. Luckily we have such a building handy, so we can use Khufu's height of 280 ₢ to represent Energy.

That leaves us with the problem of representing Mass. We know that

$$Mass = Volume \times Density$$

so we can say that $Mass \propto Volume$, and rewrite our formula as $\mathrm{E} \propto \mathrm{vc}^2$.

Now if only there was some object with an easily measurable volume, like a stone box... oh, wait...

Petrie (§59) gives the dimensions of the coffer as 89.62 × 38.50 × 41.31 Ṗ, which converts to 4.347490334 × 1.867645368 × 2.003959224 ₢. In my paper *Khufu's Coffer* [5], I made the case that the intended dimensions were 4.347 × 1.87 × 2 ₢, because 1.87 is $\frac{\pi\varphi}{\mathrm{e}}$, and 4.347 is 1.87 times the plastic ratio cubed. The height at 2 did bother me, because "nice round numbers" are not the typical approach in the great pyramid, but I accepted it due to the lack of any better ideas. Ah, the folly of youth and inexperience. The height should be 2.0067, not 2.000. The coffer is unfortunately not perfectly made, with a lot of variation in the dimensions, as Petrie noted. He also commented (§156), "The height of the coffer is not very certain, owing to so much of the top having been destroyed." So we have to figure out the probable intended dimensions, based on their love of mathematics.

The volume of the coffer is then 4.347 × 1.87 × 2.0067 = 16.31224356 ₢³. If we treat this as a pure number, remembering we are using volume as a substitute for mass, then our equation becomes

$$\begin{aligned} &\mathrm{E} \propto \mathrm{vc}^2 \\ \therefore\ & 280 \propto 16.31224356 \times 17.165 \\ \therefore\ & 280 \propto 280 \\ & \text{Q.E.D.} \end{aligned}$$

We have thus achieved our goal of representing $\mathrm{E} = \mathrm{mc}^2$ in stone.

7 Conclusion

If my analysis is correct, then the blocks on the King's Chamber floor were carefully designed with mathematical and physical constants. Such a design is clearly at odds with the accepted use as "burial chamber." As shown in *The Writing is on the Wall* [1], the mathematics continues in the block patterns on the walls.

As far as we know, the 4th dynasty had no knowledge of π or φ, let alone e, c, g_0, α or the metre. So their presence, preserved in stone for us, should give us pause to reconsider the accepted time line of human history, and when Giza was built, and by whom.

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