

Rosetta Stone

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Abstract

In this assignment you will explore hieroglyphics and Egyptian arithmetic circa 1700 B.C.E.. You will be challenged to walk in the foot steps of the 19th century scholars who first deciphered Hieroglyphics using the Rosetta Stone.

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1 Introduction

In this assignment you will explore Egyptian Numerals as they were written starting around 3000 B.C.E.. You will practice translating back and forth between Egyptian Numerals and Hindu-Arabic, explore how the Egyptians handled fractions, and see how they carried out multiplication. At the end you will try and “*decipher*” some hieroglyphics dating back to around 1700 B.C.E. by comparing English translations with the original Hieroglyphics. This is similar to what scholars did with the Rosetta Stone in the 19th century. You should start by watching these videos about the Rosetta Stone.

- The Not-So-Simple Process of Deciphering Hieroglyphs
(<https://youtu.be/oU88-BLmcmY>)

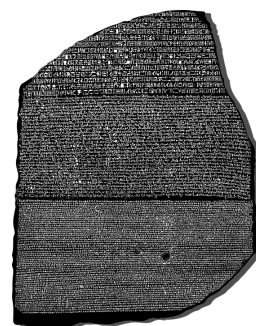


Figure 1: Rosetta Stone

- [Decoding Egyptian hieroglyphs \(the Rosetta Stone, Champolion, and Young\)](https://youtu.be/Ju2JB0e9C7A) (<https://youtu.be/Ju2JB0e9C7A>)

For all of this assignment, particularly for the last two sections, keep in mind that it is effort that counts. You need to show your work as much as possible and explain your reasoning. I am perfectly aware that you can find many of the answers on the internet, but if you don't show work I won't give you credit. You can either write up your work neatly or type it up. I will include an appendix at the end of this assignment describing some ways to type up hieroglyphs. Your work must be written up, or typed, on separate paper and turned in in class.

2 Egyptian Numerals

2.1 Numbers

Egyptians had different symbols for each power of 10 up to 1,000,000.

1	𐍌	10,000	𐍌
10	𐍎	100,000	𐍎𐍌
100	𐍎𐍌	1,000,000	𐍎𐍌𐍌
1,000	𐍎𐍌𐍌		

Table 1: Quick Number Reference

Using this we can translate back and forth between Hindu-Arabic and Egyptian Numerals.

1. 42

3. 31,047

5. 𐍎𐍌𐍌𐍌𐍌

2. 57

4. 𐍌𐍎𐍎𐍎𐍎𐍌

6. 𐍌𐍌𐍎𐍎𐍎𐍎𐍎𐍎𐍌

2.2 Fractions

When writing fractions the ancient Egyptians worked almost exclusively in unit fractions (fractions with numerator 1), that is they would have written $2/5$ as something like $1/3 + 1/15$. Using Egyptian numerals we would write this roughly as:

$$\frac{1}{3} + \frac{1}{15}$$

Here the symbol \frown indicates that it is a fraction. An exception to this notation is for $1/2$, which is written \supset instead of \frown . One possible formula for finding the unit fractions is:

$$\frac{2}{n} = \frac{1}{m} + \frac{1}{n(m)},$$

where $m = (n + 1)/2$. For example we could write $2/7$ as $1/4 + 1/28$, since $4 = (7+1)/2$. Try using this formula for the following fractions:

7. $\frac{2}{3}$

9. $\frac{2}{7}$

11. $\frac{2}{11}$

8. $\frac{2}{5}$

10. $\frac{2}{9}$

12. $\frac{2}{13}$

This only works when n is an odd number. However, what is the simple way to write $2/4$ as a unit fraction? Why would this always work when the denominator is an even number?

One of the few exceptions to the unit fraction rule was $2/3$ which sometimes had its own special symbol



From now on, for simplicity, we will write these fractions using lines or dots over Hindu-Arabic numerals so the above examples would be $1/3 + 1/15 = \overline{3} + \overline{15}$ and $2/3 = \overline{3}$.

3 Egyptian Multiplication

Egyptian multiplication was built around the idea that it is easy to double numbers. If we want to calculate 15×6 , we think of it as $15 \times 2 + 15 \times 4$ because $6 = 2 + 4$. Now all we have to do is use doubling:

$$\begin{array}{r|l} 15 & 1 \\ 30 & 2 \checkmark \\ 60 & 4 \checkmark \end{array}$$

thus

$$\begin{aligned} 15 \times 6 &= 15 \times 2 + 15 \times 4 \\ &= 30 + 60 \\ &= 90. \end{aligned}$$

Here are a couple slightly more complicated examples with whole numbers.

$$\begin{array}{r|l} 23 \times 17 = ? & \\ \hline 23 & 1 \checkmark \\ 46 & 2 \\ 92 & 4 \\ 184 & 8 \\ 368 & 16 \checkmark \\ \hline 23 + 368 = & \boxed{391} \end{array}$$

$$\begin{array}{r|l} 35 \times 110 = ? & \\ \hline 35 & 1 \\ 70 & 2 \checkmark \\ 140 & 4 \checkmark \\ 280 & 8 \checkmark \\ 560 & 16 \\ 1120 & 32 \checkmark \\ 2240 & 64 \checkmark \\ \hline 70 + 140 + 280 + 1120 + 2240 = & \boxed{3850} \end{array}$$

We can see in these examples that Egyptian arithmetic trades multiplication in general for doubling (multiplying a number by 2 or adding a number to its self) combined with addition. This means you

might need to do more individual calculations but each one is simpler, this works well with their number system. Here is an example with some fractions.

$13 \times 1\frac{2}{5} = ?$	
$1 + \overline{3} + \overline{15}$	$1\checkmark$
$2 + \overline{3} + \overline{8} + \overline{120}$	2
$5 + \overline{3} + \overline{4} + \overline{60}$	$4\checkmark$
$10 + \overline{3} + \overline{2} + \overline{30}$	$8\checkmark$

$$\begin{aligned}
 (1 + \overline{3} + \overline{15}) + (5 + \overline{3} + \overline{4} + \overline{60}) + (10 + \overline{3} + \overline{2} + \overline{30}) &= (17 + \overline{2} + \overline{3} + \overline{4} + \overline{15} + \overline{30} + \overline{60}) \\
 &= (18 + \overline{10} + \overline{12} + \overline{60}) \\
 &= (18 + \overline{5})
 \end{aligned}$$

This is far more complicated than the calculations we would normally do, but you need to recall that they had an additive notation for their numbers. Given their number system this algorithm makes sense for them.

Reflect on the Egyptian multiplication and check your understanding:

13. When we multiplied 23 by 17 why did we stop doubling when we got to 16?

14. When we multiplied $13 \times 1\frac{2}{5}$ where did the $1 + \overline{3} + \overline{15}$ come from?

15. When we multiplied $13 \times 1\frac{2}{5}$ how did we get that

$$4 \times (1 + \overline{3} + \overline{15}) = 5 + \overline{3} + \overline{4} + \overline{60}?$$

16. Redo the calculation of 35×110 , but this time double the 110 and not the 35.

17. Use the Egyptian multiplication by doubling to calculate 12×15 . (Hint: we can write $12=8+4$, both powers of 2.)

18. Use the Egyptian multiplication by doubling to calculate 25×18 .

19. Use the Egyptian multiplication by doubling to calculate $9 \times 2\frac{2}{3}$.

On a final note, one advantage of Egyptian multiplication is that we can divide using the exact same method. If we want to calculate $22 \div 7$, we rewrite that as $22 \times (1/7)$ or $22 \times \overline{7}$. Then we can use the algorithm we already have.

$\overline{7}$	1
$\overline{4} + \overline{28}$	$2\checkmark$
$\overline{2} + \overline{14}$	$4\checkmark$
$1 + \overline{7}$	8
$2 + \overline{4} + \overline{28}$	$16\checkmark$

So we get a final answer of $3 + \overline{7}$, which is what we would expect if we used our modern algorithm for division to get $22 \div 7$. This nicely highlights that multiplication and division are very closely related operations; in fact they are essentially the same.

4 Moscow Papyrus Problem 6

Now it is your turn to crack the Rosetta Stone. Figure 2 shows the calculations from problem 6 on the Moscow Papyrus which is about finding the dimensions of an enclosed region. You need to carefully compare the English translation to the Egyptian and see if you can answer these questions.¹

Questions:

20. In line 2 the author speaks of *a set and 2 arurae*, this appears to be a measure of area. Reading through the rest of the text how many square units is this equal to?
21. This piece of hieroglyphs uses special symbols for $\bar{4}$ and $\bar{2}$ can you spot them? Looking at the way Egyptian multiplication works why might they have special symbols for these fractions?
22. How can we combine $\bar{2} + \bar{4}$ with 1 to get $1 + \bar{3}$? (Hint: what happens if you multiply $\bar{2} + \bar{4}$ by $1 + \bar{3}$?)
23. Using what you did in section 3, show how multiplying $1 + \bar{3}$ by a set and 2 arurae results in 16. (Hint: you need to answer problem 20 first.)
24. Where in the diagram of hieroglyphics can we see the author multiplying 3 by 4?
25. Now look at all the other computations in the translation and look for them in the hieroglyphics.
26. Which symbols seem to express the words “*you are to*”?
27. Which symbols seem to represent the word “*result*”?
28. Make a note of all the symbols you have found English equivalents for so that you can use them as reference for the next problem.

English Translation of Problem 6:

1. Example of calculating an enclosure.
2. If you are told : An enclosure of a set and 2 arurae, the breadth having $(\bar{2} + \bar{4})$ of the length:
3. You are to treat $(\bar{2} + \bar{4})$ so as to find 1; the result is $1 + \bar{3}$.
4. [You are to take] this [12] which is in a set and 2 arurae $1 + \bar{3}$ [times]; result 16.
5. You are to calculate its square root; result 4-for the length, and the breadth has $(\bar{2} + \bar{4})$ of it, namely 3.
6. The correct procedure:

$$\begin{array}{|c|} \hline 4 \\ \hline 12 \\ \hline \end{array} 3 \qquad \begin{array}{l|l} 4 & 1\checkmark \\ 8 & 2\checkmark \end{array}$$

¹This material on the Moscow Papyrus is from “Four Geometrical Problems from the Moscow Mathematical Papyrus” by Gunn and Peet in The Journal of Egyptian Archaeology, Vol. 15, No. 3/4 (Nov., 1929), pp. 167-185, available at <https://www.jstor.org/stable/3854111>

PROBLEM No 6.

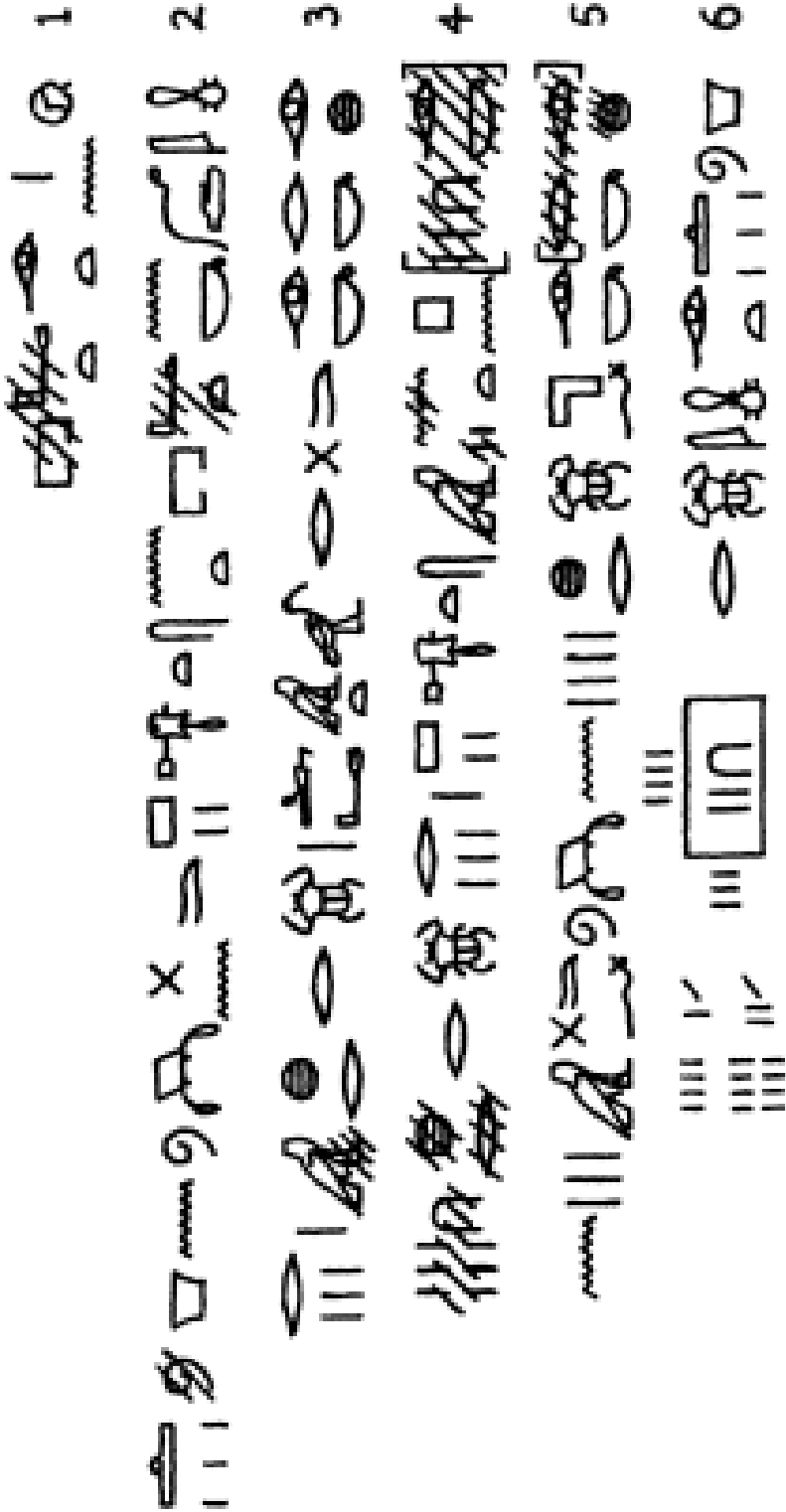


Figure 2: Moscow Papyrus Problem 6

5 Moscow Papyrus Problem 14

Repeat what you did above in section 4 with this more complicated example. Figure 3 shows the calculations from Problem 14 of the Moscow Papyrus for the volume of a truncated pyramid. Compare the English translation with the figure and try to answer these questions.

Questions:

29. In the last exercise you found symbols or groups of symbols for the phrase “you are to” and the word “result.” Use this knowledge to break up the translated paragraph into rows that roughly match the hieroglyphics.
30. Where in the hieroglyphics does the author give the dimensions 6, 4, and 2?
31. What symbol or symbols are used in different places in the hieroglyphics to represent squaring as in “square 4 to get 16.”
32. Where is the author calculating 4×2 ?
33. What might be the symbol for a sum?
34. Where on the diagram does the author write that $\bar{3}$ of 6 is 2?
35. Where is the author calculating 28×2 ?
36. In the final write up of your work for this problem and the last, try and include a little glossary of the symbols you translated.

English Translation of Problem 14:

“If you are told: A truncated pyramid of 6 for the vertical height by 4 on the base by 2 on the top: You are to square the 4; result 16. You are to double 4; result 8. You are to square this 2; result 4. You are to add the 16 and the 8 and the 4; result 28. You are to take $\bar{3}$ of 6; result 2. You are to take 28 twice; result 56. See, it is of 56. You will find [it] right.”

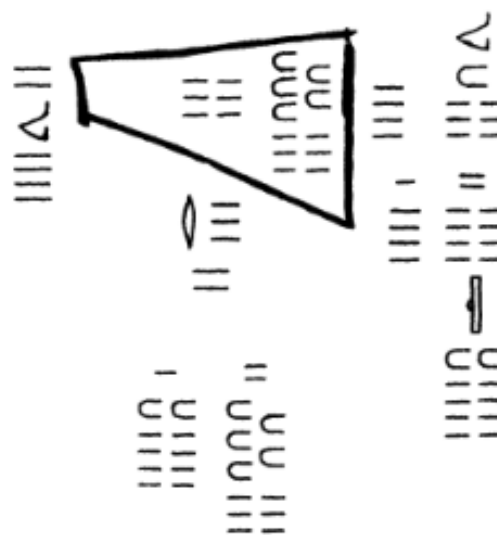
 PROBLEM No 14.


Figure 3: Moscow Papyrus Problem 14













Typing Hieroglyphs Appendix

If you are doing work with hieroglyphics and need to insert them in a document here are some ways to do that.

In L^AT_EX:

If you are using L^AT_EX to type up your work you can use the `\usepackage{hieroglf}` to typeset symbols. For example:

Some Numbers

	<code>\centering</code>
	<code>\textpmhg{\Hone}\\</code>
	<code>\textpmhg{\Hten}\\</code>
	<code>\textpmhg{\Hhundred}\\</code>
	<code>\textpmhg{\Hthousand}\\</code>
	<code>\textpmhg{\HXthousand}\\</code>
	<code>\textpmhg{\HCthousand}\\</code>
	<code>\textpmhg{\Hmillion}\\</code>
	<code>\textpmhg{\Hone-\Hone-\Hten-\Hten}</code>
	<code>\textpmhg{\Hthousand-\Hthousand}\\</code>
	<code>\pmglyph{\Hr:\textpmhg{\Hone-\Hone-\Hten}}\\</code>
	<code>\reflectbox{\pmglyph{\HM}}</code>

You can find lots of examples and tables of symbols here


<https://ctan.math.illinois.edu/fonts/archaic/hieroglf/trypmhg.pdf>

And the full documentation for the package here:

<https://mirror.las.iastate.edu/tex-archive/fonts/archaic/hieroglf/hieroglf.pdf>


You can also use the Aegyptus font by adding

```
\usepackage{fontspec}
\newfontfamily\Aegypt{\Aegyptus}
```

to your header and then you can type things like  by typing `{\Aegypt \symbol{"131A3}}`, where 131A3 is the unicode number for the beetle. You can google for the codes you want or visit

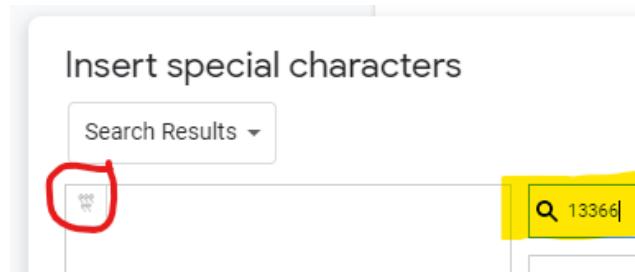
<https://unicode-explorer.com/b/13000>.

As Graphics:

One way to insert hieroglyphics is to copy and past images into your file. This is a little sloppy looking and tedious but also simple. You can either Google the image you want, or use the a snipping/screen capture tool like Microsoft's Snipping Tool App (). Or you can go to a website like the [Hieroglyphic Typewriter](#) where you can use the virtual typewriter to find the symbol you want and then right click on it to copy and paste it into you document.

In Google Docs:

You can insert Hieroglyphs in Google Docs by following the directions here [How to add hieroglyphs to Google Docs and Slides](#). This is a little tedious but they will have what you need. One way to speed this up is to find the character you need here [Egyptian Unicode Block](#), then you can use the characters number code while inserting a special character by searching using that code and then double clicking on the image.



In Microsoft Word:

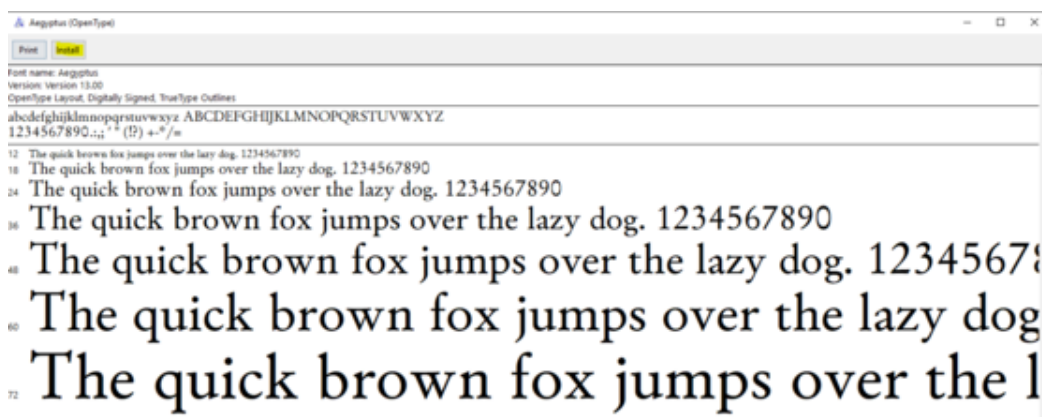
Microsoft Word can insert symbols in the same way as Google Docs once you install the fonts. Here are directions for getting the fonts installed. Click on the link:

<https://localfonts.eu/freetools/greek-free-fonts/unicode-fonts-for-ancient-scripts/aegyptus/>

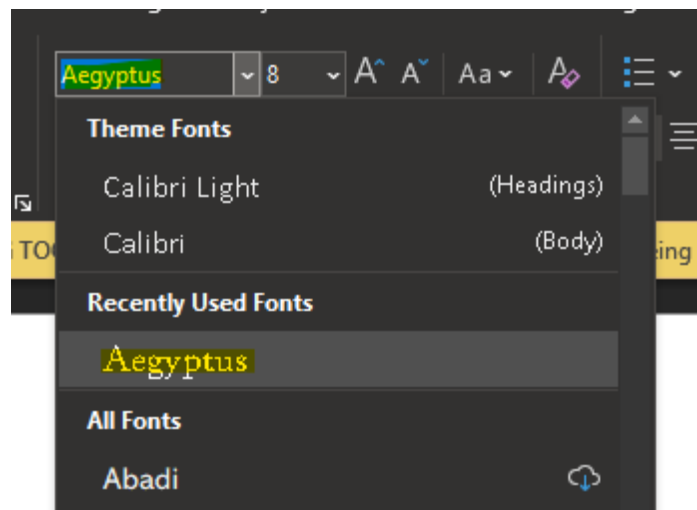
and go down the page and click the link labeled *Aegyptus Google Drive*, you will then need to download a zip file on your computer which you can then extract by double clicking on it. After extracting the file, you will need to click and run these two files:

Aegyptus.ods	OpenDocument Spreadsh...	394 KB	No
Aegyptus.odt	OpenDocument Text	1,185 KB	No
Aegyptus.otf	OpenType font file	4,474 KB	No
Aegyptus.pdf	Adobe Acrobat Document	821 KB	No
AegyptusBold.otf	OpenType font file	4,108 KB	No

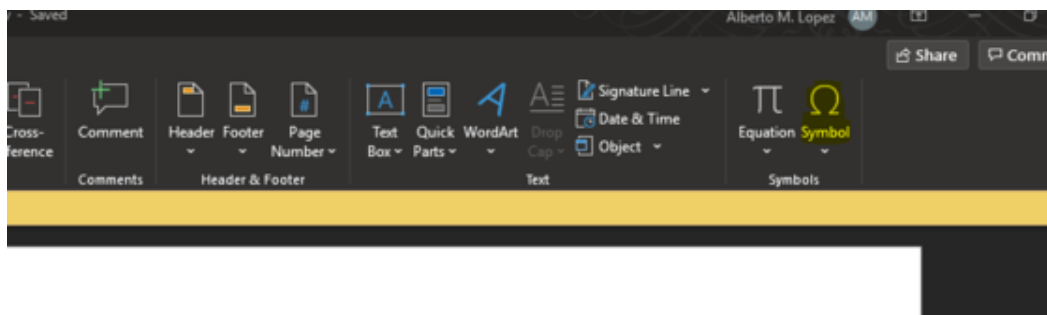
Click Install for both files:



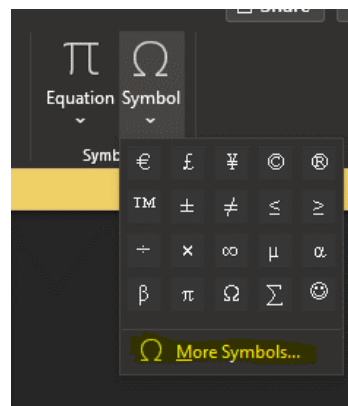
This will install a new font on your computer that's called Aegyptus. Once the font is installed, you can open up Microsoft Word and search for the font:



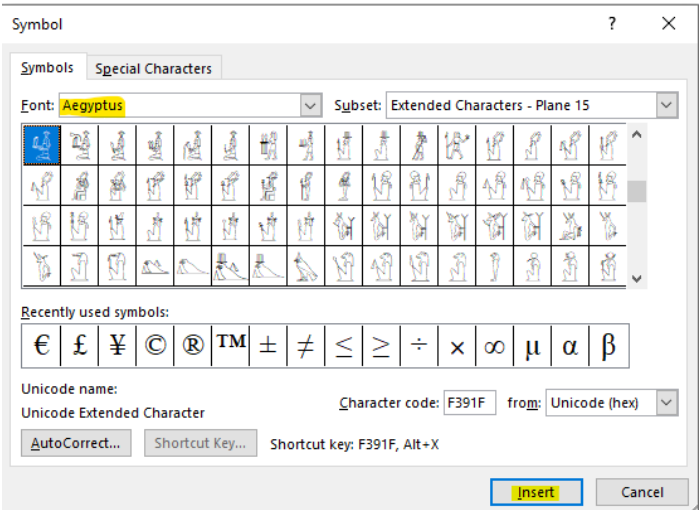
To view the hieroglyphs, click the Symbol icon (probably in the insert ribbon):



Click More Symbols:



Choose Aegyptus as the font and Extended Characters as the subset, then click the hieroglyph you wish to insert:



You can also now use the unicode numbers mentioned above. In Microsoft Word you can insert unicode characters by typing the hex value of the character, e.g. U+13366 then typing Alt-x:



To help you find the numbers quickly here are the unicode numbers for some basic symbols:

1	ı	U+133FA
10	ŋ	U+13386
100	Œ	U+13362
1,000	℥	U+131BC
10,000	ℳ	U+130AD
100,000	℔	U+13190
1,000,000	℥	U+13068
Fraction Symbol	℔	U+1308B
Two Thirds Symbol	℔	U+1308C

Table 2: Quick Number Reference with Unicode

It is useful to notice that the Œ symbol is U+13362 and looking at the unicode chart if I want six of those you can type the code U+13367 and press Alt+x to get ŒŒŒŒŒŒ.