The Egypt Centre
Y Ganolfan Eifftaidd

Mathematics exhibition

Photograph: Kenneth Griffin

Pharaohs' Formulae

Maths is fun done the Egyptian way

Egyptian numerals

One of the oldest known numeral systems was devised by the ancient Egyptians. They used hieroglyphs to represent numbers that used the base of 10 as we do today.

Units are shown as a single stroke

10's are shown as a cattle hobble

100's are shown as a coil of rope

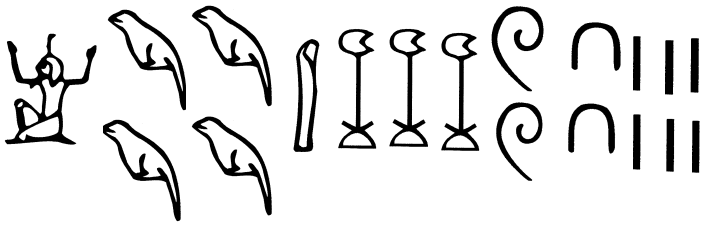
1000's are shown as a lotus flower

10,000's are shown as a finger

100,000's are shown as a tadpole

1000,000's are shown as a god with upraised arms

1,413,226 was written



Try writing your age or telephone number. How many symbols did you need?

Design your own numeral system using pictures. Write a key explaining the value of each symbol and ask a friend to write the number of their house using your number system!

Addition and Subtraction

The ancient Egyptians kept careful records of dates, measurements and accounts.

The sign for addition was a pair of legs walking forward 

 The sign for subtraction was a pair of legs walking backwards

Try these 4 sums writing the answer in Egyptian numerals

35
27

47
35

Swap sums with a friend!

After the numerals the Egyptians used a picture of the object they were counting.


123 cattle


102 birds


12 Jars of beer

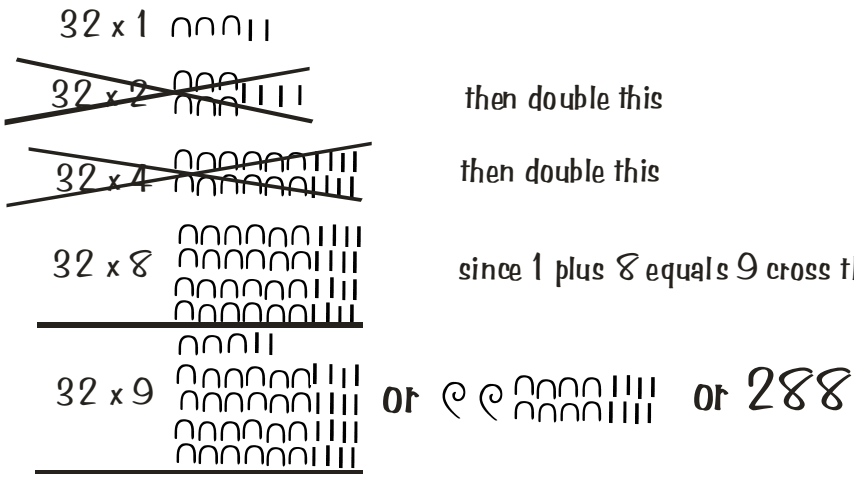

120 Loaves of bread

Count different objects around the classroom, write the number in hieroglyphs and don't forget to draw a picture of what you are counting!

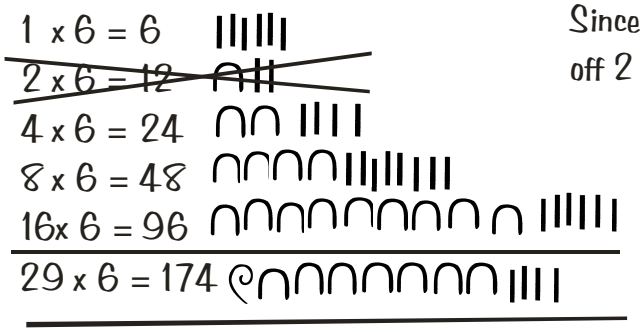
Multiplication and division

The ancient Egyptians only needed to learn their two times tables because all multiplication was done by 'DOUBLING'

For example 32 x 9
would be written:



The ancient Egyptians realised division is closely linked with multiplication and used the same system of 'DOUBLING.' To divide 174 by 6 they would ask themselves what they must multiply 6 by to get 174.



Since 96 + 47 + 24 + 6 = 174 cross off 2 x 6

The answer is 29

Try these sums using the Egyptian method

13 x 5

56 ÷ 8

Fractions

The ancient Egyptians used special symbols for fractions they used in their daily life. The word  meaning 'part' was used to denote unit fractions.

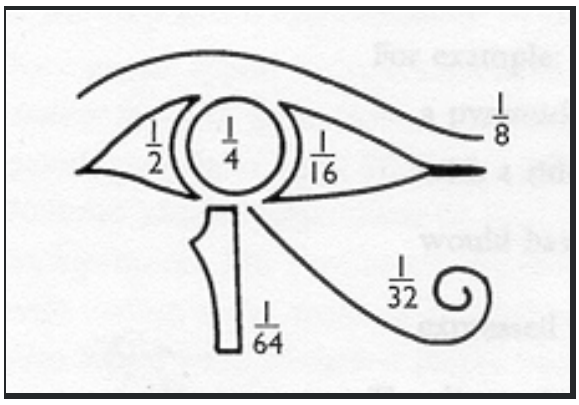
For example $\frac{1}{20}$ was written  An exception was $\frac{2}{3}$ which was written 

Because the Egyptians used almost exclusively unit fractions they would not say 2/5 of my cattle have died, they would say 1/3 and 1/15 of my cattle died

How would the Egyptians write 2/7?

fractions used for measuring volume

The official Egyptian measure for corn was the 'hekat.' Smaller measures were in certain fractions of a 'hekat' and were written in a symbol called the EYE OF HORUS.

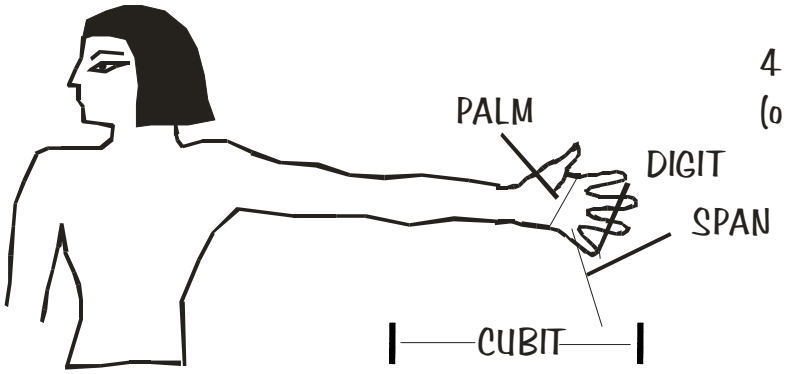


The parts of the Eye of Horus and their associated fraction values. Do they add up to 1 'hekat'?

Write 1/16 +1/4 +1/32 =? using the parts of the Eye of Horus

Measurement

Length was measured in: CUBITS, the length of your forearm; a SPAN, the length from thumb to little finger of an out-stretched hand; a PALM, the width of the palm, and a DIGIT, the width of a finger.



4 digits = 1 palm, 7 palm (or 28 digits) = 1 cubit

The Egyptians used a knotted rope to indicate the agreed length of a cubit.
The ROYAL CUBIT (52.4cm) was used the most but the SHORT CUBIT(44.9cm) was also used.

Craftsmen used a grid using the short cubit length to lay out their drawing. Try drawing a picture on centimetre square paper than transport it to a grid using a cubit based on the length of your arm. How does it compare with a friends?

A distance of 100 cubits was called a KHET. The common unit for measuring area was the SETAT or square KHET. Calculate the area of your school grounds in SETATS

Mass

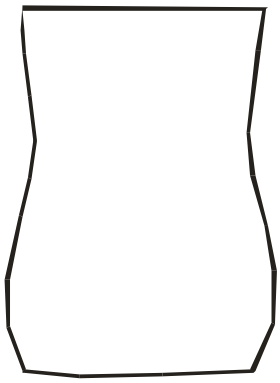
Ancient Egyptians used weighing scales and weights made of stone, pottery and bronze. Many weights are in the shape of an animal. Weights were made in units called DEBENS (about 93 grams). After 1795BC the KITE (9-10g) was used.

ACTIVITY:
Make two clay weights of different animal shapes representing a deben and kite. Weigh 5 objects using your weights in a balance scale and record their weight.

Weigh yourself! How many DEBENS or Kite do you weigh?

Capacity

To measure capacity the Egyptians used the HIN (0.47L) 10 HINW (plural for HIN) equals 1 HEKAT (4.7L) and 160 HINW or 16 HEKAT equals 1 KHAR (meaning sack).

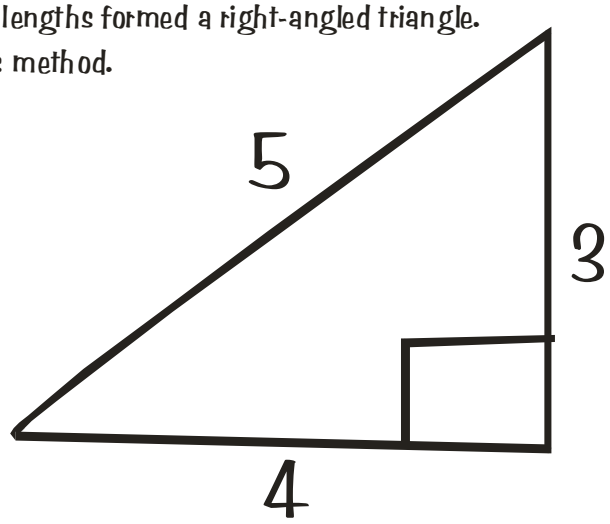


Jugs have been found inscribed with their capacity in HIN.
If this vessel holds 3HEKAT put a mark to show
2 HEKAT AND 5 HINW.

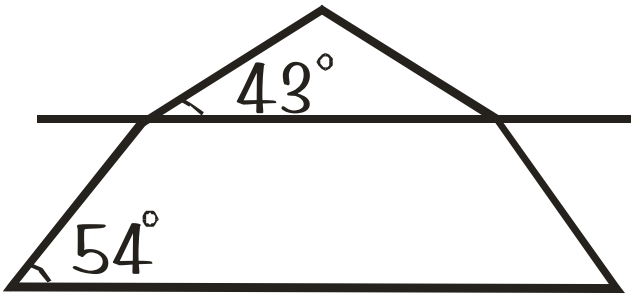
Geometry

The Egyptians built square-based pyramids, with an apex directly above the centre of the square, with a north-south- east-west orientation. This was achieved by finding the direction of a shadow cast by the noon-day sun using a vertical pole in the sand. Using multi-link blocks to make a pyramid 7 blocks square. How many blocks did you need?

A perfect square was marked out using ropes measuring 3, 4 and 5 units long. The Egyptians realised that these three lengths formed a right-angled triangle.
Mark out a perfect square using this method.



This is a drawing of Snofru's Bent Pyramid. Why do you think it was made this way?
To make the pyramid taller on the same size base what would you need to do?



Draw Snofru's pyramid with accurate angle measurements.

Volume

The volume of a cylinder was found using almost the same method we use today. I.E. VOLUME = Area of cross-section (a circle) X height. One formula the Egyptians used to calculate the area of a circle was: AREA = (diameter + (1/9) diameter)^2

So a cylinder with a diameter of 9 cubits and a height of 10 cubits would have a volume of:

VOLUME= (9-(1/9) X9)^2 X 10 = (9-1)^{2}X 10 = 8^2X 10 = 64 X 10 = 640 cubits^3

The modern calculation would be:

VOLUME = $\pi r^2 h = \pi$ X 4.5^2 X 10 = 635 cubits^3

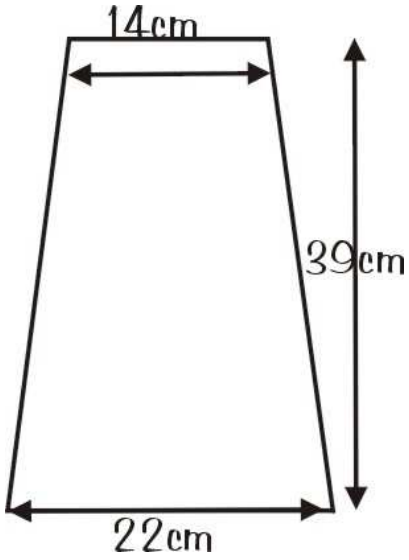
The Egyptian approximation for π was 3.16, which is remarkably close to the actual value.

Using the modern and Egyptian methods, work out the volume of a cylinder pot with a diameter of 16cm and a height of 31cm. How close are the two answers?

The Egyptians knew how to calculate the volume of a truncated pyramid using the formula

$1/3 \times h \times (\alpha^2 + \alpha\beta + \beta^2)$

α = lower base width
β = upper base width
h = height



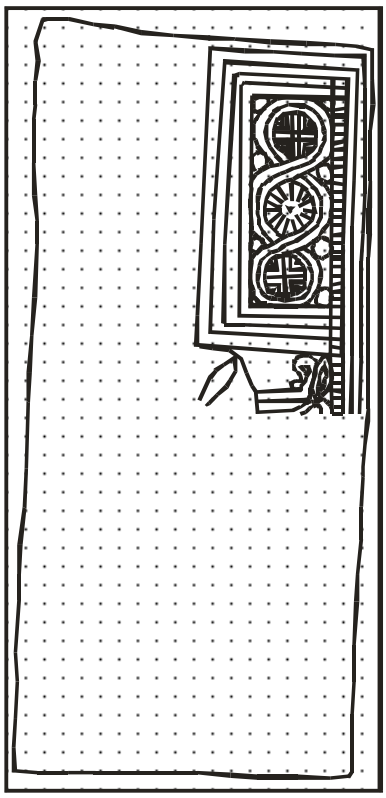
Using this formula calculate the volume of a truncated pyramid with the dimensions:: height 39cm, lower base width 22cm upper base width 14cm.

Symmetry

Many objects are symmetrical because the Egyptians liked their world balanced and ordered. Look at the Coptic Stela how many lines of symmetry are there?

What is the order of rotation for the stela?

Design your own symmetrical stela. Ask a friend to work out the lines of symmetry and order of rotation.

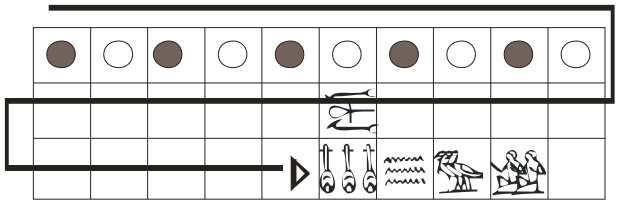


If you only draw a quarter of your stela can your friend work out the remaining design?

Games

The most popular game was the board game called SENET where two players had an equal number of pieces to race off the board. We do not know exactly how senet was played.

Starting position with direction of play.



This is one possible version

Throw the die to move. Each roll of the die moves only one piece. The aim is to be the first player to play all their pieces off the 3rd row. Before any player can play a piece off the board all players must be off the 1st row. A throw of '5' is ignored and the player throws again.

A player can 'capture' an opponent's piece by landing on it. In this case the captured piece is placed from where the 'victor' started. However, two pieces of the same colour together in a row protect each other and neither can be 'captured'.

Three pieces the same colour together in a row make a 'wall 'for the player and stops their opponent passing until the wall is disbanded. If a player cannot move forward they must move their piece backwards. A throw of '2' or '3' ends a player's turn and is the last move for that turn. What is the probability of this happening?

These are 'protected' squares that stop a piece being captured. 

This is a 'water trap'  If a piece lands on this square the piece is moved back to 

If this square is occupied the piece moves backwards to the next available square.

The ancient Egyptians would have used 4 'throw sticks' decorated on one side only. Sticks that landed decorated side up were counted as one. Make your own senet game and hold a senet tournament using throw sticks instead of die.

Time

The Egyptians observed the Nile and the Moon and divided the year into 12 months and 3 seasons. AKHET was the season when the Nile flooded, PERET was the spring season and SHEMU was the harvest season. Each season consisted of 4 months of 30 days totalling 360 days. 5 days were added to celebrate major gods making a total of 365 days in the year.

Draw out a calendar using these divisions.

The Egyptians were the first to divide day and night into 12 hours each. Time was measured by observing the position of the sun and the stars. During the day time could be measured using a sun-dial. A vertical pole was pushed into the sand or a shadow clock was used. The shadow clock has a sloping surface that the shadow was cast on with scales for the variation in each month.

How many degrees did the shadow move in 6 hours?

The Egyptians also used a water clock, which was a water-filled vessel with a hole in the base through which the water drained away.

Try making a shadow and water clock marking hour divisions on each.