5. All in the air

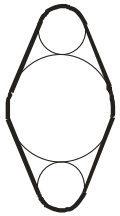
The earliest known depictions of juggling are in carvings from Ancient Egypt. They seem to show people juggling with balls and other objects.

Suppose you are juggling 5 balls at four throws per second, with all the balls going to the same height. Also suppose your hands are full 70% of the time. How high must you throw the balls?
(Assume g=9.8 m/s^2)

6. Prime defence

Ahmose was not the strongest of all his tribe but he was clever and he was Thutmose's champion.
He had to fight Shaustatar, the mightiest warrior of the Mitannians, who had challenged Thutmose. Ahmose had the legendary shield, the Aegis of Neith, for protection. It had been crafted in the dim and distant past and was made up of a number of different pieces of wood all of different sizes.
The Aegis had a magical quality as the areas of the individual pieces formed a consecutive sequence of prime numbers with a total area of less than 1000 units.

The fight began and Shaustatar's first stroke was so mighty that pieces representing half the area of the Aegis fell to the ground. A second stroke caused half the remaining area to fall. A third stroke similarly caused half the remaining area to fall. A fourth blow caused three quarters of the remaining area to fall. Now Ahmose only had a single piece of his shield remaining but Shaustatar was tiring so Ahmose rushed in and dispatched him with a single blow.
What was the size of the last piece of shield and
what were the areas that fell to the ground with each blow?



7. Triad Trophy

Thutmose asked for a special trophy to be made for Ahmose. It was to be made from three circular discs of silver. The central disc was of radius 9cm and the other two were of radius 4cm. The three discs were to be surrounded by a gold band of width 1cm.
What was the length of the gold band?

The competition is promoted by Liverpool Mathematical Society (LivMS) www.livmathssoc.org.uk
The Liverpool Mathematical Society incorporates the Liverpool Branch of the MA and the ATM.
The competition is sponsored by the Worshipful Company of Actuaries Charitable Trust

WORSHIPFUL COMPANY OF ACTUARIES
CHARITY • CITY • COMMUNITY

Open Challenge '23
For Year 13 or below

Rules

It should be attempted at home during February half term.
Your entry must be your own work.
For individual entries only. You should attempt all questions.
Entries without any working out at all or written on this sheet will not be marked.
It is possible to win a prize even if you have not completed all of the questions, so hand in your entry even if it is not quite finished.
You must print your name, date of birth and school in neat, legible writing on the front sheet.
Pupils under 15 years of age should only attempt this in exceptional circumstances.

Either you or your maths teacher needs to **return your entry by 10 March** to this address:

Open Challenge '23 Entries
Mrs A. Carter
Danes Court
Mudhouse Lane
Burton
Neston
CH64 5TS

An evening of online activities will be held in early May during which there will be a virtual prizegiving. Prizes and certificates **will be posted** to schools and colleges.
Solutions will be posted on www.livmathssoc.org.uk shortly afterwards.
We hope that you enjoy the questions.

1. Count me in

Between 2362 BC and 2312 BC the population of Memphis increased by 30 000. Dividing up the population into adults and children, and males and females, the following information can be given about the number of men, women, boys and girls.

In 2362 the census showed that 60% of the people were males. There were half as many boys as females and for every four boys there were three girls.
In the 2312 census, 25% of the total were children. The number of adults was five times the number of boys, and there were as many women as males.
The number of children now equalled the number of females in 2362.
How many women were there in 2362, and how many in 2312?

2. On your marks

Every year the people of Hyksos compete in teams for the Avaris Cup. Each team has two members who compete together by running and chariot riding over the course, which is 4 *iter* long (42 km). Here are some of the rules for the race:

- Each team starts together at the start line.
- Each team of two is allowed only one chariot. Only one team member may ride the chariot at any time. (This usually means that one member rides the chariot at the start, dismounts the chariot at some point on the course, and then runs to the finish line. The other team member starts by running. When he or she reaches the chariot, they mount it and ride to the finish line.)
- Both team members have to cross the finish line.
- The time recorded for a team is the time for the second member to cross the finish line, or the time for both members if they cross the line together.

The table shows the steady running and chariot speeds, all in km/h, for three teams. Assume that these are the speeds for the team members in the actual 42 km race.

Which team won the Avaris Cup?

Team	Members	Running	Riding
A	Tahl	12	28
	Julah	12	28
B	Ronkol	16	35
	Rena	10	15
C	Undina	10	35
	Hanak	14	25

3. Date the Dynasty

After the defeat of Psusennes, the calendar of Egypt was restarted, with the first year of King Osorkon's reign becoming the new Year 1. Osorkon ruled for 33 years and was succeeded by his son. Another Osorkon was also succeeded by his own son, but himself followed his own brother, and ruled for 23 years.

One king Takelot succeeded his own brother and reigned for 8 years, and the other followed his own father and reigned for 3 years, but they were both succeeded by their own brothers. King Harsiese succeeded his own father, and was followed by a Takelot after a reign of 14 years. Even with this repetition of names, no two brothers bore the same name, of course. One king Shosenq ruled for 11 years after his brother, and was succeeded by another Shosenq. A Shosenq also succeeded the Shosenq who reigned for 17 years after his own father. The Shosenq who followed his own brother's son enjoyed a reign of 23 years, and was succeeded by his own brother. The current king is also a Shosenq, and he succeeded his own father.
What are the dates of these nine kings?

4. Jumping to conclusions

As part of the celebrations for the coronation of Ramesses II, a female gymnastics competition was held. Once it had finished the judges retired to decide the scores. While they were waiting, each woman made two statements about how they thought the contest had gone:

Abar said: Beketaten was first; Dendera was last
Beketaten said: I was second; Abar was third
Chione said: I was third; Dendera was fourth
Dendera said: Beketaten was third; Abar was fourth
Edjo said: I was first; Chione was last.

The results were finally announced, and two facts were discovered.
First, there were no ties, and second, to everyone's surprise it turned out that each woman had made one **true** statement and one **false** statement (not necessarily in that order).

(a) One woman made statements that prove that Beketaten was not third. Who was she? In a sentence or two give a brief reason for your answer.
(b) Who was fourth? In a sentence or two give a brief reason
(c) Who was last? In a sentence or two give a brief reason for your answer.
(d) Write down, in order from first to last, the placing of the five women.
(In this part of the question you do not have to give a reason for your answer.)