MATHEMATICAL EDUCATION
ON MERSEYSIDE

Sponsored by

Challenge ’19

Year 8 or below

Illustrations by Will Ashworth and Theo Chaddock

Rules

1) Challenge ’19 should be attempted at home during February half term.
2) Your entry must be your own work, though of course you may ask for help on how to get started or for the meanings of unfamiliar words.
3) Entries without any working out at all or written on this sheet **will not be marked**.
4) It is possible to win a prize or certificate even if you have not completed all of the questions, so hand in your entry even if it is not quite finished.
5) Please make sure that you staple your pages together and you must write **your name and school neatly on every page.**

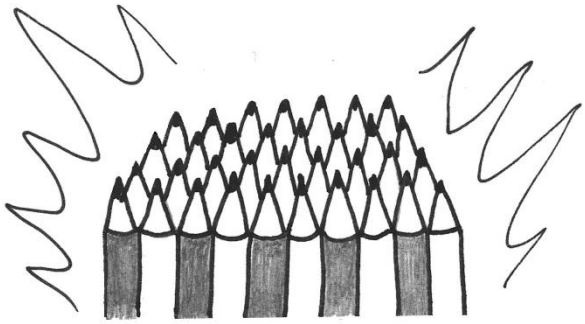
Either you or your maths teacher needs to return your entry by 8th March to this address:

Challenge ’19 Entries,
Chris Marchant,
Department of Mathematical Sciences,
University of Liverpool,
Peach Street,
Liverpool,
L69 7ZL

A Prize-Giving Evening will be held at the University of Liverpool on 15th May.
We hope that you enjoy the questions.

1. Pencil Problem

Graphite is one of three forms of pure carbon, along with diamond and Buckminster-fullerene. Graphite is principally used in pencils. Ken has a bundle of hexagonal pencils arranged as a regular hexagonal array. There are 18 pencils in total around the edges of the hexagonal array. How many pencils are in the bundle all together? The outside surface of each individual hexagonal pencil is painted with one of a selection of colours. The Marketing Department require that when packed in bundles, touching pencils be of different colours. What is the minimum number of colours required to be used to satisfy this requirement?



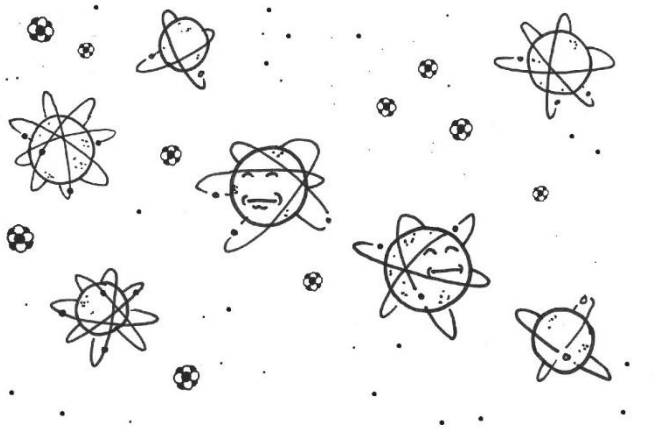
(Pencils waiting to be bundled)

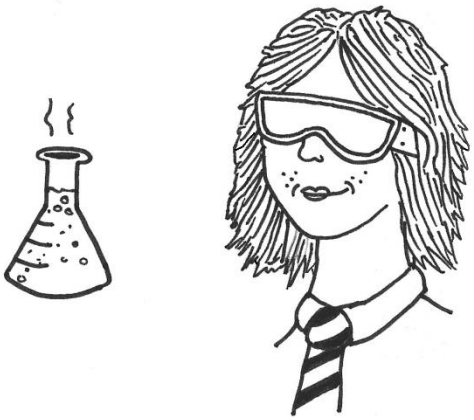
2. Luke's Light Lunch

Chris wants to know what Luke is having for lunch. Luke, being periodically difficult, replies with, "Crack this code: 22,7,39 / 29,4,16 / 8,9 / 75,13 / 6, 2, 99, 99 / 8, 7 / 5, 92, 7, 16 / 74, 53, 90 / 91, 52."

3. Three in a Row

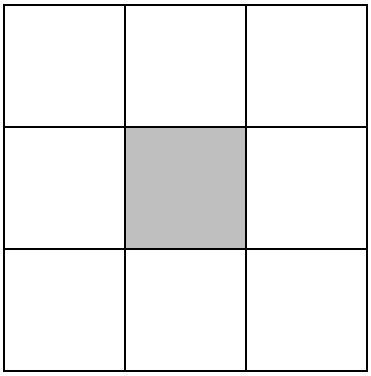
The atomic number of an element is the number of protons in its nucleus. A particular 3 elements in the Periodic Table have atomic numbers adding up to 42. The atomic number of the second element is 2 higher than the first and the third is 2 higher than the second. Identify these elements by name.





4. Find the Solution

Cate needs a solution of iodine to contain 95% pure water. She has 700ml in her conical flask and her tests show that only 630ml of the solution is pure water. How much water does she need to add to ensure her solution is suitable?

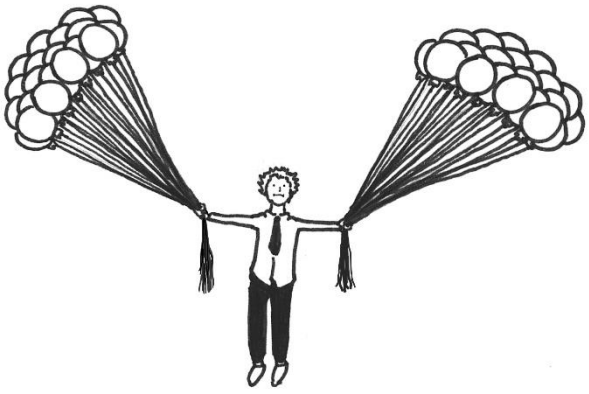


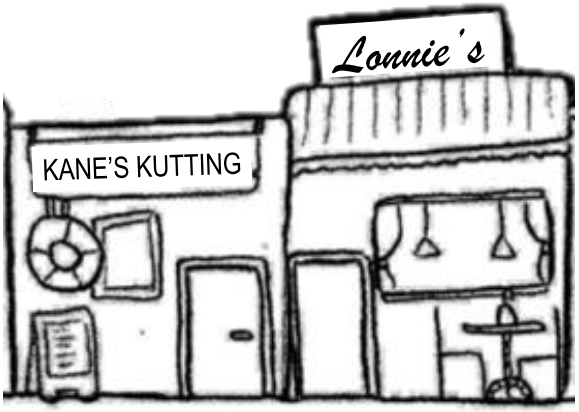
5. A Mercury Switch

Mercury is a highly toxic liquid metal and is traditionally used in thermometers and in movement sensors. Peter has two types of racks, each with a different number of slots which he uses to hold his vials of mercury. Peter's lab consists of 8 tables arranged as a square with space in the middle. On Monday, Peter had a total of 41 vials, Peter places one test tube rack on each of his tables. Being very particular, Peter insists that there be a total of 15 vials on each side of his lab. How many vials could his racks hold? How did he arrange the racks in his lab?

6. Up, Up and Away

Chloe and Libby want to tie Ryan to a bunch of approximately spherical helium balloons of diameter 0.3m. The volume of each balloon can be approximated using the formula $4r^3$. Given that 1 litre of helium can lift 1g, and that Ryan weighs 5 stone and 5lb, estimate how many balloons they need to make him float.





7. Wire Cutters

Copper is a ductile metallic element, used to make wire. Lonnie's Hardware supplies wire only in particular lengths, all of which are positive powers of 2 feet long; that is, 2, 4, 8, 16, 32 feet, etc.

Kane's old-fashioned machine will cut yards of wire from a length. Pieces resulting from a cut may either both be used, or else one will go to waste. Show how he can make pieces of copper wire whose lengths in feet are one of each of the whole numbers from 1 to 20 inclusive, while minimising the amount of wastage.

MEM is proud to acknowledge generous financial support from the following during the past year:

The University of Liverpool
Liverpool Hope University
Liverpool John Moores University
Mercer Limited
The P H Holt Foundation
Liverpool Mathematical Society

The competition is promoted by

Mathematical Education on Merseyside (MEM)
Registered Charity No 517028,
Department of Mathematical Sciences,
University of Liverpool,
Peach Street,
Liverpool,
L69 7ZL