



Because maths matters!

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Because maths matters!

Writing stimulating maths problems for GCSE students

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In each of these calculations, the decimal point has been missed out of every number on the left hand side. a , b , c , d , e and f are all positive whole numbers.

Find the values of a , b , c , d , e and f and write out each calculation correctly.

1. $321 + 480 + 799 = a^2$
2. $144 + 426 + 634 = b^2$
3. $325 + 257 + 705 = c^2$
4. $527 + 893 + 348 = d^2$
5. $471 + 989 + 701 = e^2$
6. $985 + 612 + 995 = f^2$

Starter questions

For each question consider if it is a good problem?

Why do you think it is/isn't?

Question 1

$$\frac{\blacksquare}{5} + \frac{\blacksquare}{\blacksquare} = \frac{7}{10}$$

How many ways can you find to make $\frac{7}{10}$ by replacing the $\blacksquare$'s with positive whole numbers from 1 to 10 (you can use numbers more than once if you wish).

Question 2

How many ways can you make exactly 4.8×10^6 by multiplying two positive numbers together?

Question 3

The first term of a *linear* sequence is 5. The sequence also includes the term 25 somewhere in it.

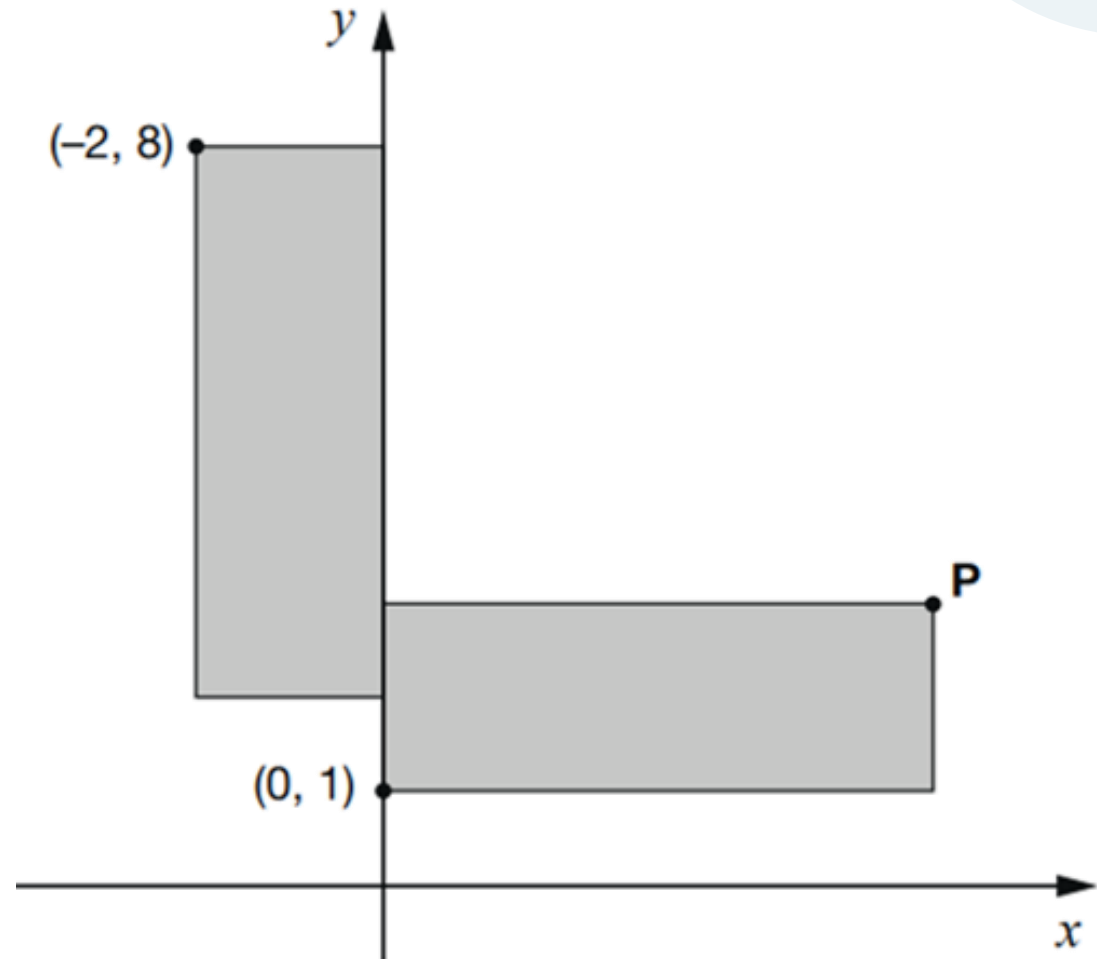
The n^{th} term of the sequence is given by $an + b$ where a and b are whole numbers. How many possible values of a and b can you find?

Question 4

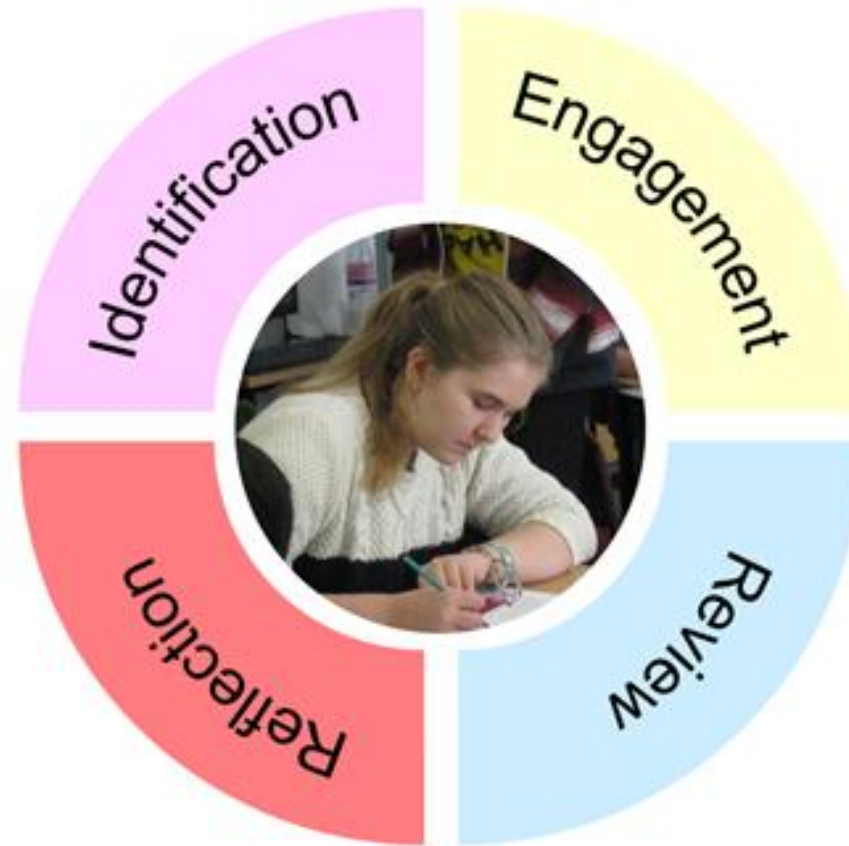
These two rectangles are congruent.

The length of each rectangle is **three times** its width.

What are the coordinates of point P?



Our four stages of problem solving



Applying our four stages

The reflection stage

Go back through the problems – try to reflect “what’s the point?” (of each problem)

Feedback for each problem

- What about it is good?
- Areas for discussion from the problem
- Areas for understanding
- Anything we can squeeze out of the problem



Characteristics of a good problem

Engages students, piques their interest...

Has more than one approach

Not an example of a normal maths exercise

Has low enough floor that the maths isn't a barrier

Has a high ceiling and can be extended

Leads to deep discussion

Allows for deeper understanding of a mathematical concept

Solvable with what they know or leads to discussion which extends their knowledge



Writing a good problem

What I do when I need to write a problem (or a set of problems)

- Look for inspiration
- Consider the background knowledge of the target audience
- Think about the key relationships in the mathematics to be used
- Try lots of things out – efficiently if I can
- Think “is there something I want the students to be able to see?”
- Consider the reflection stage that follows solving the problem



Inspiration

Textbook or exam questions

- Anchors the required knowledge
- Initially ask myself “What can I change?” or “What if?”
- Is there an underlying generalisation I can bring out?
- Can numbers be removed?
- Can it be successfully changed: closed question → open problem?
- Is there a discovery to be made?
- Is there something else I could write that is based on but different to this?

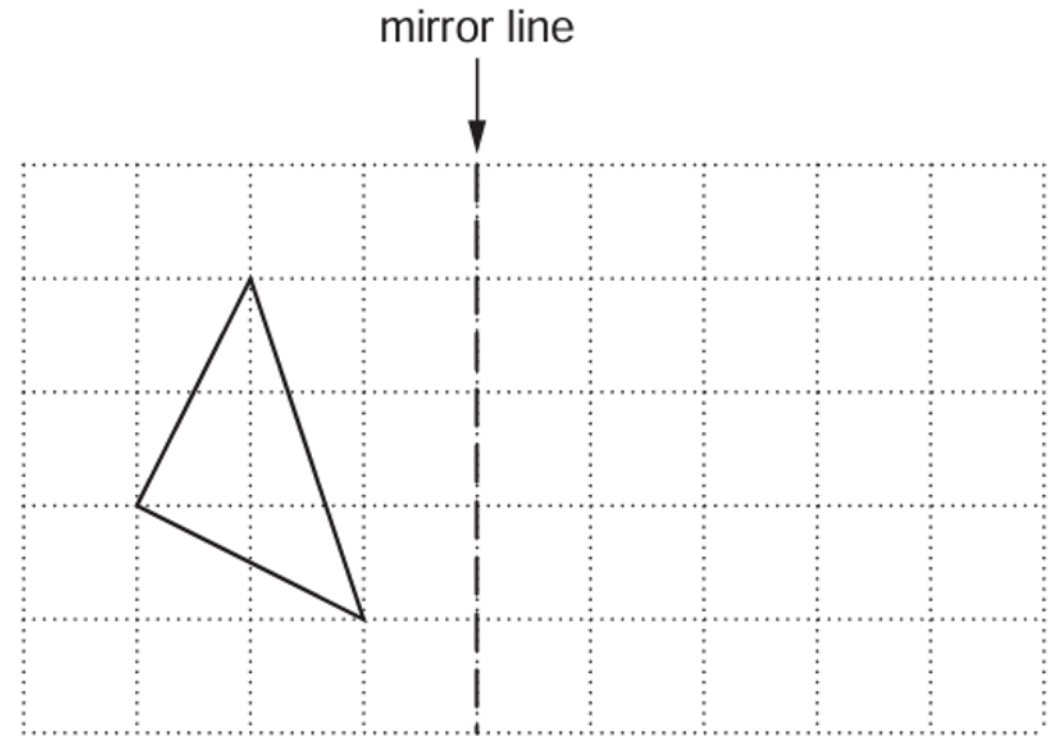


Original question

OCR 2024 Foundation Paper 2

Reflect the triangle in the mirror line

2 marks



As a foundation problem

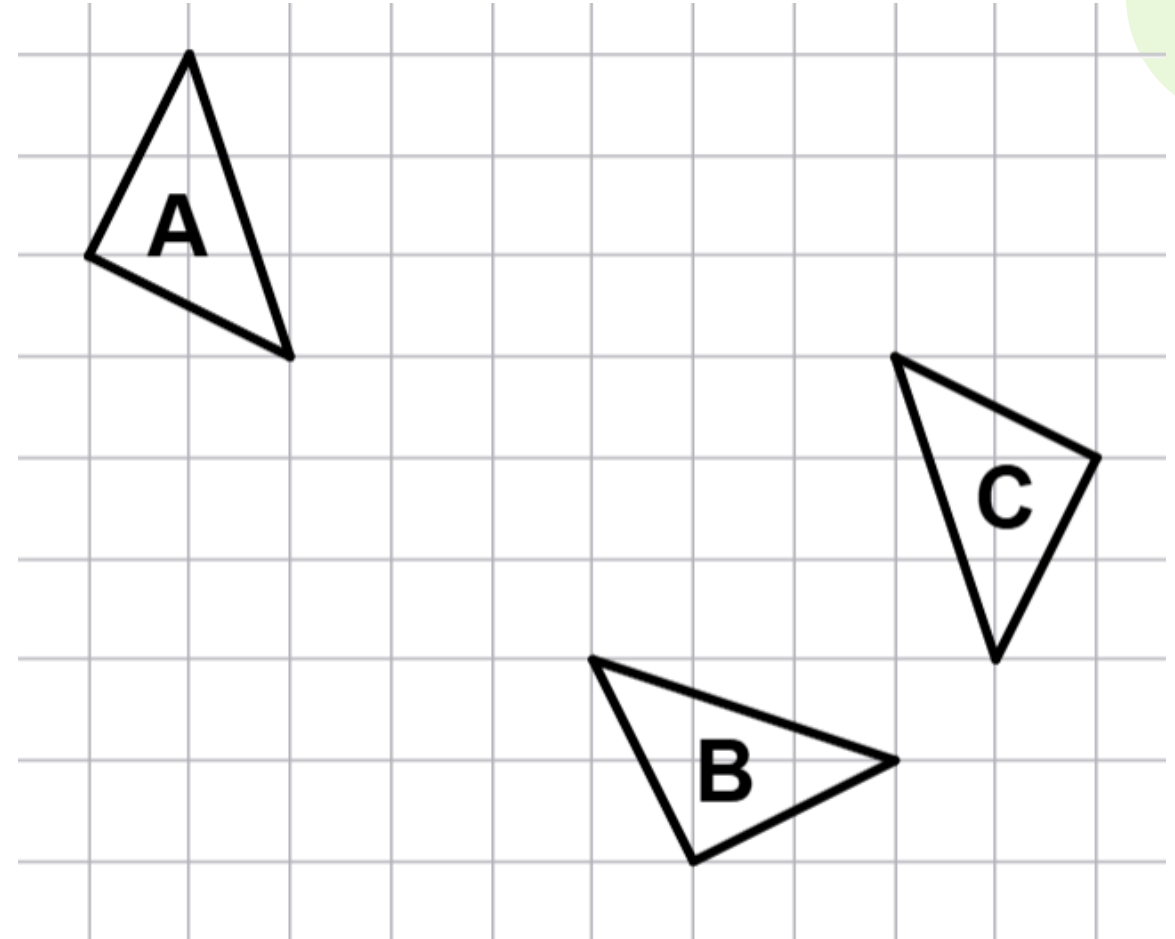
The diagram shows a shape, A and its reflection B in a mirror line.

It also shows shape C which is a reflection of B, in a different mirror line.

Draw the two mirror lines on the diagram.

C is a 180° rotation of A.

Where is the centre of rotation?



As a harder higher problem

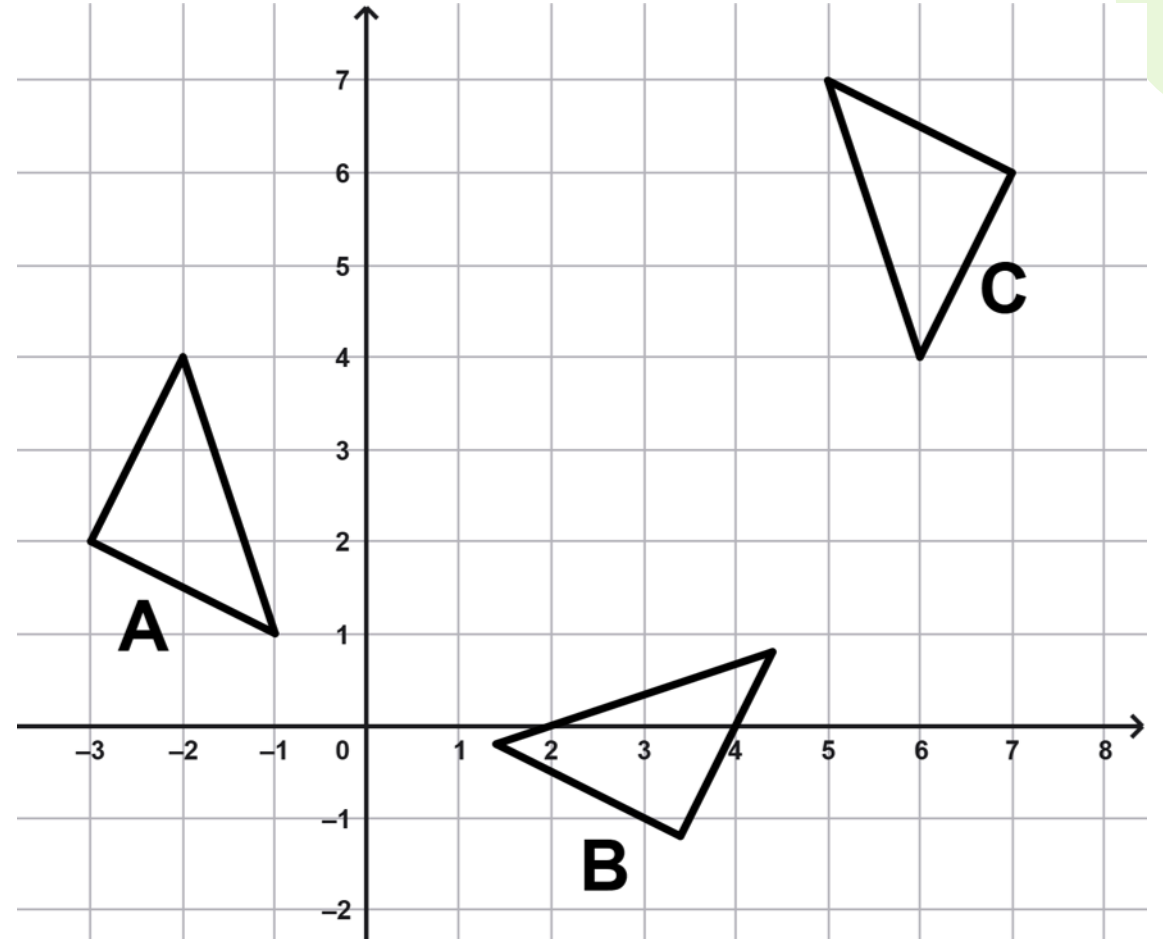
The diagram shows a shape, A and its reflection B in a mirror line.

It also shows shape C which is a reflection of B, in a different mirror line.

Find the equations of the two mirror lines.

C is a 180° rotation of A.

Find the coordinates of the centre of rotation?



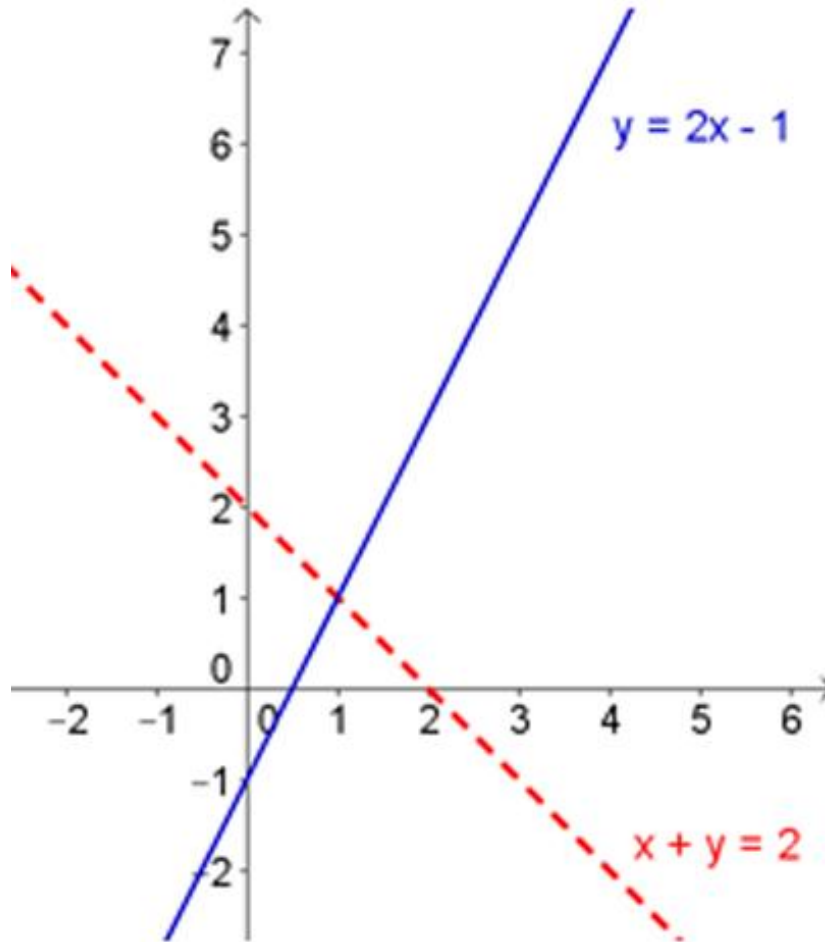
Inspiration

Where the mathematics leads...

- What is in the next stage of learning (GCSE → A level possibly)
- Is there something that a student could discover?
- Can this be done without introducing new knowledge?
- What is the key knowledge that is required to progress?



An example that leads to matrix transformations



Reflect the line $y = 2x - 1$ in the line $x + y = 2$.

What is the equation of the new line?

What equation would you get if you reflect the line $y = 2x - 1$ in $x + y = 5$?

Is there a rule for reflecting the line $y = 2x - 1$ in any line of the form $x + y = k$?



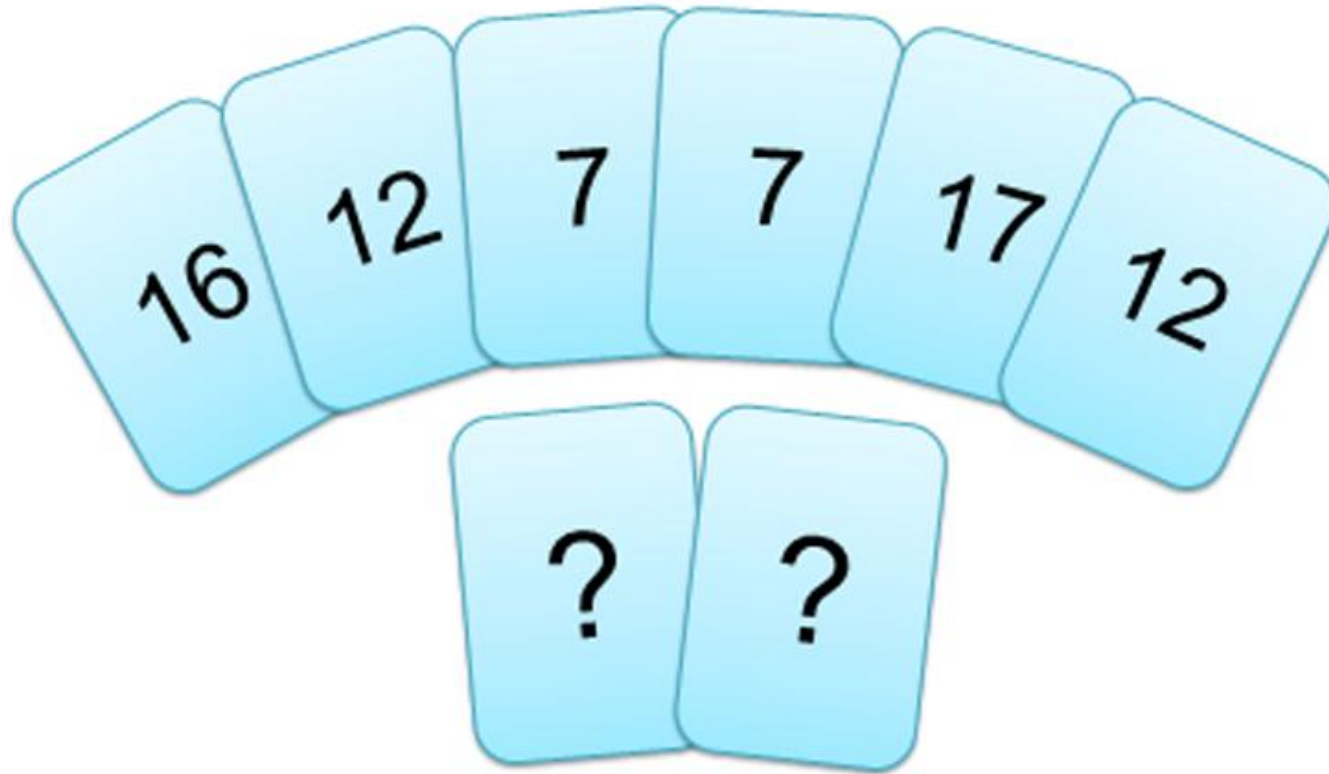
Inspiration

Specific knowledge – facts/techniques

- Is there a particular maths fact I want the students to remember?
- Is there a technique/skill I want students to practise?
- What are the key requirements of that skill?
- What situations give rise to that knowledge/skill being required?



An example for testing specific knowledge



What numbers are on the two mystery cards if the mode of all of the cards is 12 and the mean is 13?



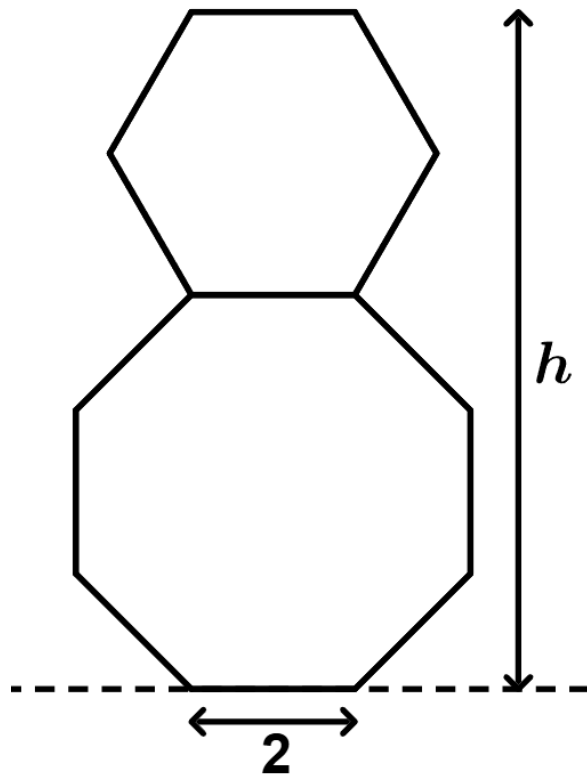
Inspiration

Playing with maths

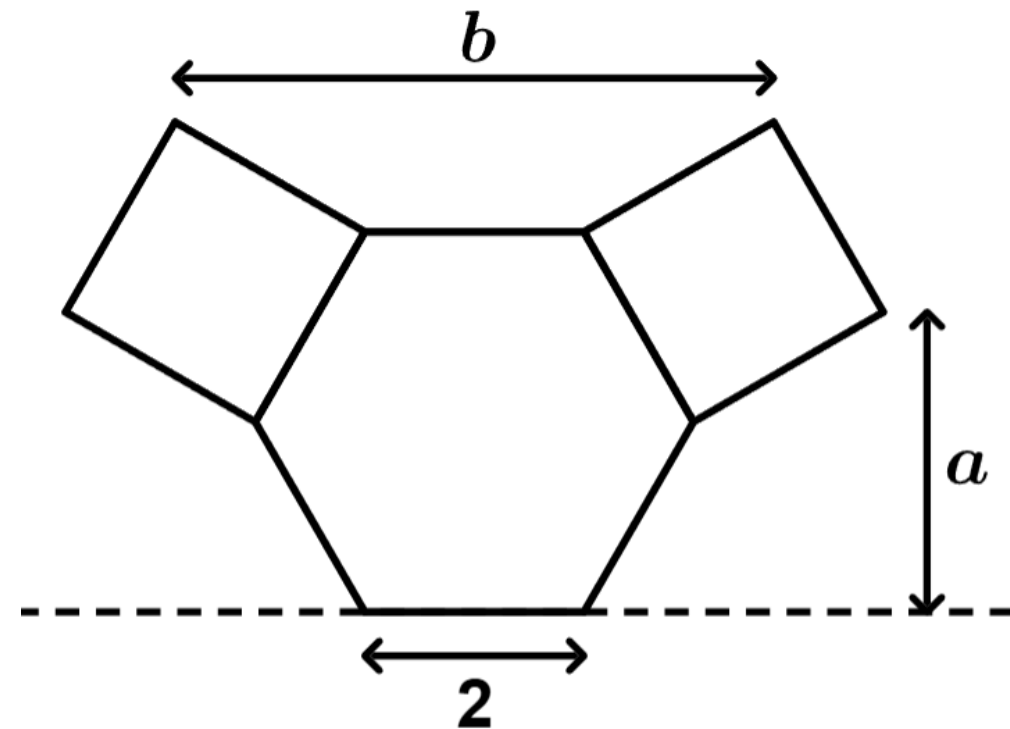
- Diagrams using Desmos or Geogebra
- Interesting graphs
- Constructions
- Can I write a sequence where...?



Two geometrical problems



Find h , giving your answer in surd form



Find a and b , giving your answers in surd form



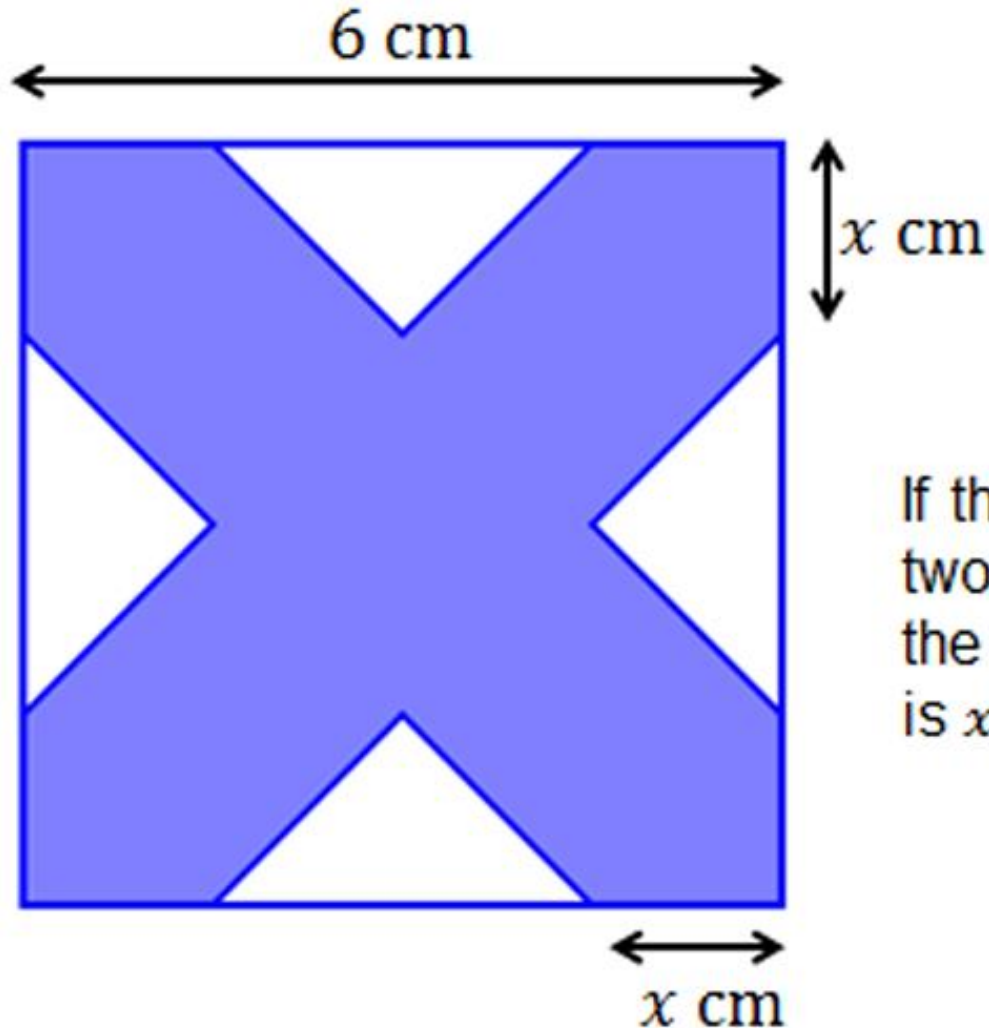
Inspiration

Looking at a range of existing problems or reading some interesting maths

- UKMT
- Axiom Maths
- Admissions tests
- Online puzzles
- Mathematical Gazette
- Can I write something similar (or even different by inspired by)



A problem inspired by a UKMT question



If the shaded cross covers two-thirds of the area of the large square, how big is x ?



Inspiration

A blank canvas

- What is the ability range of the students?
- What do they already know?
- Can I connect some of the things they know in one problem?
- What is the extent of their confidence?
- Can I produce a problem that develops problem-solving skills without requiring absolute confidence in a topic?



An example from the Cambridge Maths School Admissions paper

A curve C has equation $y = x^2 + bx + c$.

C passes through the points $(3, -4)$ and $(1, 2)$.

Which of the following statements is/are true?

- I The y intercept of C is below the x axis
- II C crosses the x axis twice
- III C has reflection symmetry in the line $x = 3.5$

- A I only
- B II only
- C III only
- D I and II only
- E II and III only



Writing a problem

Things I ask myself when writing problems

- Is the problem realistic for the students (in terms of difficulty)?
- Is the problem unambiguous?
- Does the problem solve a useful purpose?
- Does the problem do what I want it to?
- Does the problem do more than I want it to (a bonus)?
- Is it a good problem?



Write a problem

It's your turn!

- You have some exam questions as starting points
- Don't feel obliged to stay “within” a topic – make links
- Try to state what you are trying to get from the problem
- Write a problem including at least 2 of the characteristics

You also have some problems to (possibly) give some inspiration



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