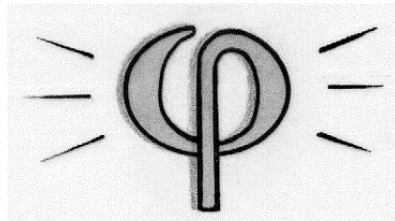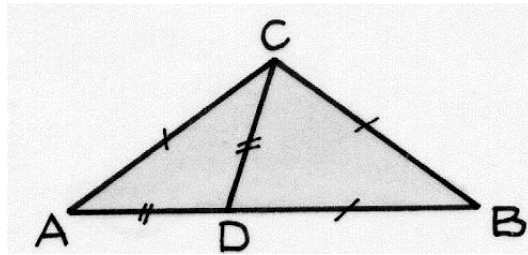**Question 2** **Gold and silver** **5 marks**

The three triangles ABC, BCD and ACD are isosceles.

Calculate their angles.

Note: the triangle BCD is called a golden triangle. You could find out why.

**Questions 3**   **Roll the dice**   **7 marks**

The sum of the two numbers on opposite sides of a dice is always 7.
A dice with 6 faces is placed on a 4 x 4 grid as shown. The face of the dice in contact with the grid is the number 4. The squares on the grid are the same size as the face of the dice.
The dice is rolled over on an edge to move to another square eventually reaching the square marked A. This takes 6 moves. There are 20 different possible paths.
For each path you can find the total of all the numbers that had contact with the grid.

Find the path that has the smallest total and another which has the biggest total.
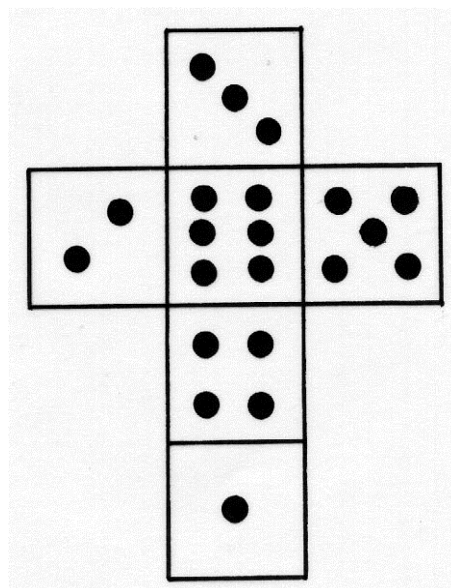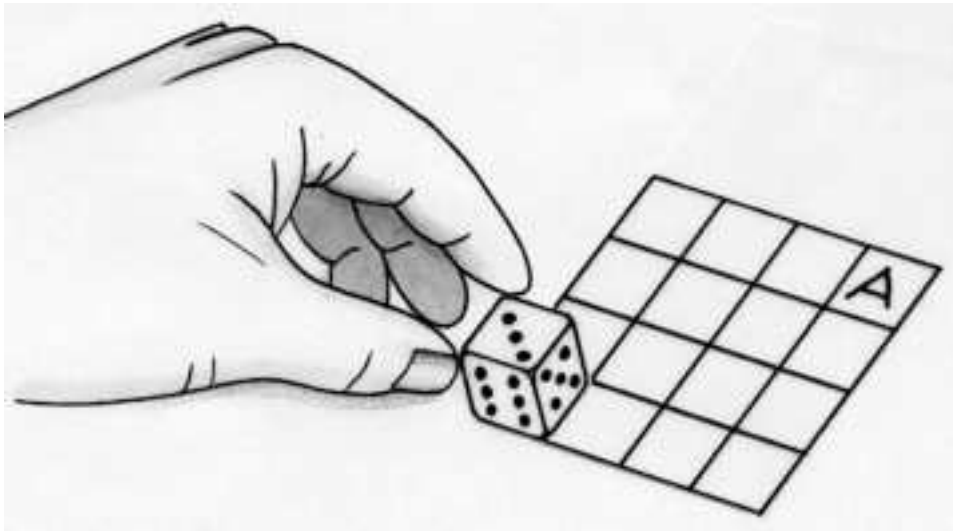
Question 4   **All in a row**   **5 marks**

Five tokens have been placed on a strip of six squares. Each token has been numbered using a different digit from 1 to 5.
The game is to move the tokens and place them in ascending order from left to right keeping to the rules:
- at every move there is only one token on each square
- each token can be moved once and once only
- a token can leap over one or more others
- at the end of the game the empty square is on the extreme right.

At the beginning of the game the token ③ is on the first square on the left and the token ④is on the second square. List the possible positions of the other tokens at the start of the game.
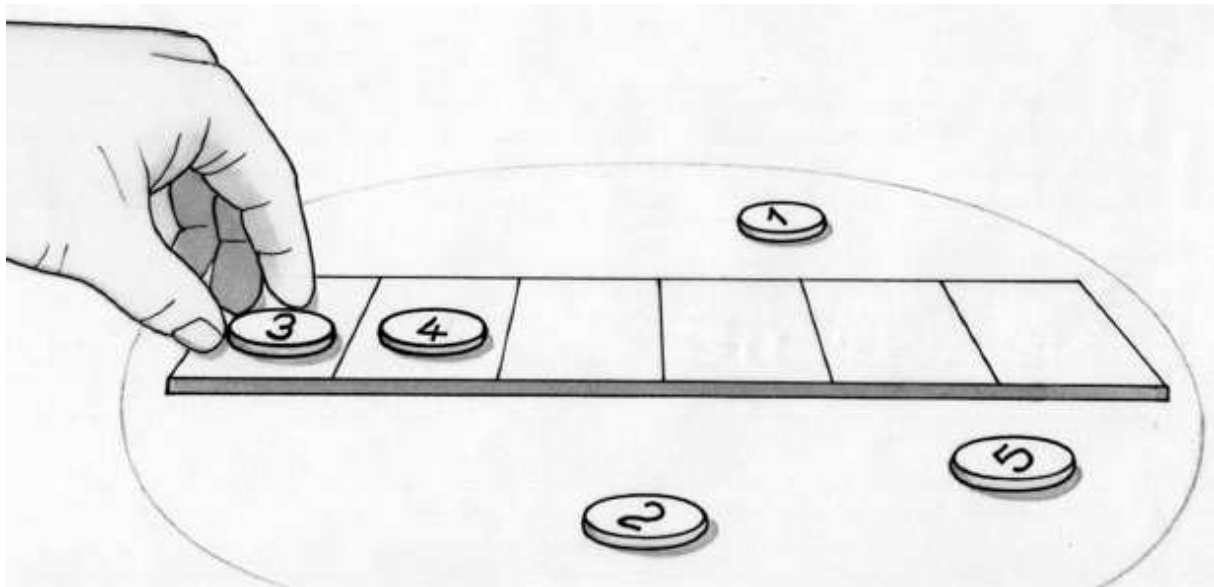
Question 5　　　　　　　**Cross over**　　　　　　　**7 marks**

While on his ski holiday Oscar was sitting on chair 110 of the chair lift when he passed chair 130 going down. At the very same time his sister Eloïse who was in chair 290 passed chair 250.
The chairs which are evenly spaced are fixed to the cable in numerical order starting with chair 1.

Work out the total number of chairs using this information. Justify your answer.
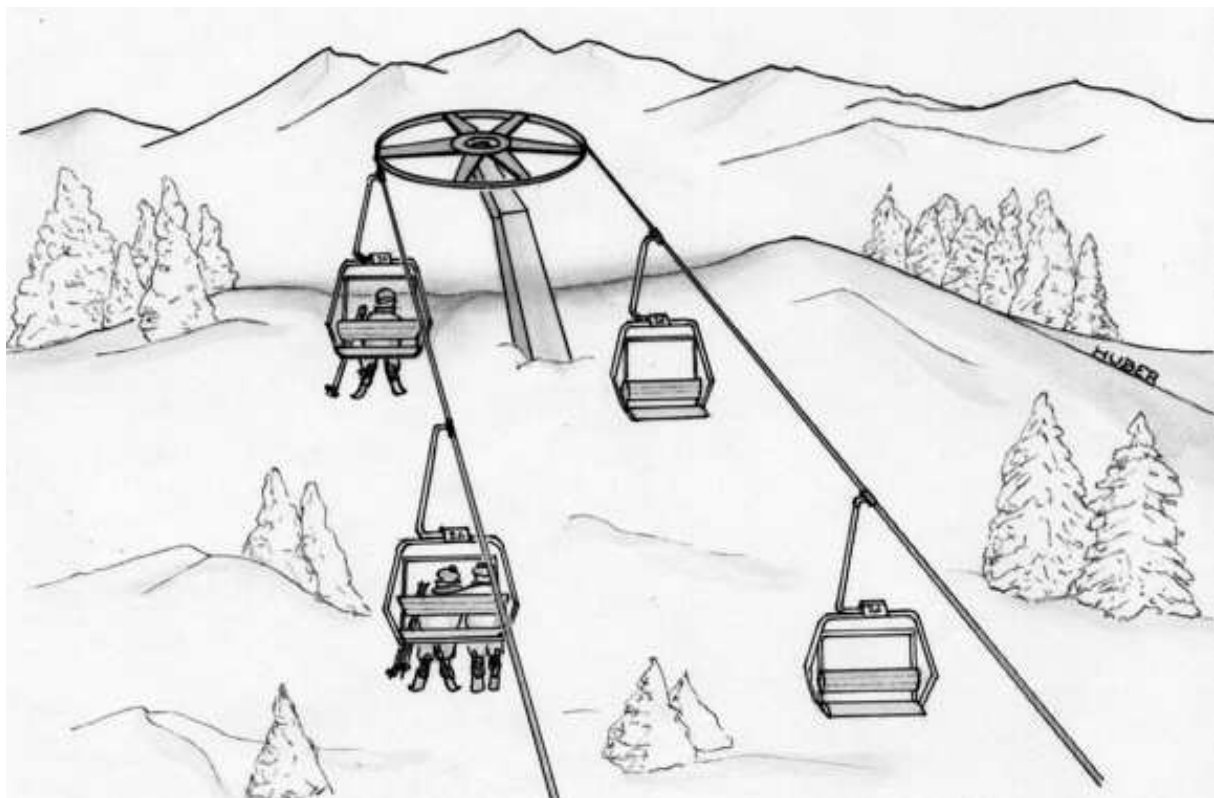
Astrid has written 5 equations using the letters of her name to help her work out, if she ever needs to, the 6 number code for her wall safe.

$$A + S = T$$
$$R + I = A$$
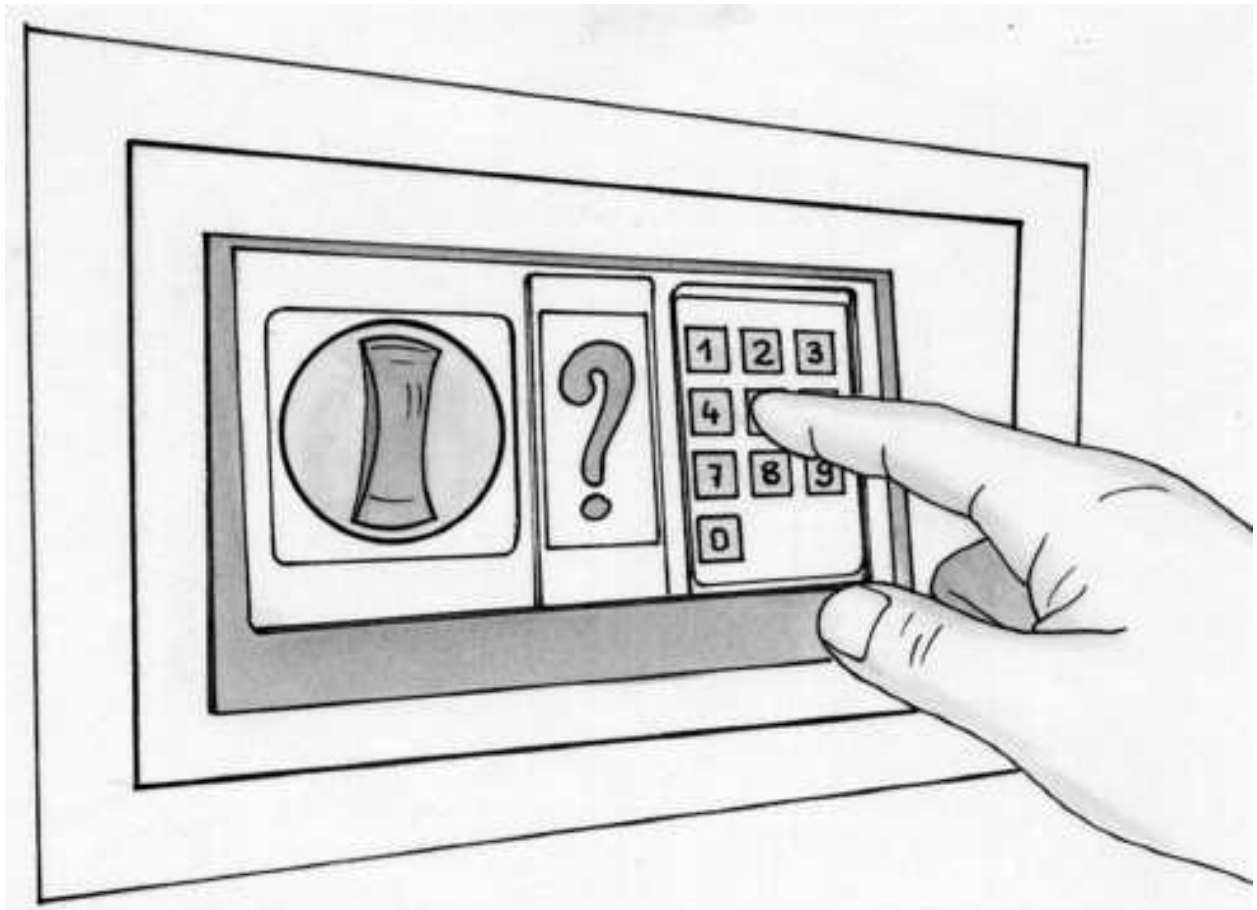$$A - S = D$$
$$D \times D = I$$
$$T : D = I$$

Each letter of her name corresponds to a digit in the code.
The 6 digits in the code are different.
The 6 digits in the code are written in the order of the letters in her name.

Find Astrid's code. Justify your answer.

Question 7   **Too many trolls**   **7 marks**

You have fallen into a subterranean labyrinth of interconnected halls that is home to a tribe of trolls, creatures as ugly as they are dangerous. Your goal: to get out without being caught!

To help you have a plan of the labyrinth, 20 magic potions and some important information:
- there are 9 halls containing a total of 72 trolls
- 11 trolls are in hall C
- hall B, into which you have fallen, is empty
- the sum of the number of trolls in any straight line, including diagonals, is always the same
- each magic potion can immobilise only one troll
- you can only get out of a hall after you have immobilised all the trolls that are in there.
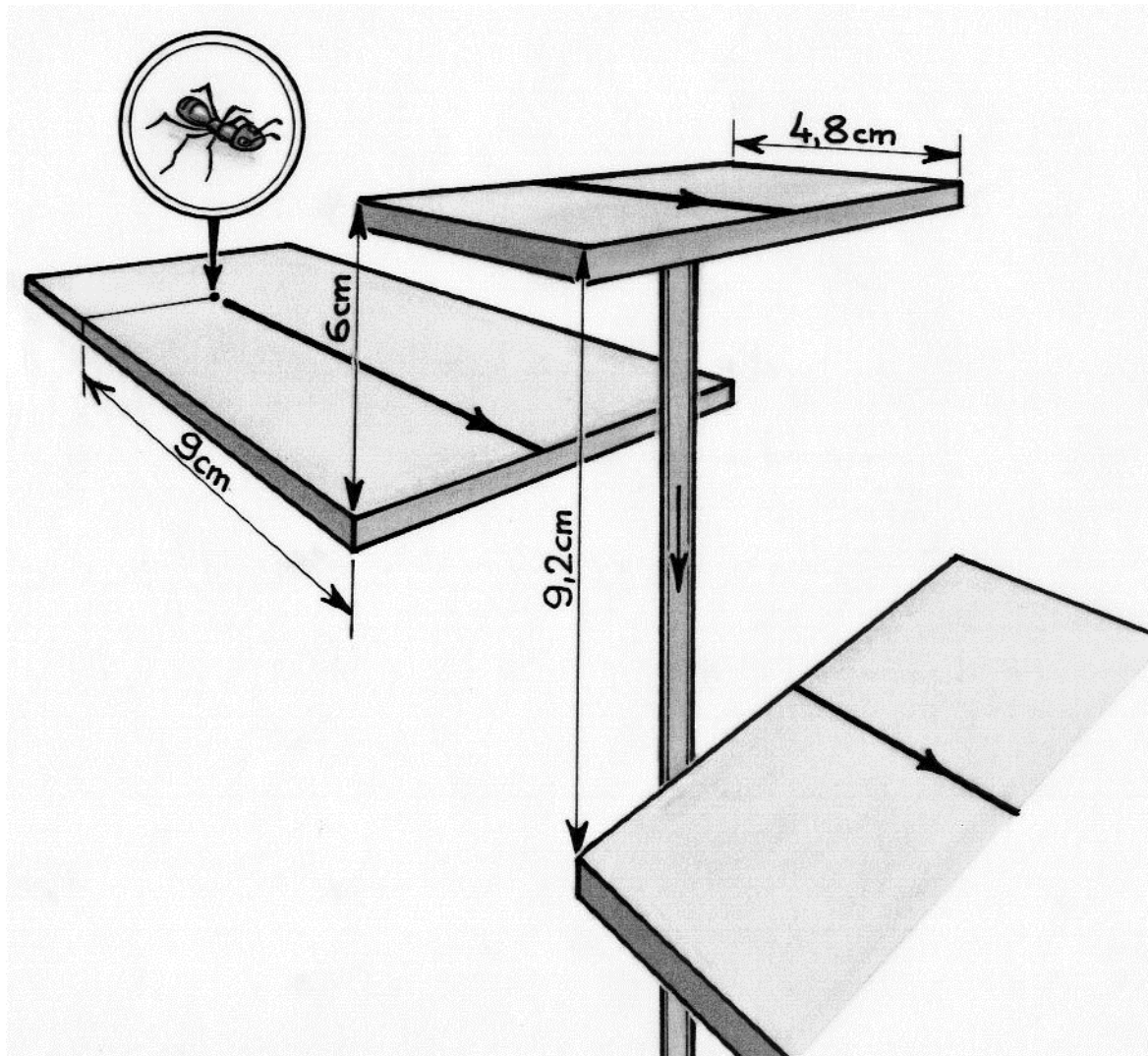- the exits from the labyrinth are in halls G, H and I.
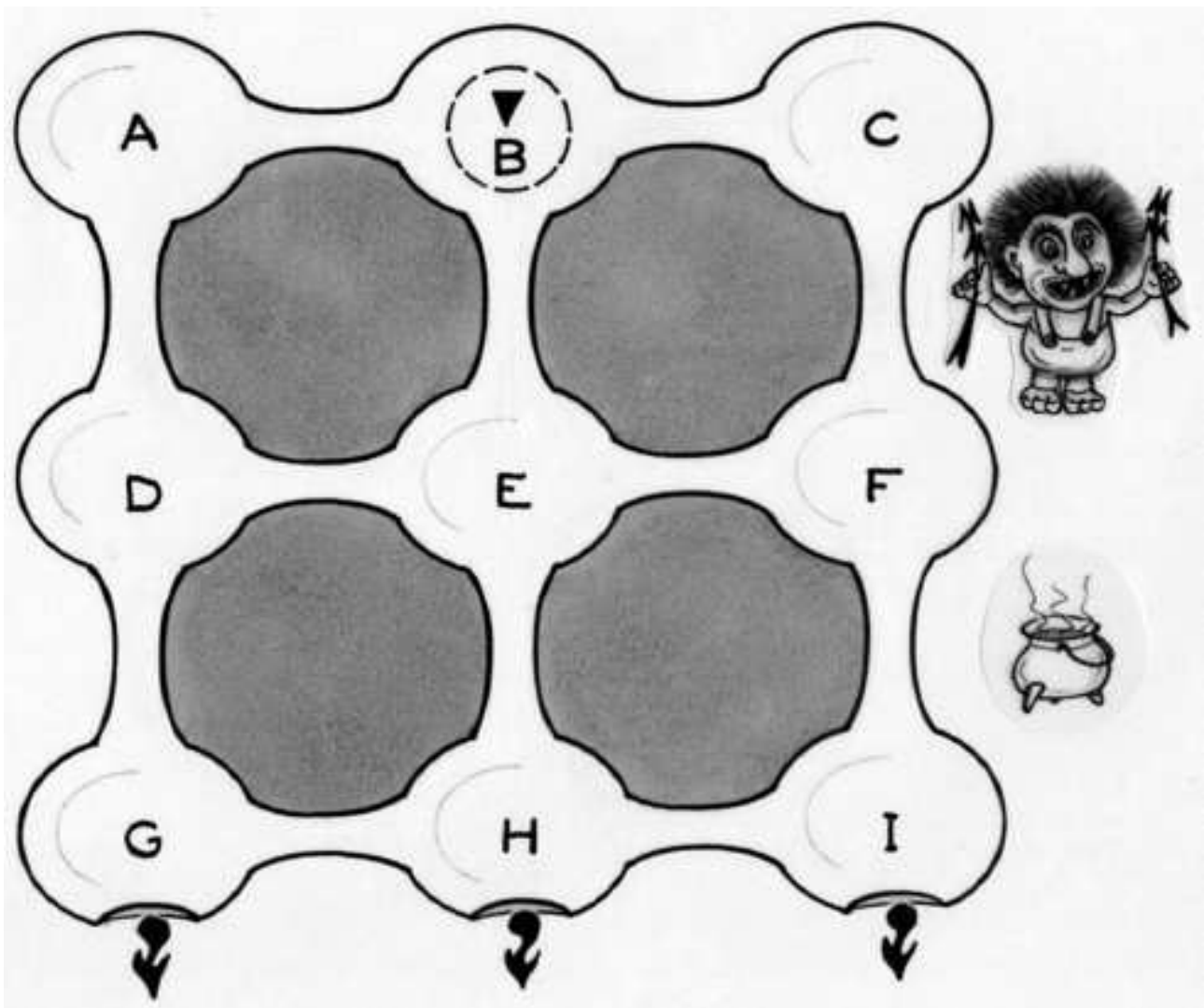
What pathway will you take to get out of the labyrinth? Explain your answer.

Question 8 **Walk this way** **5 marks**

On the walkway shown in the diagram an ant is moving at constant speed along the line up the middle. The platform is also moving down at a constant speed.
When the ant is 9 cm away from the edge the moving platform is 6 cm above the walkway on the left hand side. It is 9.2 cm above the right hand side of the walkway. The platform is 4.8 cm wide.
The ant can only move on a flat surface, it cannot jump or go up or down steps.

Can the ant move from one side of the walkway to the other without difficulties? Justify your answer.
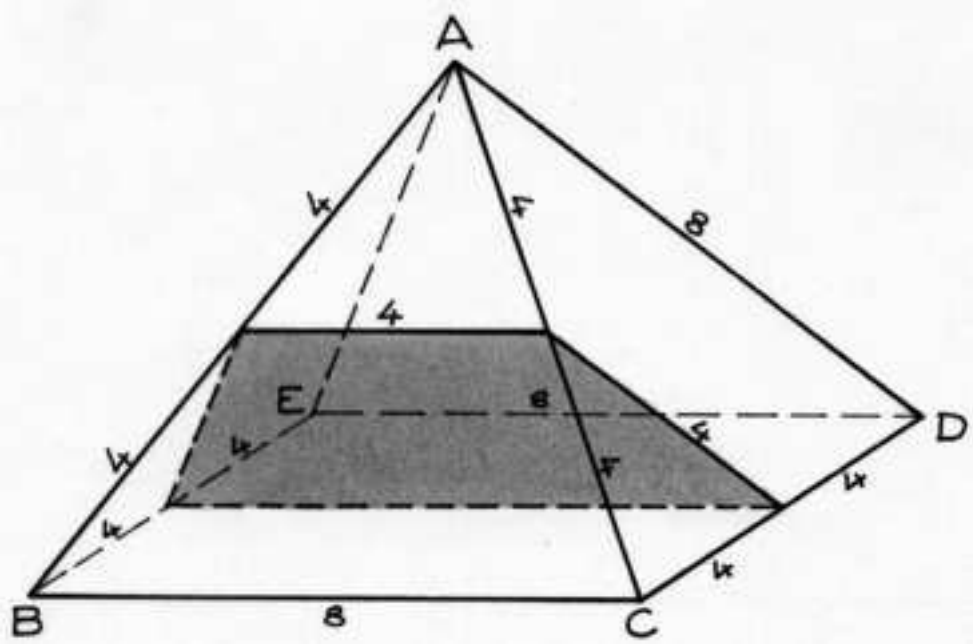
Question 9　　　　　　　**Net result**　　　　　　　　　　**7 marks**

A regular pyramid with apex A and square base BCDE is cut by a plane which passes through the mid-points of the sides CA, CD, BA, and BE. The cut produces two solid figures: a hexahedron with 6 faces and a pentahedron with 5. The lengths shown are in centimetres.

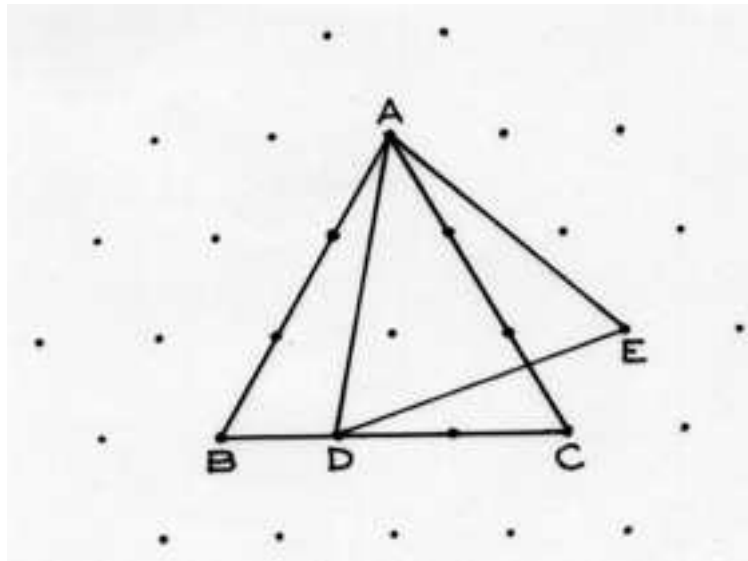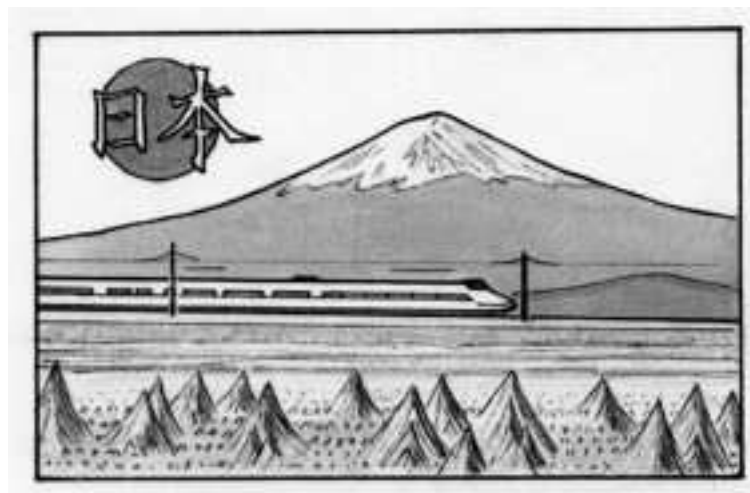*Construct the nets of the two solids.*

Question 10   **Meaningful relationship**   **10 marks**

Two equilateral triangles ADE and ABC have been drawn on an isometric grid as shown.

What is the relationship between the areas of the two triangles? Justify your answer.

Question 11   Give them an inch   5 marks   Senior classes only

Up until 2012 the diameter of the wheels on a mountain bike was 26 inches. Since 2015 that diameter size has been discontinued. Now mountain bikes are fitted with wheels of diameter 27.5 inches or 29 inches.
When a wheel of radius R meets an obstacle of height h the cyclist has to make more effort to get over the obstacle. The smaller the angle α is, the smaller the effort needed.
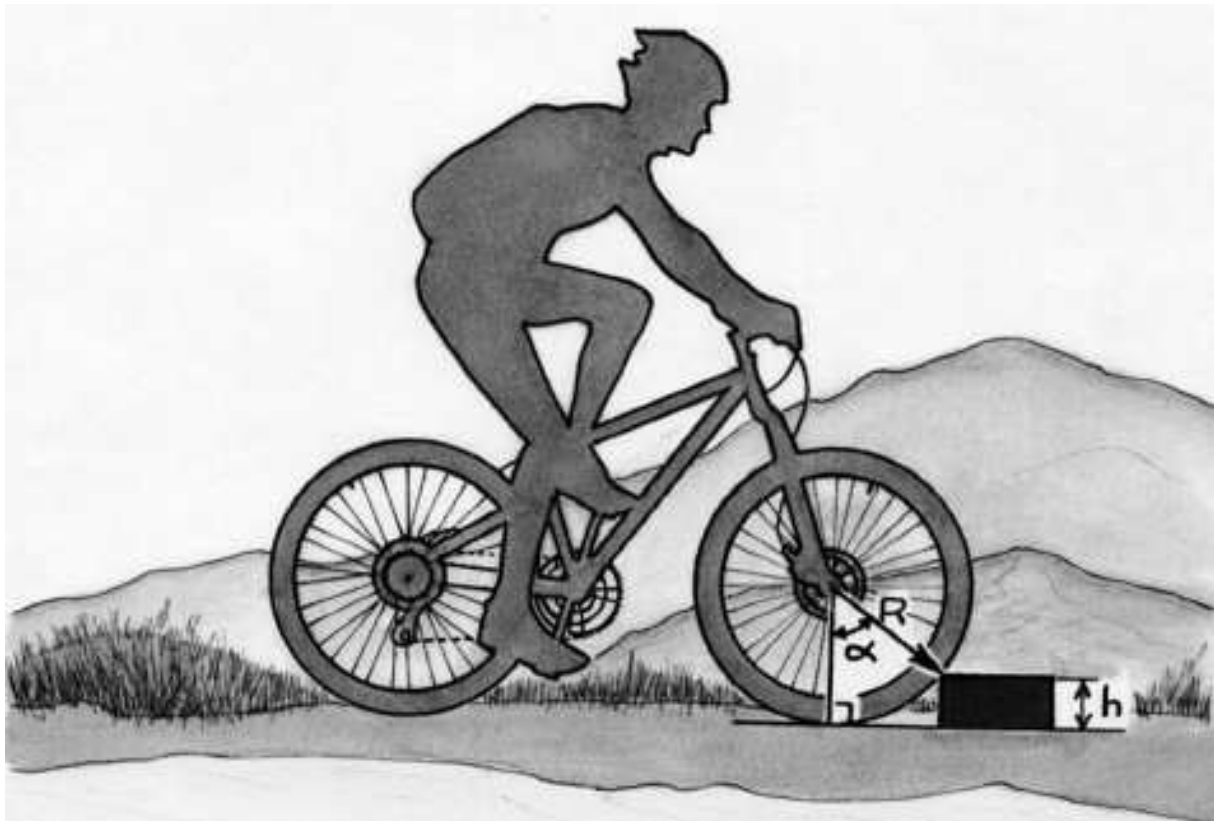
For an obstacle of height h = 8 inches, calculate the angle α for each of the three wheel diameters.

Question 12   **Equal opportunities**   **7 marks Senior classes only**

The diagram shows two correct equations. The first one with digits is quite amazing.

$$\frac{9}{5} + \frac{3}{5} = \frac{93}{55} + \frac{39}{55}$$

Show that the first equation is correct.

$$\frac{a}{c} + \frac{b}{c} = \frac{ab}{cc} + \frac{ba}{cc}$$

In the second one a, b and c represent 3 different numbers.

Show that this equation is also correct no matter what values a, b and c have as long as c is not zero.

Question 13 General   Area formula   10 points Senior classes only

How can you calculate the area of a convex quadrilateral?*

This process will allow you to discover the formula.:

Draw a convex quadrilateral and mark the mid-points of the four sides. Draw a line in red which joins the mid-points of two opposite sides. Draw a line in green from another mid-point perpendicular to this red line. Then draw a line in blue from the fourth mid-point perpendicular to the red line. Cut the quadrilateral into the four parts as shown. Put the four parts together to form a rectangle. It is then easy to find the area of the rectangle.

Prove that the figure you get is a rectangle.
Stick your rectangle to the answer sheet.
Draw another convex quadrilateral. After showing what measurements you need to know in the quadrilateral, write down the formula which gives its area.
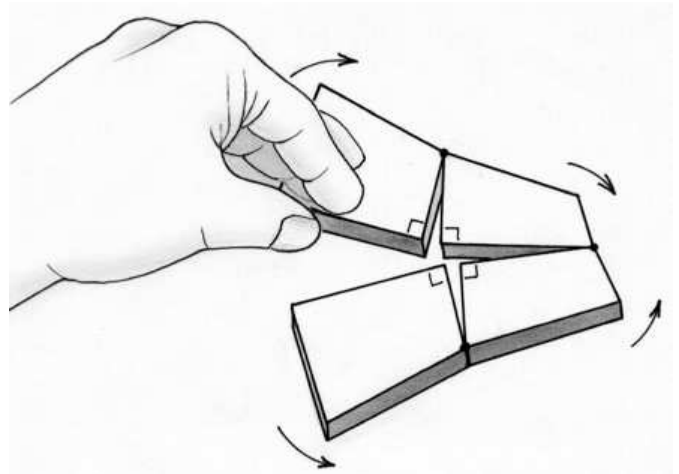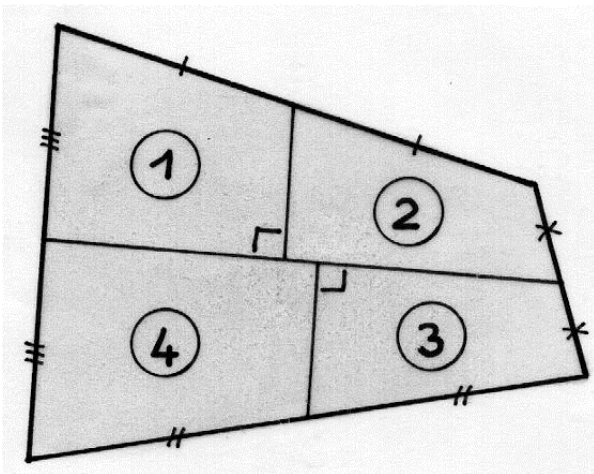
*Note: A convex polygon is one which has all its interior angles less than 180°. Here is a nice animation that lets you see that.

http://www.mathopenref.com/polygonconvex.html

Question 13 Pro   **It's all gone cold**   **10 marks   Senior classes only**

A crime has taken place. The clues left behind show that Mme Pilton was killed at the exact moment that she put her teabag into the boiling water. The experts from MsF arrived at the scene at 17h12.

They noted the temperature of the water: 30°C. Their laboratory has shown that if the temperature is measured at time T then one minute before that it was :

$$\frac{107\,T - 141}{100}.$$

Using this information work out the time the crime was committed.
Solutions developed using a spreadsheet are accepted.