MATHEMATICS
EXPLORATION PROBLEMS

Name : _____ **Participant ID :** _____

Country : _____ **Seat Number:** _____

22nd International Mathematics and Science Olympiad
Alor Setar, Kedah, Malaysia
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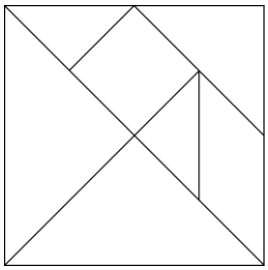
Instructions:

1. Write your name, country, and Participant ID on every page of the Answer Sheet.
2. Write your answers only on the Answer Sheet.
3. Answer all questions in Arabic Numerals or English.
4. There are **6** questions in this paper.
5. Each question is worth 6 marks and partial credit may be awarded.
6. You have **120** minutes to complete this paper.
7. You are provided with some manipulatives for exploration on some questions.
8. Use black pen or blue pen or pencil to write your answer.

Do not turn over this page until you are told to do so.

EXPLORATION PROBLEMS

1. A tangram is a seven-piece puzzle, formed by cutting a square into two large right isosceles triangles, one medium right isosceles triangle, two small right isosceles triangles, one square and one parallelogram as shown in the diagram below.

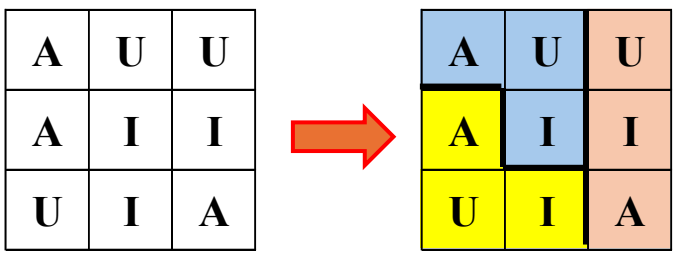


The goal is to arrange all the seven (7) pieces to form a specific outline, such as an animal, an object or even letters and numbers.
The pieces must fit together without any overlap and all pieces must lie flat on a surface.

A. Use one (1) set of tangram puzzle to form Diagram A. (1 point)
B. Use one (1) set of tangram puzzle to form Diagram B. (2 points)
C. Use two (2) sets of tangram puzzles to form Diagram C. (3 points)

Diagram A Diagram B Diagram C

2. In a 3 × 3 grid with the letters A, I and U, we draw segments along the grid lines to divide the grid into 3 separate pieces and we need to shade all the pieces using different colours. Each piece must contain exactly 3 letters, and those letters must be all different. The completed solution is shown below.



A. The 4 × 4 grid below is filled with the letters I, M, S and O.

Draw segments along the grid lines to divide the grid into 4 separate pieces and shade all the pieces using different colours. Each piece must contain exactly 4 letters, and those letters must be all different. (1 point)

I	M	I	S
O	S	O	M
S	M	I	O
M	S	O	I

B. The 6 × 6 grid below is filled with the letters C, E, N, D, O and L.

Draw segments along the grid lines to divide the grid into 6 separate pieces and shade all the pieces using different colours. Each piece must contain exactly 6 letters, and those letters must be all different. (2 points)

N	L	D	N	O	N
L	L	E	E	C	O
D	O	O	N	D	E
N	C	E	D	C	C
E	L	O	O	C	L
C	D	N	L	D	E

C. The 8 × 8 grid below is filled with the letters K, E, D, A, H, M, Y and S.

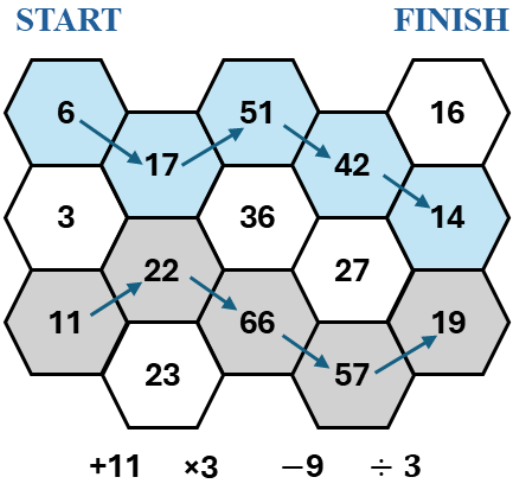
Draw segments along the grid lines to divide the grid into 8 separate pieces and shade all the pieces using different colours. Each piece must contain exactly 8 letters, and those letters must be all different. (3 points)

H	A	E	K	Y	Y	A	D
A	M	E	D	Y	H	K	M
H	S	A	M	D	S	S	K
K	Y	E	S	K	M	H	S
S	A	M	H	Y	D	Y	E
E	D	D	S	H	Y	A	H
A	M	E	H	S	E	K	E
Y	D	K	M	M	K	D	A

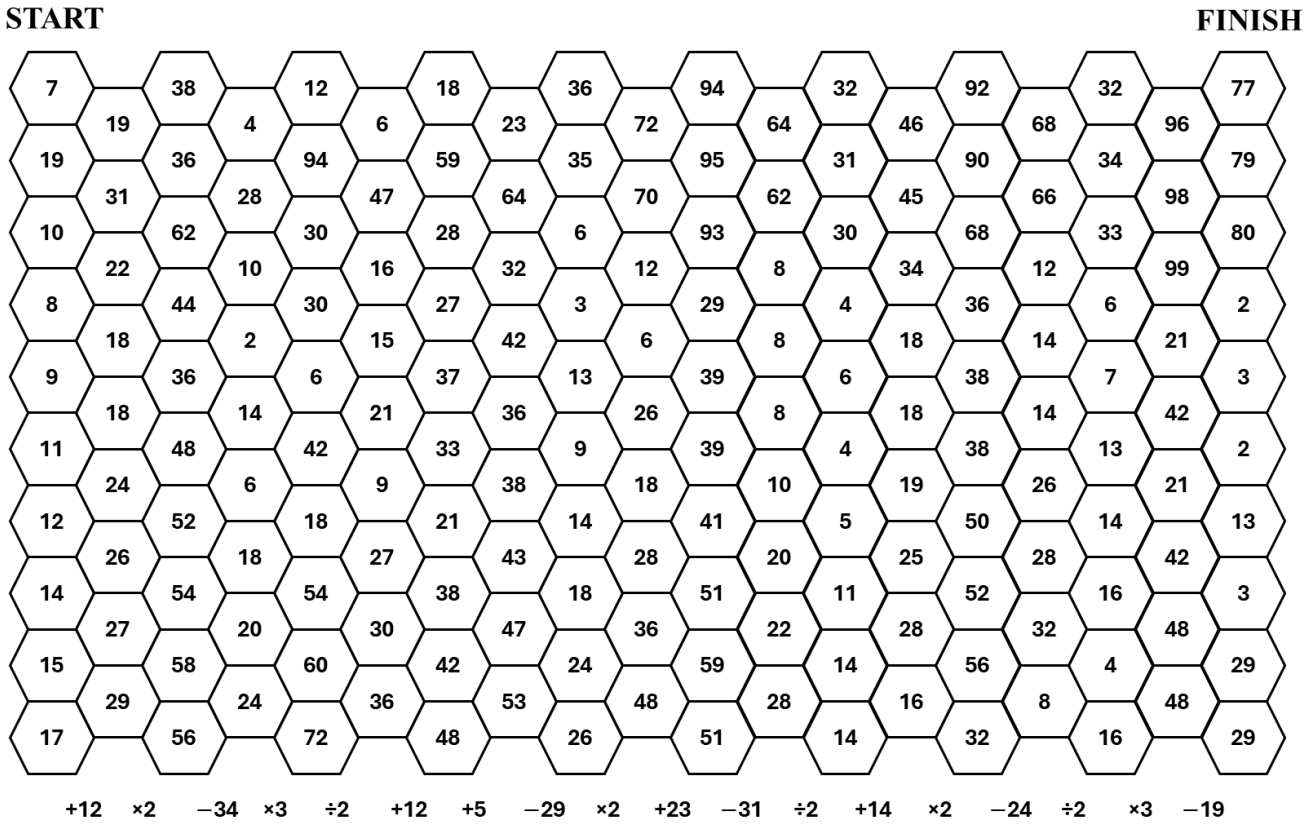
3. In any honeycomb grid, you must always begin at the **START** column on the leftmost side and end at the **FINISH** column on the rightmost side.

A. A path is considered correct if the result of each operation matches the adjacent number in the next column.

For example, in the honeycomb grid shown below, there are two correct paths, which are 6 → 17 → 51 → 42 → 14 (shaded in blue) and 11 → 22 → 66 → 57 → 19 (shaded in gray).

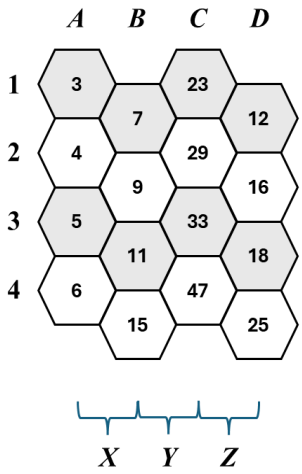


Find and shade all the correct path(s) that can be found in the honeycomb grid below using a coloured pencil.



B. Now, let us observe a variant of the honeycomb grid.

The diagram on the right shows a 4 × 4 honeycomb grid with four rows labelled as 1, 2, 3 and 4; four columns labelled as *A, B, C* and *D*; and three operations labelled as *X, Y* and *Z*.



Unlike the honeycomb grid earlier, this variant uses variables to represent the operations.

Operation *X*, when applied to the number in column *A*, produces the number in column *B*. Similarly, Operation *Y*, when applied to the number in column *B*, produces the number in column *C*. Lastly, Operation *Z*, when applied to the number in column *C*, produces the number in column *D*.

But it is known that in each of the operations, there are exactly three correct calculations and one incorrect calculation.

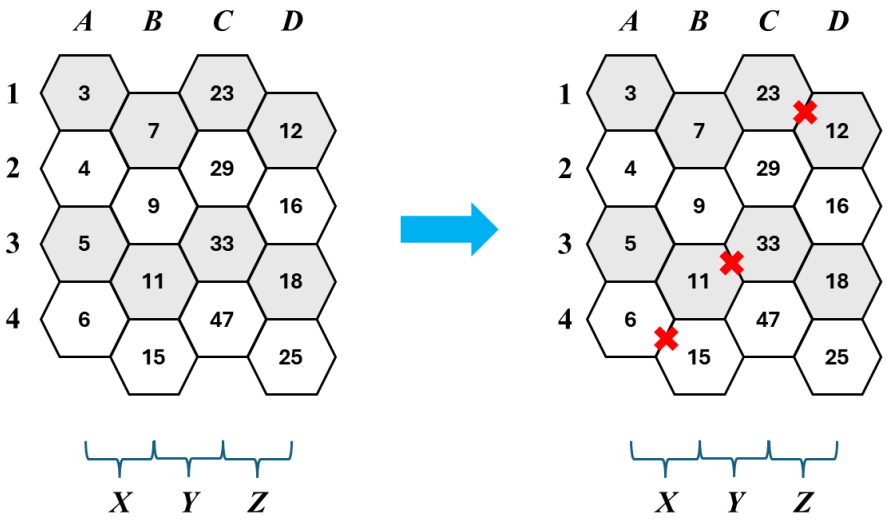
Our goal is to put a "×" mark on those segments where the calculations are incorrect.

For example, let *a*, *b, c* and *d* be the numbers in column *A, B, C* and *D*, respectively.

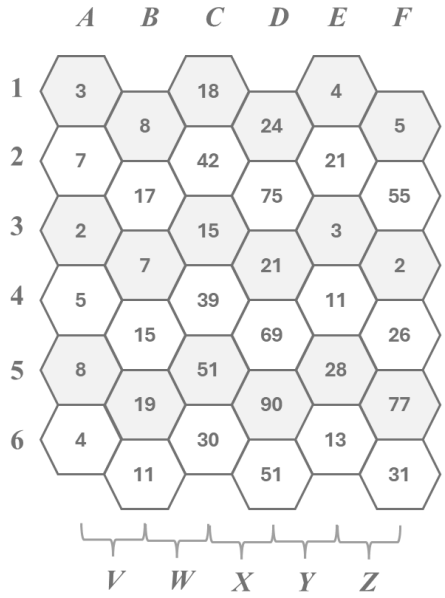
Observing operation *X*, one possible operation for it is $b = 2a + 1$. We can see that it is correct in rows 1, 2 and 3, but incorrect in row 4, so we place the "×" on it.

Observing operation *Y*, one possible operation for it is $c = 3b + 2$. We can see that it is correct in rows 1, 2 and 4, but incorrect in row 3 , so we place the "×" on it.

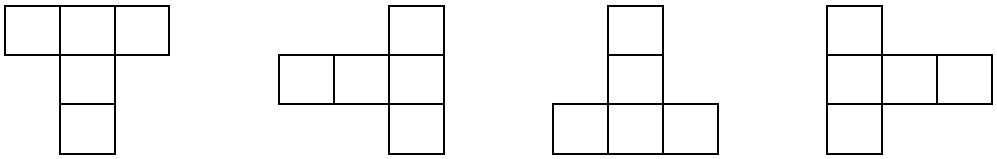
Observing operation *Z*, one possible operation for it is $d = (c + 3) \div 2$. We can see that it is correct in rows 2, 3 and 4, but incorrect in row 1, so we place the "×" on it.



Now, in the 6 × 6 honeycomb grid shown below, where each operation has exactly four correct calculations and two incorrect calculations, place an "×" mark on all segments where the calculations are incorrect.



4. You have a clear plastic sheet in the shape of the letter T. When placed on a grid, the sheet covers five-unit squares. It must be positioned so that it lies along the grid lines and it must be completely inside the grid (no part of it may lie outside the grid).
There are four possible orientations in placing the plastic sheet as shown below:



Now, consider the following 6 × 6 grid, where each unit square contains a number:

1	1	8	0	3	4
7	4	1	2	9	0
3	2	0	3	0	1
3	4	2	1	1	8
4	7	9	0	4	8
4	0	1	4	2	5

How many different ways can you place the T-shape on the grid so that the sum of all the numbers covered by it equals 16?

Show your solutions by shading the T-shapes on the grids below using a coloured pencil. (Note: Shade one T-shape solution per grid.)

5. The goal is to find all the treasures hidden on the map.
In each map, some unit squares contain numbers that are already given. Each number indicates how many treasures are touching that unit square, including the eight surrounding unit squares (on the sides and corners), but not the unit square itself.

Your task is to complete the map by filling in each empty unit square according to the following rules:

- Fill in with "T" if the unit square contains a treasure.
- Fill in with the correct number if the unit square does not contain a treasure.

A. (1 point) B. (2 points) C. (3 points)

	1	2	
	2		2
2			
	2	2	

	2		2	
2		1		1
		1		1
2		2		3
	1			

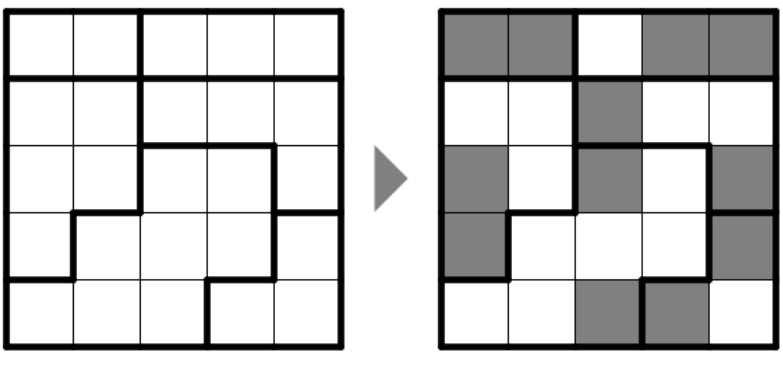
	1		1		
	2	1		2	2
1				1	
	3		3		1
1	3		3		
	2		2	1	

6. You are given a grid, which is divided into regions (the shapes may or may not be different).

Your task is to shade each of the grid according to the following rules:

- Each region must contain exactly two shaded cells. (the two shaded cells may or may not be adjacent).
- Each shaded cell must share a side with exactly one other shaded cell. (the shaded cells may or may not be in the same region.)

For example, in the 5 × 5 grid with six regions shown on the left, the completed solution is shown on the right.



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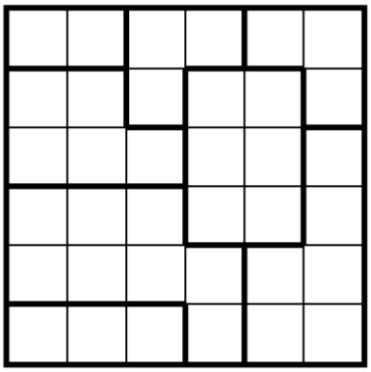
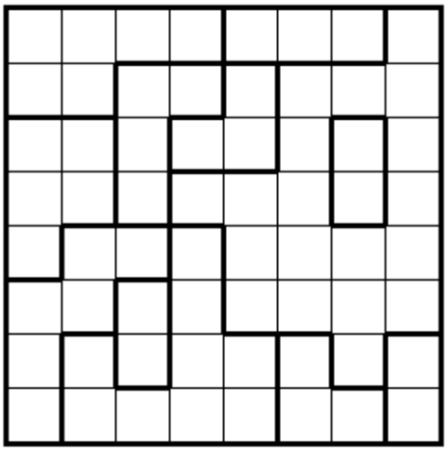
A. 6 × 6 grid with eight regions. (1 point)



B. 8 × 8 grid with twelve regions. (2 points)



C. 10 × 10 grid with twenty-one regions. (3 points)