VISUAL SPATIAL MATHLYMPICS

FOR PRIMARY SCHOOLS

April 2022

1 hour 30 minutes

Instructions to Mathlympians

1. Do not open the booklet until you are told to do so.

2. Attempt ALL 25 questions.

3. Diagrams are not drawn to scale.

4. Write your answers neatly on the ANSWER SHEET provided.

5. Marks are awarded for correct answers only.

6. **Use of calculators is not allowed.**

Questions in Section A carry 2 marks each, questions in Section B carry 3 marks each, questions in Section C carry 4 marks each and questions in Section D carry 5 marks each.
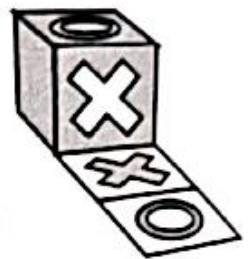
1. In the diagram below, which of the 7 squares can be removed so that the remaining 6 squares form the net of a cube?
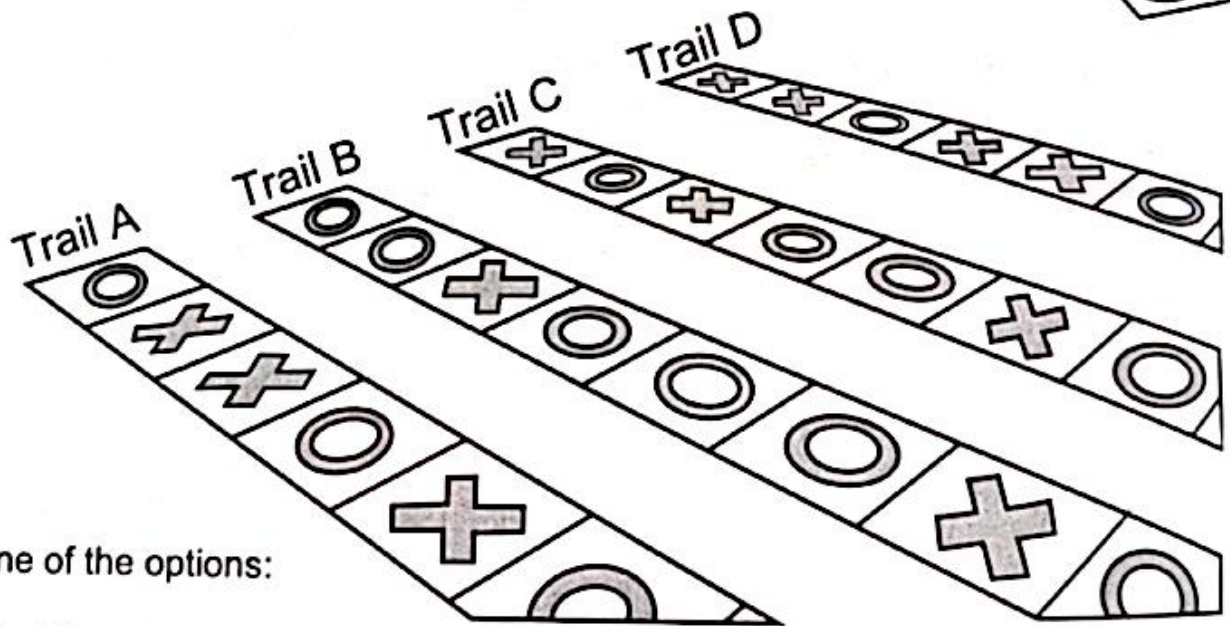
   Choose one of the options:

   1) Only 1
   2) Only 2
   3) Only 6
   4) Only 7
   5) Only 1 or 2
   6) Only 1 or 6
   7) Only 1 or 7
   8) Only 2, 6 or 7
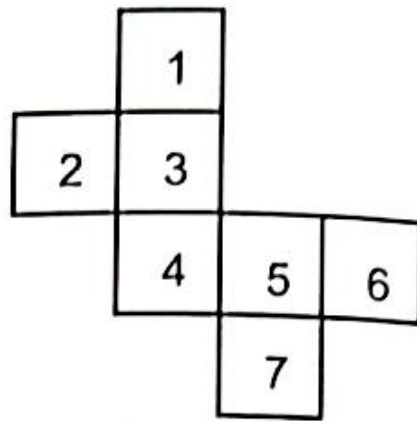
2. A wooden block is embossed with X and O on four of its faces. When it is rolled forward on soft wet sand, it leaves a trail as shown on the right.

   Which of the trail(s) below could be made by the wooden block?

   Choose one of the options:

   1) Trail A only
   2) Trail B only
   3) Trail C only
   4) Trail D only
   5) Trail A and C
   6) Trail B and D
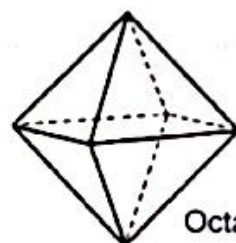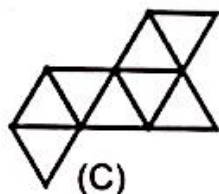   7) Trail A, B and C
   8) Trail B, C and D

3. Figures A to G show solids that are made from unit cubes glued together at their faces. How many of these solids cannot fit through the 3-unit² hole shown on the right?

A   B   C   D

3-unit² hole

E   F   G
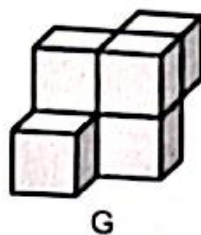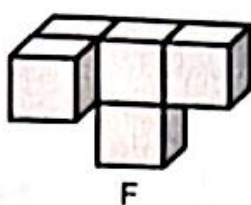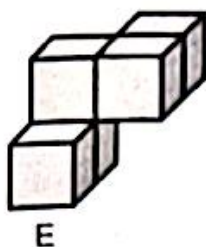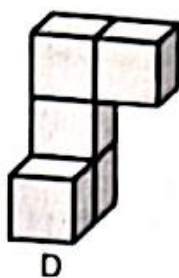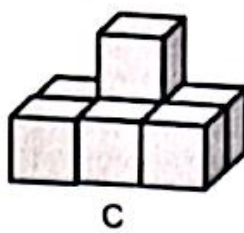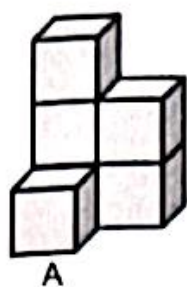
Choose one of the options:

1) One
2) Two
3) Three
4) Four
5) Five

4. List all the nets can be folded to make an octahedron.

(A)   (B)   (C)

Octahedron

(D)   (E)   (F)
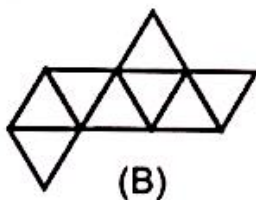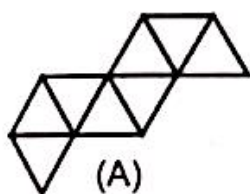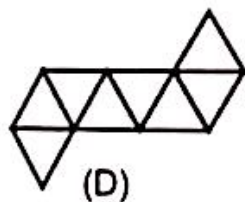
Choose one of the options:

1) A, C, D, F
2) B, D, E, F
3) C, D, E, F
4) A, B, C, D, F
5) B, C, D, E, F

7

5. A transparent cube has a thick continuous piece of rope glued along some of its edges and faces. The diagram below shows three views of the solid.
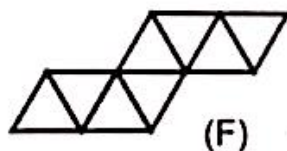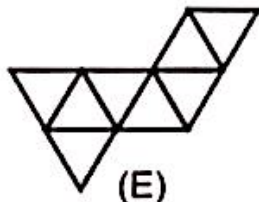
TOP   SIDE   FRONT
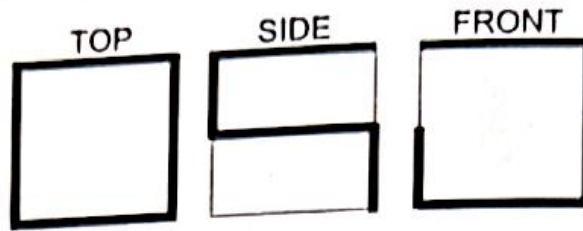
Which of the following shows the correct solid?

Choose one of the options:
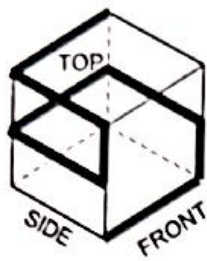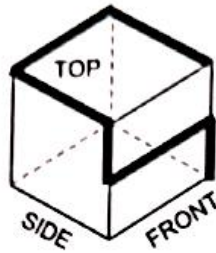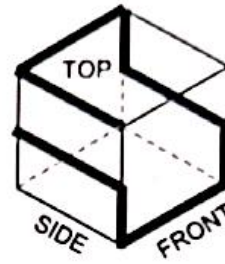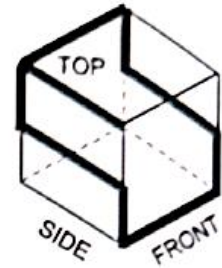
(1)   (2)   (3)   (4)

Section B:
Each of questions 6 to 10 carries 3 marks.

6. How many unique nets of a tetrahedron are there?

tetrahedron

8
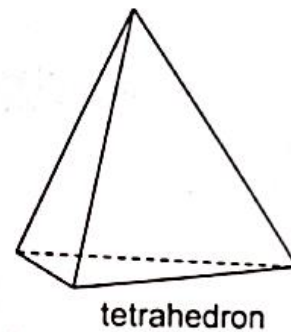
7. Line 1 and Line 2 are parallel.
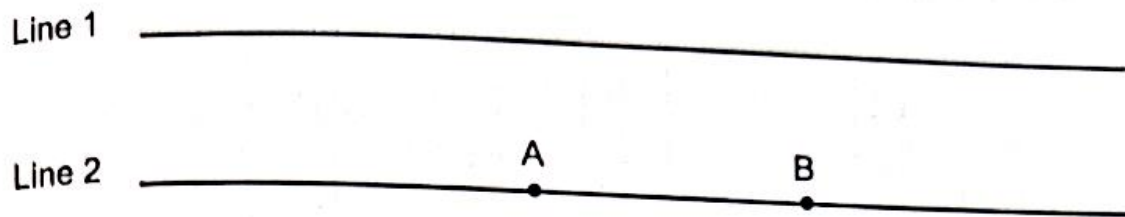
Line 1 ——————————————————————————

Line 2 ————————————•————————•————————
                          A   B

Points A and B lie on Line 2. How many positions can a third point be marked on Line 1 such that together, the three points form an isosceles triangle?

8. You want to arrange 5 stickers in each of 6 straight lines. What is the fewest number of stickers you will need?

9. The diagrams below show the three views of a solid built with unit cubes stacked (not glued) together. Each of these cubes is labelled either A, B or C.
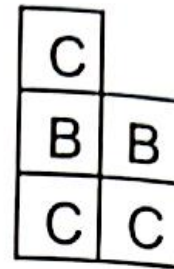
```
      ┌───┐                ┌───┬───┐            ┌───┐
      │ C │                │ A │ C │            │ C │
  ┌───┼───┤            ┌───┼───┼───┤            ├───┼───┐
  │ A │ B │            │   │ C │ B │            │ B │ B │
  ├───┼───┘            ├───┼───┼───┤            ├───┼───┤
  │ C │                │ C │ B │ C │            │ C │ C │
  └───┘                └───┴───┴───┘            └───┴───┘
      Top                   Side                   Front
```
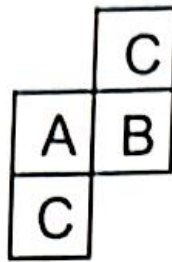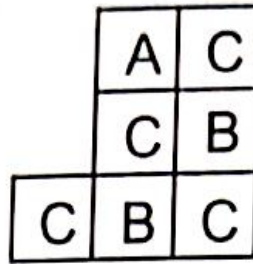
How many of each type of cubes are used if the least number of cubes is used?

10. When a plane slices through a sphere, the shape of the cut-surface (cross-section) is always a circle.

How many different-sided cross-sectional shapes can be obtained by slicing a plane through a tetrahedron?

sphere

tetrahedron

Section C
Each of the questions 11 to 20 carries 4 marks.

11. The given figure shows an arrangement of 25 pebbles.
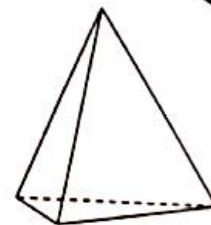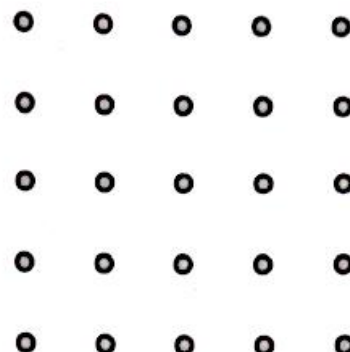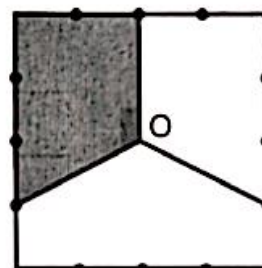How many ways do 4 of these pebbles mark out the
four corners of a square?
(Hint: There are more than 30 ways.)

12. The square given is cut into two identical trapeziums and a pentagon.
O is the centre of the square.
What fraction of the square is shaded?

13. The figure below shows a cuboid with a right-angled triangular prism EFGHIJ attached to one of its sides. CF is 12 cm and AF is 13 cm. ∠EGF is a right angle. EG is longer than FG and is a whole number of cm. What is the length of EG?
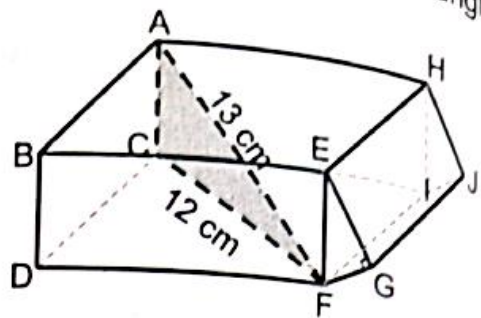
4. The given figure is made up of a large regular hexagon, two partially shaded medium regular hexagons and a shaded small regular hexagon. The length of each side of the large hexagon is twice the length of each side of the medium hexagon. The length of each side of the medium hexagon is twice the length of each side of the small hexagon. What fraction of the large hexagon is shaded?
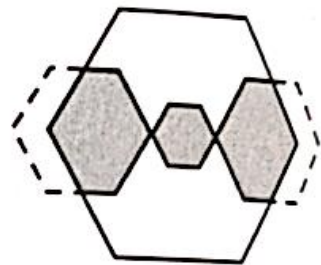
15. The given figure is made up of two circles. The area of the shaded small circle is 36% of the area of the large circle. What is the ratio of the perimeter of the small circle to the perimeter of the large circle?
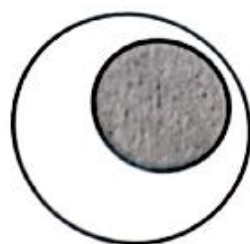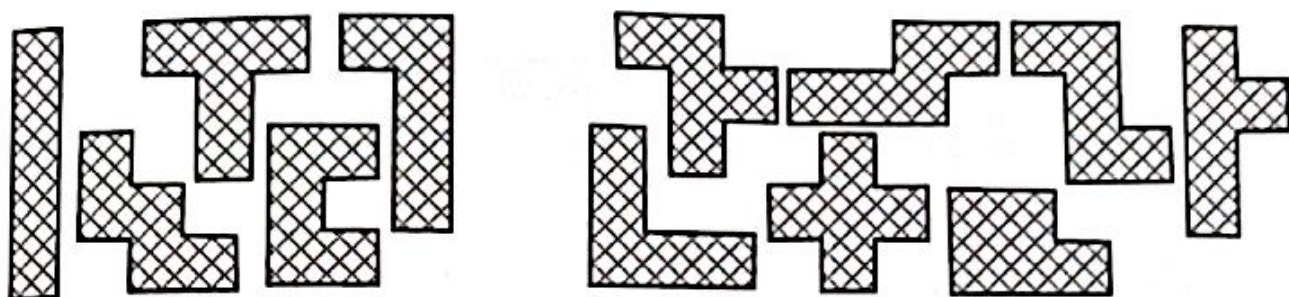

Section D:
Each of questions 16 to 20 carries 5 marks.

16. Pentominoes are shapes made up of five squares joined edge to edge. There are altogether twelve different pentominoes as shown below.

These twelve pentominoes can be arranged to fit into the grey part of the rectangle grid shown below with a W-shaped hole in the middle. The pentominoes may be rotated or flipped over. Five of these pentominoes have been drawn in for you. Draw lines in your Answer Sheet to show the positions of the remaining seven pentominoes.
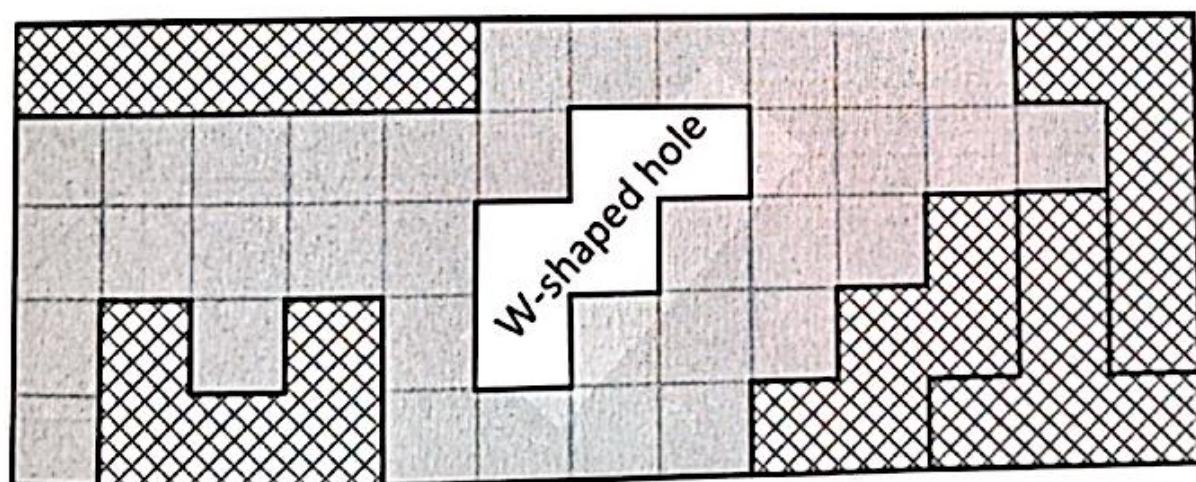
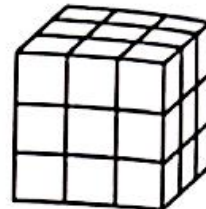17. Study the given cube. It is formed by attaching 27 unit-cubes together. The surface area of the cube is $6 \times 9 = 54$ unit^2.

If any cube may be detached except the one cube deep in the centre, what is the least number of cubes you need to detach to get a total surface area of 72 unit^2 ?

8. Both triangles ABC and A'B'C' are identical. DE is parallel to BC and FG is parallel to B'C'.

The shaded areas are equal.
The ratio AD : DB is 4 : 1.
What is the ratio A'F : FB'?
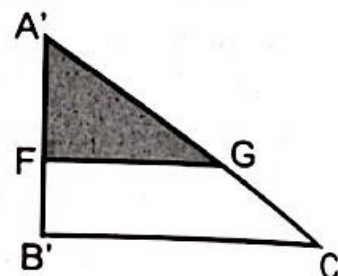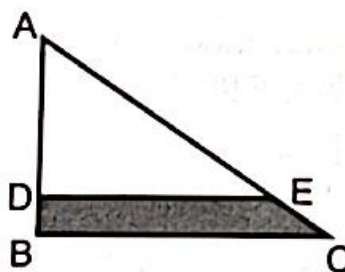
19. There are eighteen points, equally spaced, on the circumference of a circle. At most, how many points can you choose to avoid picking four corners of a rectangle?

20. Two secret agents are in different locations on the map, having just stepped out of a building and facing the road. Agent A is facing South and Agent B is facing West. They were both given the same instructions below which will allow them to meet at a particular road junction.
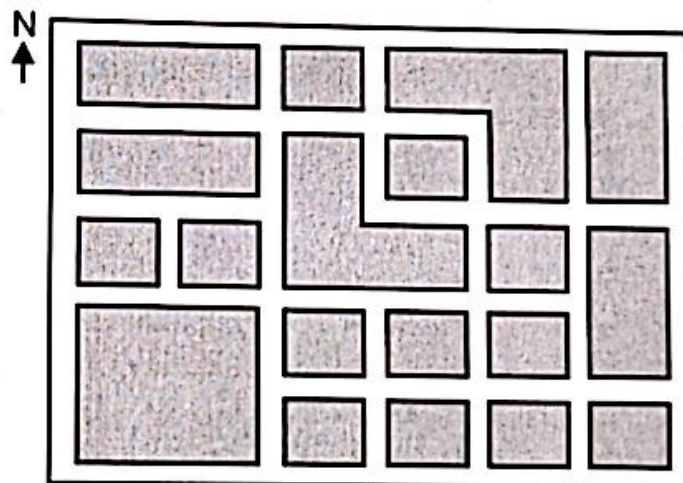
    Turn to face your left.
    Walk to the first junction.
    Turn right and walk to the first junction.
    Turn left and walk straight on to the second junction down the road.
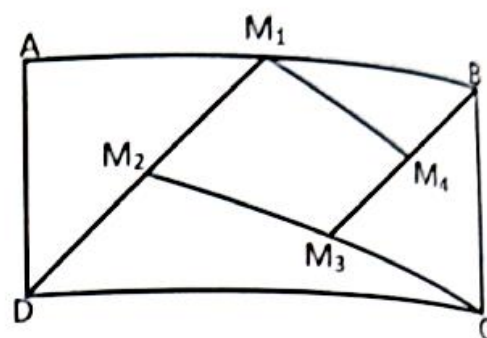   Turn right and walk to the first junction.

    On the map in your Answer Sheet, mark X at the junction where the two agents will meet.

N
↑

Section E

Each of the questions 21 to 25 carries 5 marks.

21. ABCD is a rectangle. M_1 is the mid-point of AB.
    M_2 is the mid-point of DM_1.
    M_3 is the mid-point of CM_2.
    M_4 is the mid-point of BM_3.
    Find the ratio of the area of $M_1M_2M_3M_4$ to the area of ABCD.

22. A proper 6-sided die has dots arranged so that the total number of dots on opposite faces always add to 7.
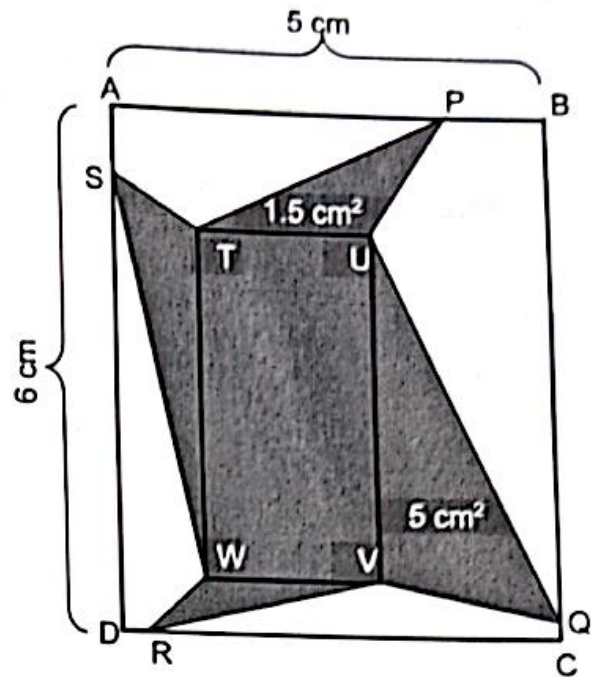
    When 27 of such dice are arranged to form a 3 × 3 × 3 cube that rests on an opaque surface, what is the maximum total number of dots observable?

16
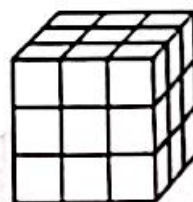
23. The shaded area of the given figure is $\frac{8}{15}$ of the area of rectangle ABCD. The area of triangle UVQ is 5 cm² and the area of triangle PTU is 1.5 cm².

Given that UV : BC is 2 : 3,

a) What is the area of triangle STW?

b) What is the area of triangle RVW?

24. A solid cone and a cylinder have the same base area and the same height. The volume of the cone is $\frac{1}{3}$ the volume of the cylinder.

The cylinder contains some water. When the cone is inverted, and placed inside the cylinder, the water level in the cylinder rose to $\frac{1}{3}$ of the height of the cylinder.

What fraction of the cylinder is filled with water?

$\frac{1}{3}$ of height {
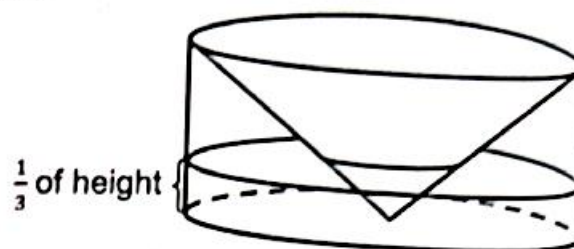
25. At 3 p.m., an ant and the tip of the minute hand are at the same position on the rim of a clock. The ant starts walking at a constant speed away from the minute hand anticlockwise round the rim of the clock face. When it meets the minute hand for the first time after 3 o'clock, the ant turns around and walks in the opposite direction, at the same constant speed. The ant meets the minute hand for a second time after a further 20 minutes. Again, the ant turns around and goes in the opposite direction at the same constant speed. At what time will the ant meet the minute hand for the third time after 3 p.m.?

End of Paper

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Section A

Each of the questions 1 to 5 carries 2 marks.

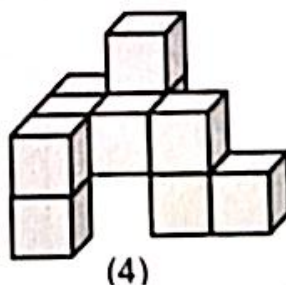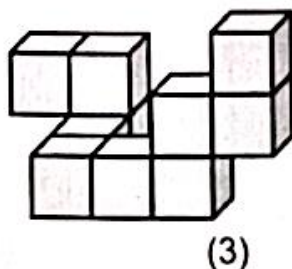1. At least how many rubber bands must you cut in each case so that all three bands can be separated?
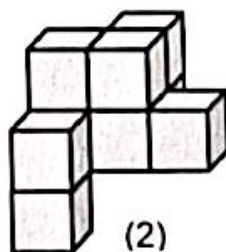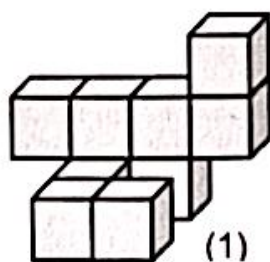

A   B   C   D

Choose one of the answer options.

|	A	B	C	D
(1)	1	2	1	1
(2)	2	1	0	2
(3)	2	1	2	0
(4)	1	2	1	2

2. Study Figure A and Figure B given.

A   B
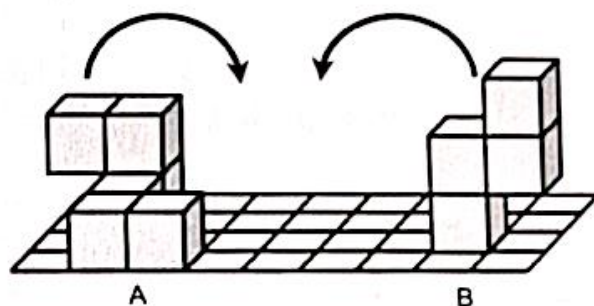
Which of the answer options below shows the resulting solid after Figure A has been rotated clockwise and Figure B has been rotated anticlockwise?

(1)

(2)

(3)

(4)

21

3. A square piece of paper with the letter A at the top left corner is folded as shown in Steps 1 and 2. Holes are then made through the layers after Step 2.
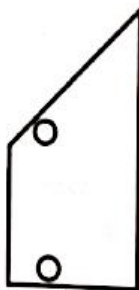

Step 1
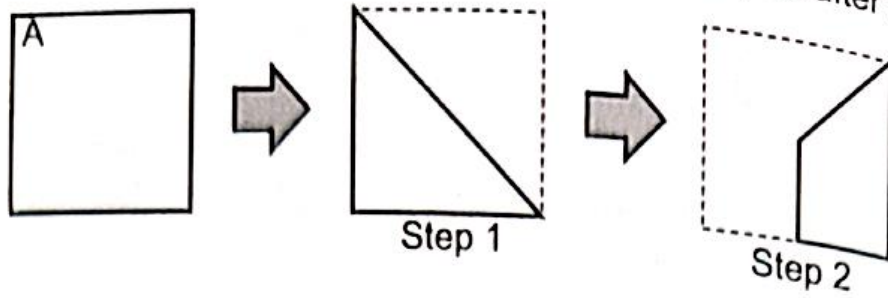
Step 2

When the paper is unfolded, the paper has holes as shown:
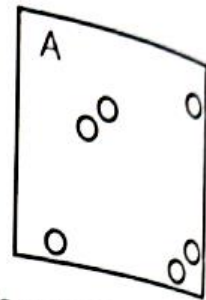
Which of the answer options below correctly shows the positions of the holes made after Step 2?
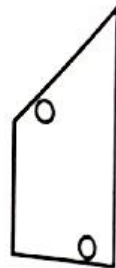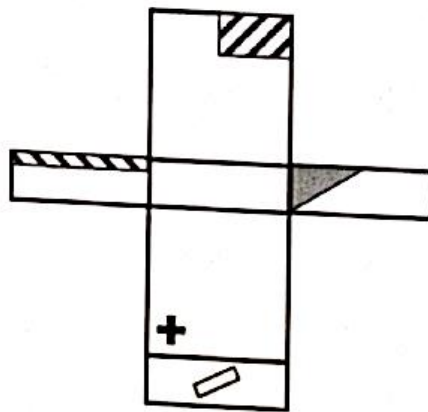

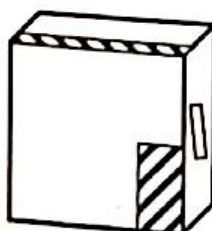(1)   (2)   (3)   (4)

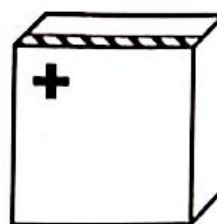4. Study the net given.

Which of the answer options below is INCORRECT in showing the 3D solid made from the net?
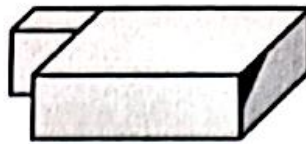

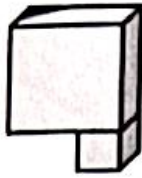(1)   (2)   (3)   (4)
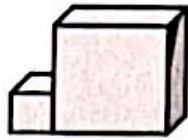
22

5. Study the 3D object given below.
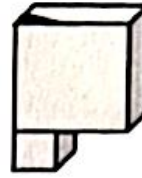
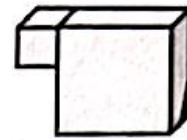Which of the following answer options is a rotation of the object?
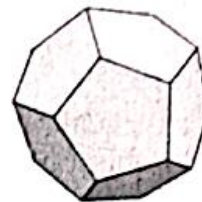
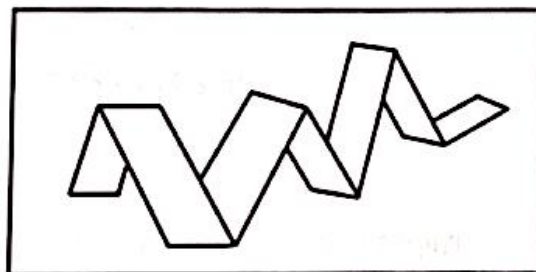(1)   (2)   (3)   (4)

ection B:
ach of questions 6 to 10 carries 3 marks.

The figure shown is a regular dodecahedron.
Each of its twelve faces is a regular pentagon.
How many edges does the dodecahedron have?

ı) Imagine that light is shining directly above this folded strip.
    In your Answer Sheet, shade the surface(s) of the strip, if any, which are
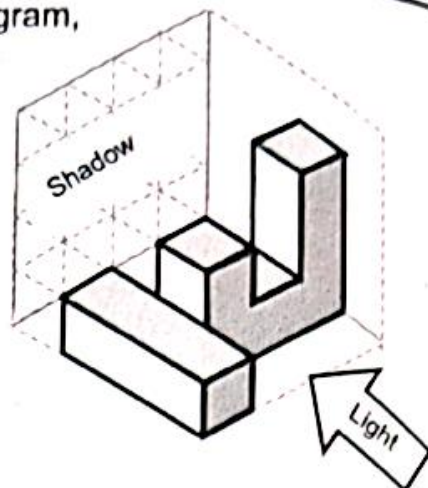   shadowed.

) Judging from the surfaces already shadowed, shade other surface(s), if any,
   which are shadowed.

23
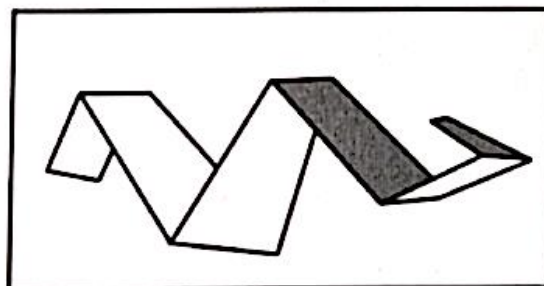
8. A source of light, as indicated by the arrow in the diagram, shines on the given 3D solid and casts a shadow.

   Draw and shade the shadow in the grid on your Answer Sheet.

9. You are given 9 square pieces of coloured paper.
   The colours are Blue, Black, White, Green, Pink, Purple, Red, Yellow and Orange. You are told to arrange the pieces of paper in a 3-by-3 arrangement according to the instructions given below:

   • Purple is vertically above Yellow and on the adjacent right of Green.

   • Black is on the adjacent right of Blue and vertically above Yellow.

   • Yellow is on the adjacent left of Orange.

   • Orange is not adjacent to White.

   • Blue is vertically above Red and Green.
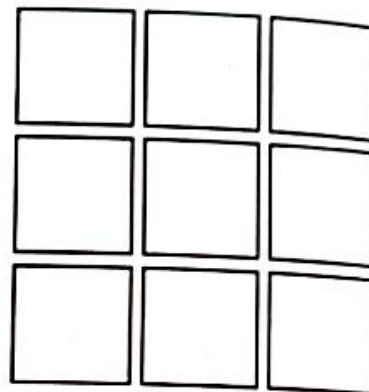
   Where is Pink?
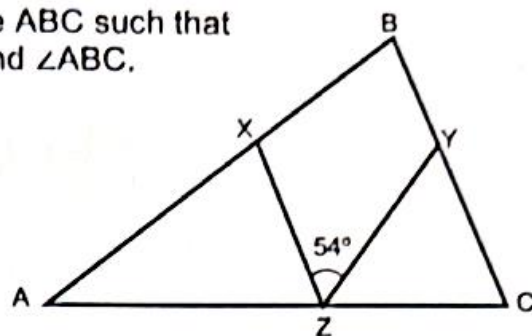   Write the word 'Pink' in the correct position on the Answer Sheet.

10. In the grid below, how many straight line segments can be drawn that joins exactly two dots and passes through one dot in between?
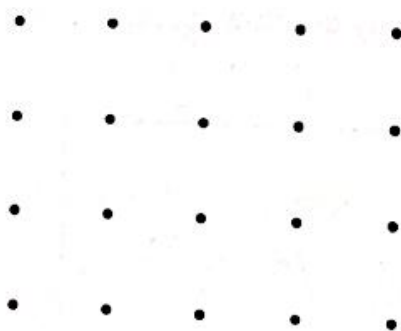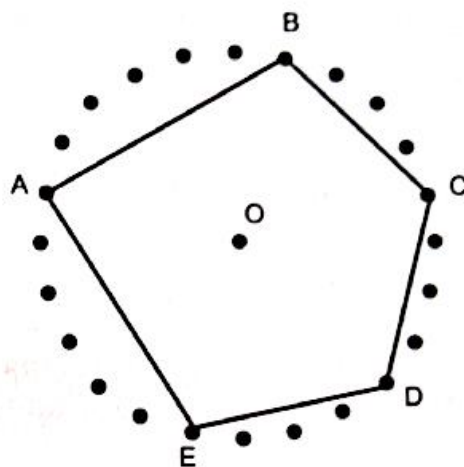
Section C
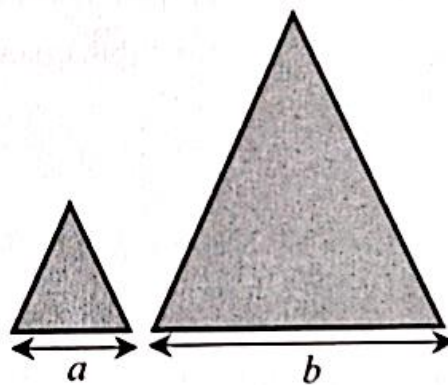Each of the questions 11 to 20 carries 4 marks.

11. Given that X, Y and Z are points on triangle ABC such that AX = AZ and CY = CZ, and $\angle XZY = 54°$, find $\angle ABC$.
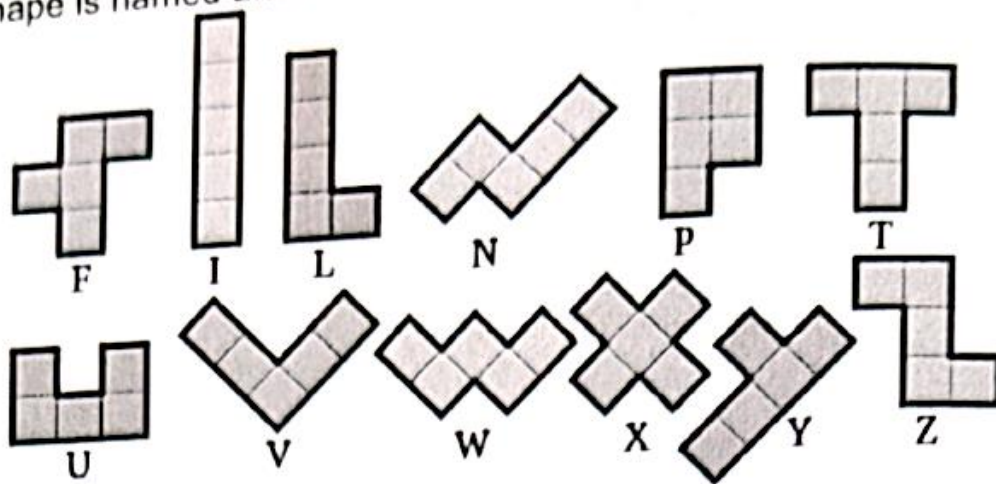
12. The dots around the circle in the diagram are equally spaced. Find $\angle ACE$.

13. Both triangles shown below are similar triangles.
    If the area of the small triangle is 16% of the area of the large triangle, what is the ratio of a to b ?

14. The figures below are twelve 2-dimensional pentomino shapes. Each shape is named after a letter which it resembles.

This is a 3-dimensional drawing of the T-shaped pentomino:
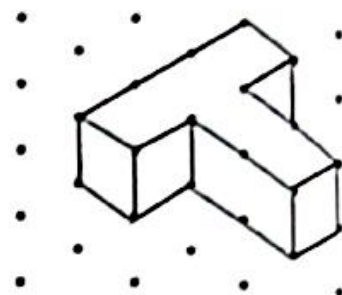
This is part of a 3-dimensional drawing of another pentomino: Which pentomino is it? (State the letter it resembles.)
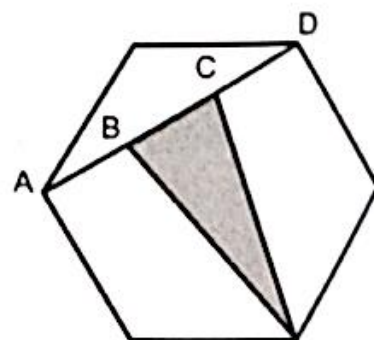

15. The hexagons shown below are regular hexagons.

   a) What fraction of this hexagon is shaded?

   b) Given that AD is a straight line and AB = BC = CD, what fraction of this hexagon is shaded?
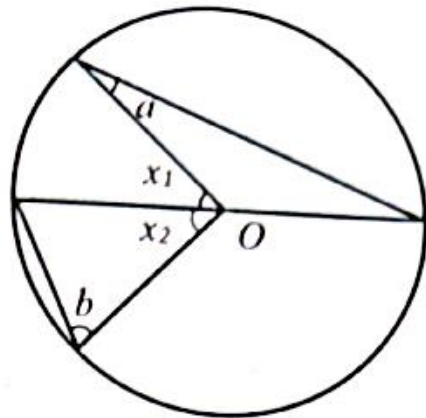
16. O is the centre of the circle.
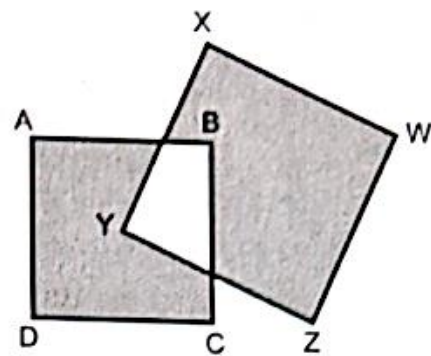   Given that $\angle x_1 = \angle x_2$,
    what is the value of $\angle a + \angle b$?

17. ABCD is a square of side of 10 cm, WXYZ is a square of side 12 cm.
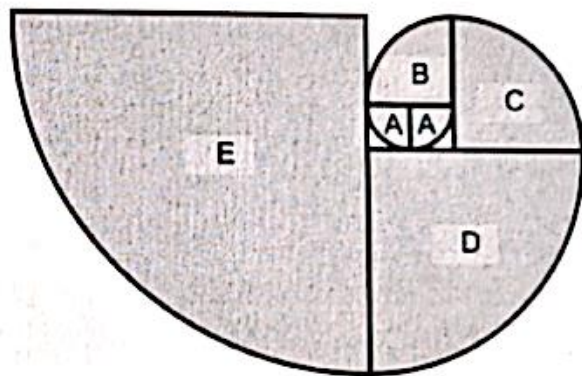   Y is the centre of square ABCD.
    What is the total area of the shaded parts of the figure?

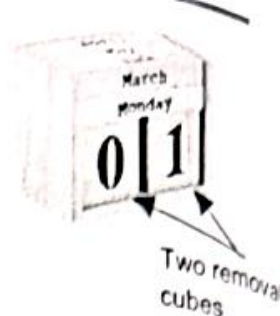18. The figure below is made of 6 quadrants – A, A, B, C, D and E.
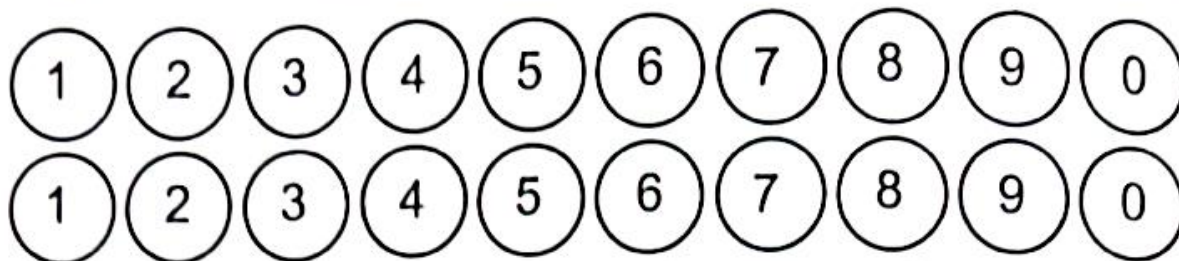   If the area of quadrant A is 1 unit^2, what is the area of the shaded figure?

19. What is the angle of each vertex of a regular n-sided polygon?
    Give your answer in terms of n.

20. By fixing numbered stickers on two cubes, you could form all the dates from 01 to 31 on a calendar.

You have these number stickers:

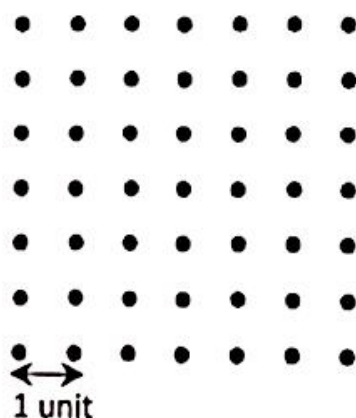$$\text{①②③④⑤⑥⑦⑧⑨⓪}$$

$$\text{①②③④⑤⑥⑦⑧⑨⓪}$$

If you have pasted the three number stickers, 3, 4 and 6, on the first cube, what is the sum of the six numbers you should paste on the second cube?

Section E
Each of the questions 21 to 25 carries 5 marks.

21. In the grid on your Answer Sheet, draw a square with an area of 20 unit². Each corner of the square must touch a dot.


1 unit

22. The time shown on a clock is 5 minutes past 2 o'clock. How many minutes later will the minute and hour hands of the clock next make an angle of 50°?
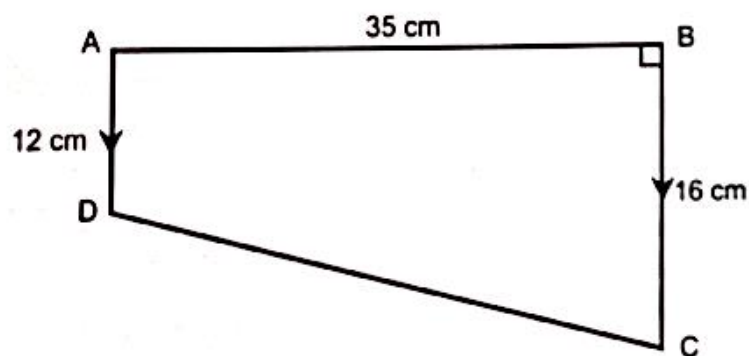
23. In the figure, the areas of triangles ABF, DFG, CDG are 42 cm², 3 cm² and 6 cm² respectively. AF is 6 times as long as FD. Find the difference of the areas of AEF and DEF.
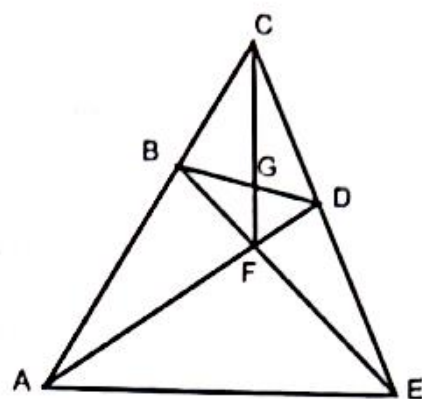
24. I have a sphere which fits exactly into a cylinder.
I want to fill the cylinder with water such that when I place the sphere inside the cylinder, the water will just reach the brim without spilling out.
If the capacity of the cylinder is 900 ml, how much water should I put into the cylinder, given that volume of sphere = $\frac{4}{3}\pi r^3$ where r is the radius of both the sphere and the radius of the base of the cylinder.
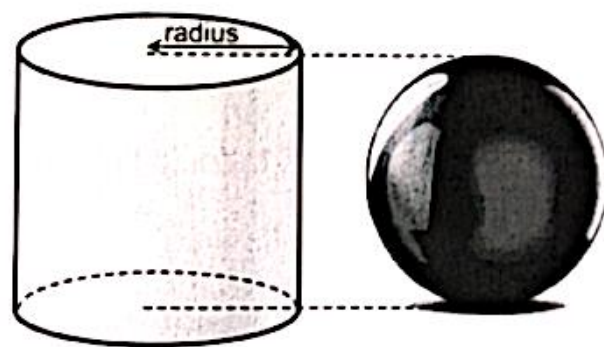
25. AD, AB and BC are three sides of a trapezium where AD is parallel to BC and AB is perpendicular to BC. X is a point on AB such that the sum of the lengths of DX and XC is the least. What is the length of AX?

End of Paper

29