Exploring Some Geometric Themes

Standard difficulty · 20 questions · 40 marks · Time: 32 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. A solid has 8 faces and 12 vertices. By Euler's formula, how many edges does it have?
(a) 22 **(b)** 20 **(c)** 19 **(d)** 18

2. A design starts with 5 shaded triangles. Each step of the Sierpinski pattern replaces every shaded triangle with 3 smaller ones. After 5 steps, how many shaded triangles are there?
(a) 1215 **(b)** 75 **(c)** 5120 **(d)** 1220

3. Euler's formula for a solid with flat faces is:
(a) F − V − E = 0 **(b)** F + V + E = 2 **(c)** F + V − E = 2 **(d)** F + E − V = 2

4. A prism has a hexagonal base. How many faces does it have?
(a) 7 **(b)** 6 **(c)** 8 **(d)** 12

5. A pyramid has a triangular base. How many edges does it have?
(a) 6 **(b)** 4 **(c)** 9 **(d)** 3

6. A prism has a nonagonal base. How many vertices does it have?
(a) 18 **(b)** 11 **(c)** 9 **(d)** 27

7. A pentagonal prism has how many edges?
(a) 7 **(b)** 15 **(c)** 10 **(d)** 12

8. A Koch-style fractal starts as a shape with 8 sides. Each step turns every side into 4 sides. After 3 steps, how many sides are there?
(a) 20 **(b)** 216 **(c)** 64 **(d)** 512

Section B — Short answer — 8 × 2 = 16 marks

9. For a prism with a heptagonal base, find the number of faces, vertices and edges, and check Euler's formula.

10. For a pyramid with a decagonal base, find the number of faces, vertices and edges, and check Euler's formula.

11. A Sierpinski triangle starts with an area of 176 cm^2. Each step keeps 3 of the 4 smaller triangles. What fraction of the area is still shaded after 2 steps, and how many cm^2 is that?

12. A Koch snowflake starts as an equilateral triangle of side 27 cm. Each step replaces every side with 4 sides, each a third as long. What is the perimeter after 3 steps?

13. An 8 × 5 × 5 block is painted on the outside and cut into 200 unit cubes. How many cubes have paint on exactly 3, 2, 1 and 0 faces?

14. A solid has F = 18, E = 48. Use Euler's formula to find V.

15. A net for a cuboid 20 cm × 10 cm × 9 cm is cut from card. How much card does the net use (its total surface area)?

16. A staircase is built from cubes: 1 cube in the first column, 2 in the next, up to 4 in the last. How many cubes is that? How many would a 4-step pyramid of squares (1^2, 2^2, …) need?

Section C — Word problems — 4 × 4 = 16 marks

17. Ananya paints a big wooden cube and cuts it into 216 equal small cubes (6 along each edge). How many small cubes have no paint at all? How many have paint on exactly two faces?

18. Vikram draws a Sierpinski triangle for a poster, going 6 steps deep. How many shaded triangles are there at the end, and what fraction of the big triangle is shaded?

19. A gift box 22 cm long, 24 cm wide and 13 cm high is made from a single net of card. How much card is needed? How much for 10 boxes?

20. A tent is shaped like a pyramid with a nonagonal base. How many faces, vertices and edges does it have? Check that Euler's formula holds.

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Answer key

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Q	Answer	Working
1	**(d) 18**	F + V − E = 2: 8 + 12 − 2 = 18
2	**(a) 1215**	5×3^5
3	**(c) F + V − E = 2**	faces, vertices, edges
4	**(c) 8**	6 side faces + 2 bases
5	**(a) 6**	3 round the base + 3 up to the apex
6	**(a) 18**	9 on each of the 2 bases
7	**(b) 15**	3 × 5
8	**(d) 512**	8×4^3
9	**F = 9, V = 14, E = 21; 9 + 14 − 21 = 2**	faces 7 + 2, vertices 2 × 7, edges 3 × 7
10	**F = 11, V = 11, E = 20; 11 + 11 − 20 = 2**	faces 10 + 1, vertices 10 + 1, edges 2 × 10
11	**9/16; 99 cm^2**	$(3/4)^2 \times 176 = 99$
12	**192 cm**	the perimeter is multiplied by 4/3 each step: $81 \times (4/3)^3$
13	**3 faces: 8; 2 faces: 48; 1 face: 90; none: 54**	corners 8; edges 4 × (6 + 3 + 3); faces 2 × (18 + 9 + 18); inside 6 × 3 × 3
14	**32**	F + V − E = 2
15	**940 cm^2**	2 × (200 + 90 + 180)
16	**10; 30**	1 + 2 + … + 4; $1^2 + 2^2 + \ldots + 4^2$
17	**64 with no paint; 48 with two faces**	inside cube 4^3; 12 edges × 4
18	**729; 729/4096**	3^6 triangles, each $1/4^6$ of the area
19	**2252 cm^2; 22520 cm^2**	2 × (528 + 312 + 286)
20	**10 faces, 10 vertices, 18 edges; 10 + 10 − 18 = 2**	a pyramid: 9 + 1 faces, 9 + 1 vertices, 2 × 9 edges

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