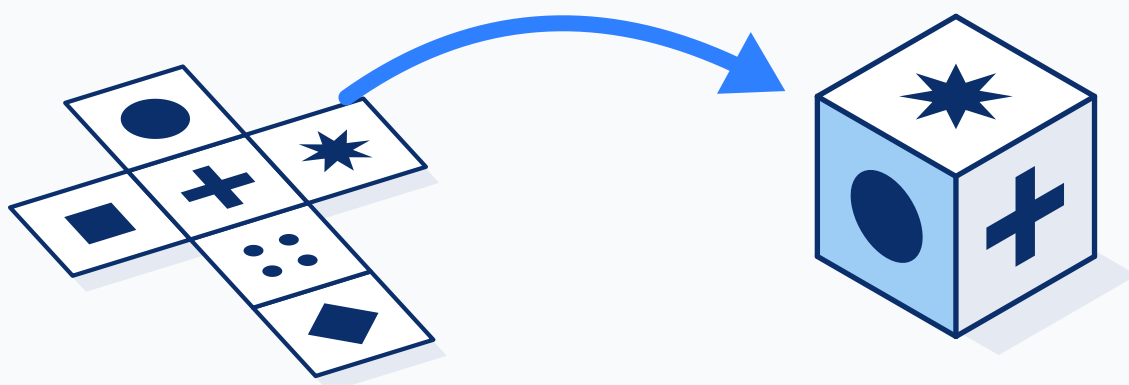


3D Spatial Reasoning

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Cube nets • Views of 3D shapes • Turning 3D shapes • Paper folding

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In this sample

These pages come from 3D Spatial Reasoning, Book 1: Foundation. Each of its four sections starts here as it does in the book, with what to do, three tips and two worked examples, followed by its first 10 questions. The question numbers are the book's own.

Work through a set, then mark it with the quick answer key on page 20. The answers and explanations, from page 21, say why the right answer is right and why each of the others is wrong.

Every question has exactly one right answer.

Before printing, each question was checked by computer, twice, by two methods written independently. A question was used only if both methods found exactly one correct option and the drawing itself settled the answer. Page 25 explains the checks.

Section 1: Cube nets (questions 1 to 10)	3
Section 2: Views of 3D shapes (questions 51 to 60)	7
Section 3: Turning 3D shapes (questions 101 to 110)	11
Section 4: Paper folding (questions 151 to 160)	15
Quick answer key	20
Answers and explanations	21
How every answer was checked	25
The full book	26

SECTION 1

Cube nets

What to do

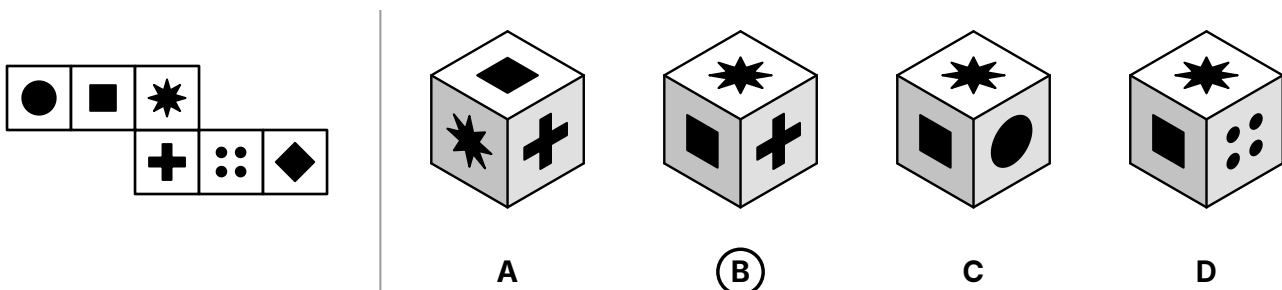
Each net folds up to make a cube, with the patterns on the outside. Find the one cube, out of four, that the net could make.

How to solve it

1. Find the pairs of opposite faces first. Two squares in a straight line on the net, with one square between them, end up opposite each other. Two opposite faces can never be seen at the same time.
2. Squares that touch along an edge on the net are next to each other on the cube.
3. Check the order. Imagine folding the net up around one face you can see, and check that the other two faces land on the correct sides of it. A mirror-image order is always wrong.

Worked example 1

Ex. This net folds to make a cube, with the patterns on the outside. Which cube could it make?



Answer B. The cross, star and square meet at one corner of the folded cube in this order.

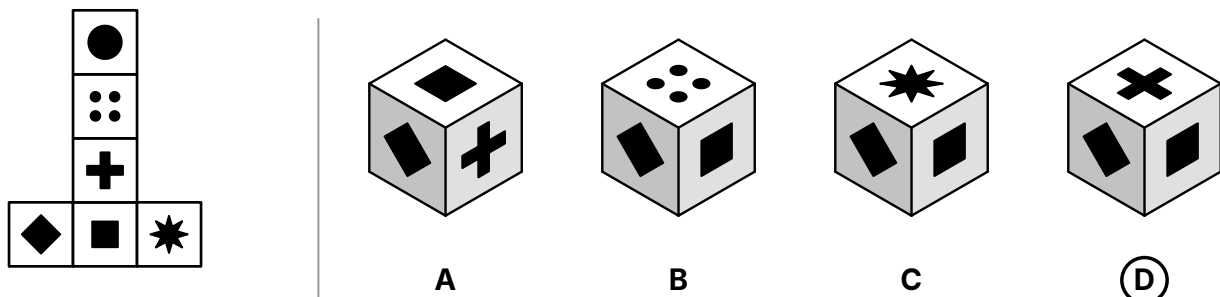
A is wrong: these faces are next to each other on the cube, but in mirror-image order.

C is wrong: the circle and the star are on opposite faces, so they cannot be seen together.

D is wrong: the four dots and the square are on opposite faces, so they cannot be seen together.

Worked example 2

Ex. This net folds to make a cube, with the patterns on the outside. Which cube could it make?



Answer D. The square, cross and diamond meet at one corner of the folded cube in this order.

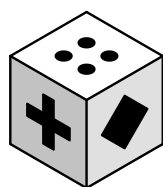
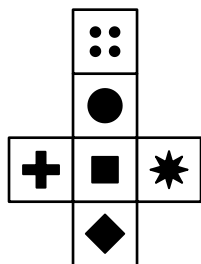
A is wrong: these faces are next to each other on the cube, but in mirror-image order.

B is wrong: the square and the four dots are on opposite faces, so they cannot be seen together.

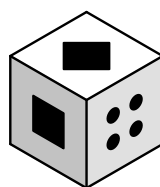
C is wrong: the star and the diamond are on opposite faces, so they cannot be seen together.

Set 1 · Questions 1 to 10

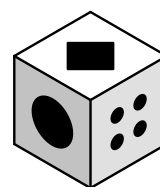
- 1 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



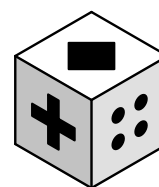
A



B

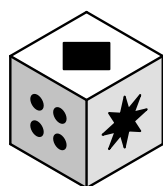
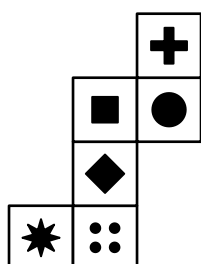


C

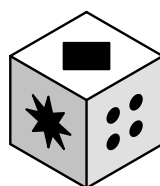


D

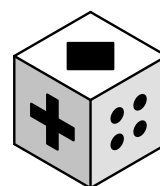
- 2 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



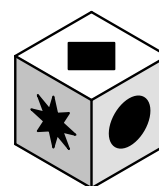
A



B

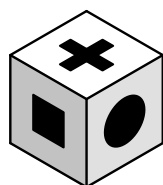
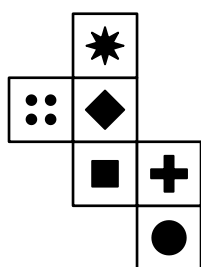


C

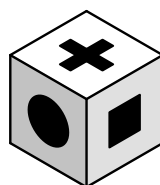


D

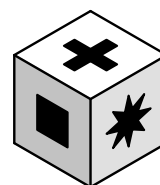
- 3 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



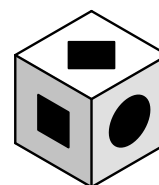
A



B

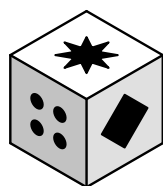
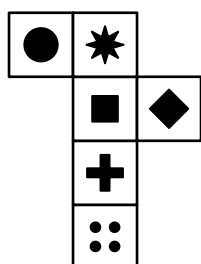


C

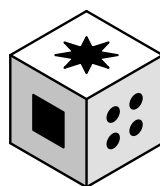


D

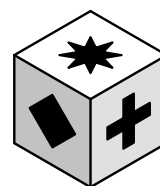
- 4 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



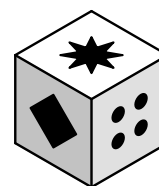
A



B

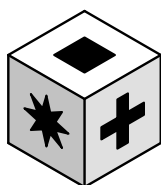
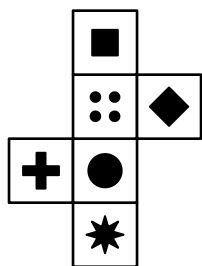


C

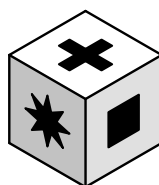


D

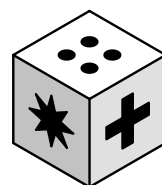
- 5 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



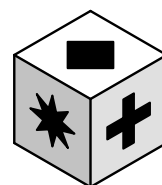
A



B

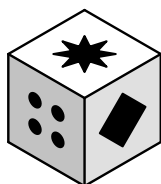
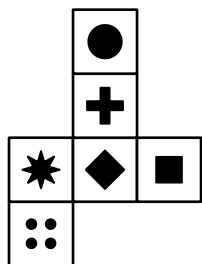


C

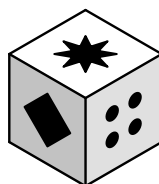


D

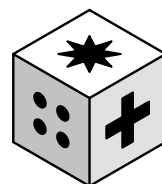
- 6 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



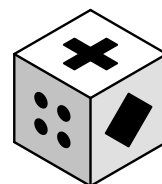
A



B

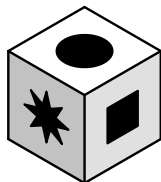
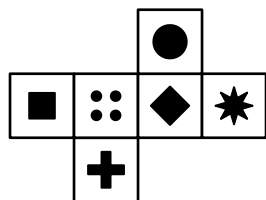


C

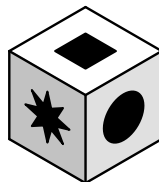


D

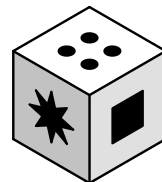
- 7 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



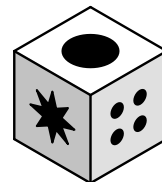
A



B

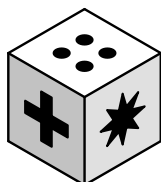
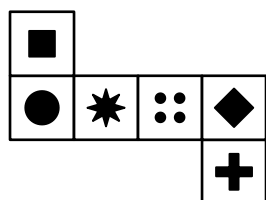


C

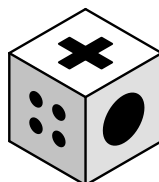


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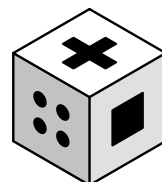
- 8 This net folds to make a cube, with the patterns on the outside. Which cube could it make?



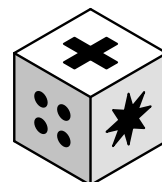
A



B

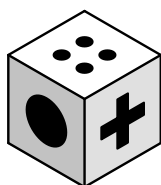
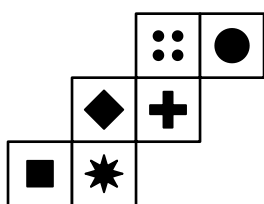
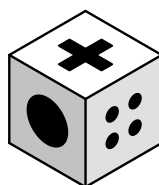
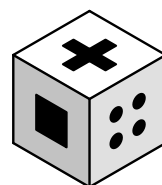
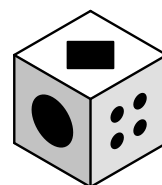


C

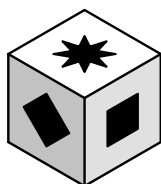
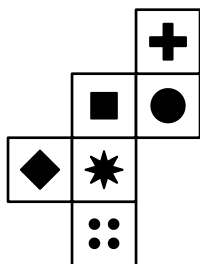
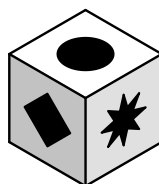
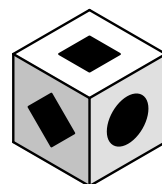
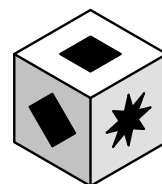


D

- 9** This net folds to make a cube, with the patterns on the outside. Which cube could it make?

**A****B****C****D**

- 10** This net folds to make a cube, with the patterns on the outside. Which cube could it make?

**A****B****C****D**

Score: _____ out of 10

SECTION 2

Views of 3D shapes

What to do

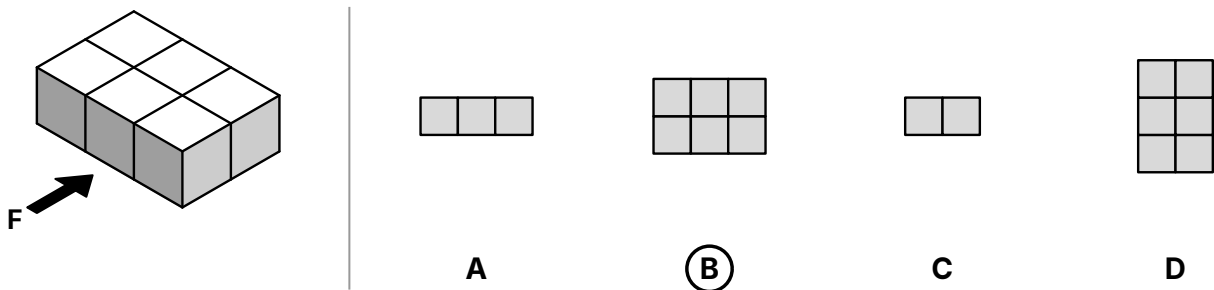
Each shape is made of the number of cubes stated, and every cube sits on the table or on top of another cube. In this book every cube can be seen. Arrow F marks the front. Find the view asked for.

How to solve it

1. View from above: look straight down. Each column of cubes, however tall, shows as one square. The front, marked F, is at the bottom of the view.
2. View from the front: look along arrow F. Each column of squares is as tall as the tallest stack in that line, from front to back.
3. Keep left and right the right way round. Seen from the front, the shape's left side stays on the left.

Worked example 1

Ex. This shape is made of 6 cubes. Every cube sits on the table or on another cube. Which is the view from above? (The front, marked F, is at the bottom.)



Answer B. This is the view from above.

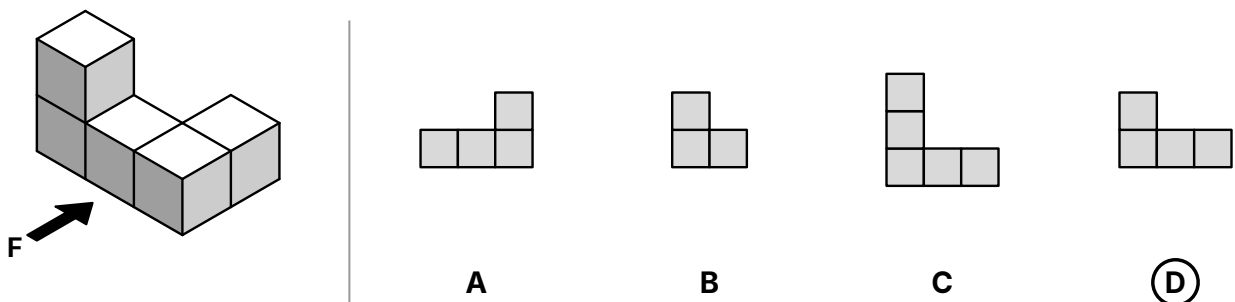
A is wrong: this is the view from the front.

C is wrong: this is the view from the side.

D is wrong: this is the right view turned round.

Worked example 2

Ex. This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from the front, looking in the direction of arrow F?



Answer D. This is the view from the front.

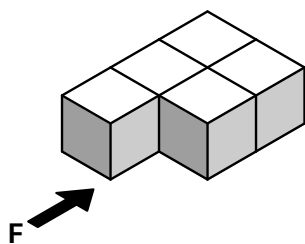
A is wrong: this is the right view reversed, left to right.

B is wrong: this is the view from the side.

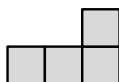
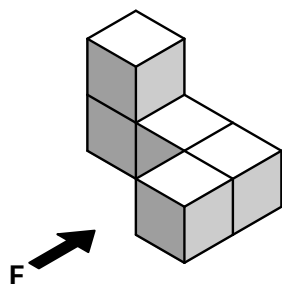
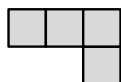
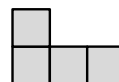
C is wrong: this has a square too many.

Set 1 · Questions 51 to 60

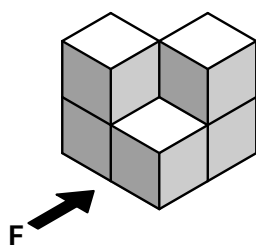
- 51** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from the front, looking in the direction of arrow F?

**A****B****C****D**

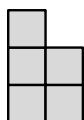
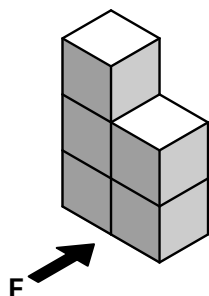
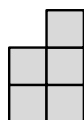
- 52** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from the front, looking in the direction of arrow F?

**A****B****C****D**

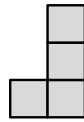
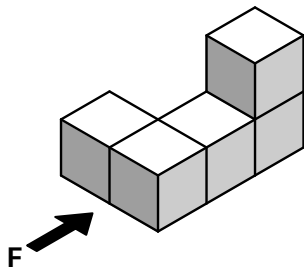
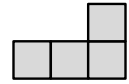
- 53** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from above? (The front, marked F, is at the bottom.)

**A****B****C****D**

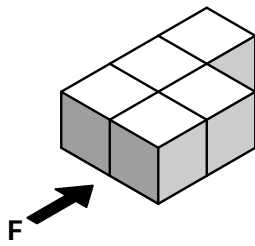
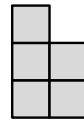
- 54** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from the front, looking in the direction of arrow F?

**A****B****C****D**

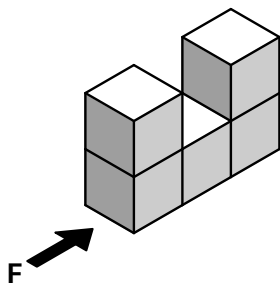
- 55** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from above? (The front, marked F, is at the bottom.)

**A****B****C****D**

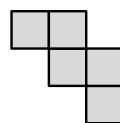
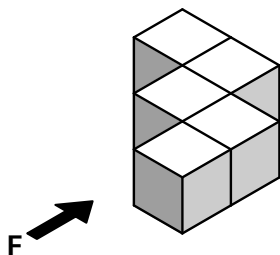
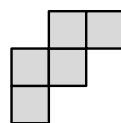
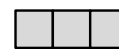
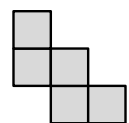
- 56** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from the front, looking in the direction of arrow F?

**A****B****C****D**

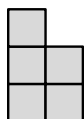
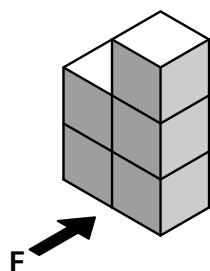
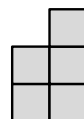
- 57** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from the front, looking in the direction of arrow F?

**A****B****C****D**

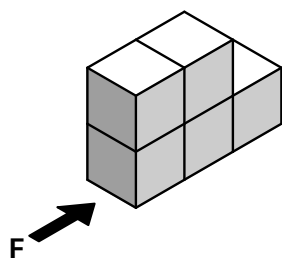
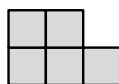
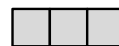
- 58** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from above? (The front, marked F, is at the bottom.)

**A****B****C****D**

- 59** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from the front, looking in the direction of arrow F?

**A****B****C****D**

- 60** This shape is made of 5 cubes. Every cube sits on the table or on another cube. Which is the view from above? (The front, marked F, is at the bottom.)

**A****B****C****D**

Score: _____ out of 10

SECTION 3

Turning 3D shapes

What to do

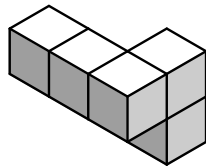
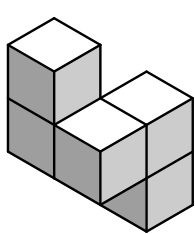
All the shapes are made of 5 cubes joined face to face. Find the one option that is the first shape turned around. A mirror image does not count.

How to solve it

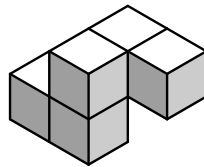
1. Pick a part of the first shape that stands out, such as a long arm or a corner, and look for it in each option.
2. Count the cubes along each arm. Turning a shape never changes these counts.
3. Check how the arms are arranged. A mirror image has the same arms the other way round, and no turn can make it match.

Worked example 1

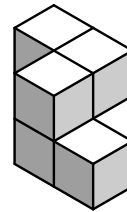
Ex. Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.



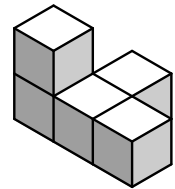
A



(B)



C



D

Answer B. This is the first shape, turned.

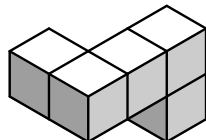
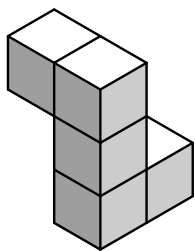
A is wrong: this is a different shape: its cubes are not arranged the same way.

C is wrong: this is a mirror image of the first shape. No turn can make it match.

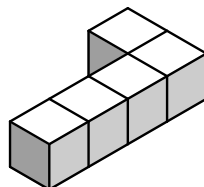
D is wrong: this is a different shape: its cubes are not arranged the same way.

Worked example 2

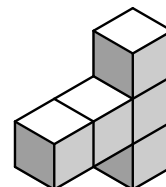
Ex. Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.



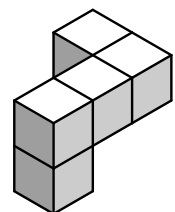
A



B



C



(D)

Answer D. This is the first shape, turned.

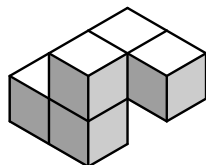
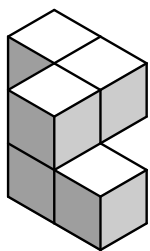
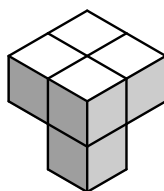
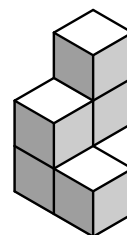
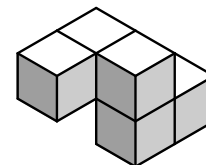
A is wrong: this is a mirror image of the first shape. No turn can make it match.

B is wrong: this is a different shape: its cubes are not arranged the same way.

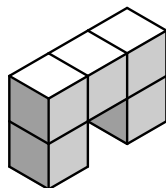
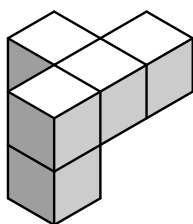
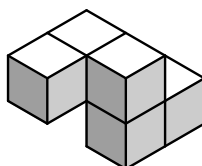
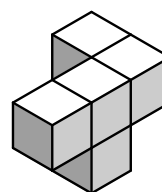
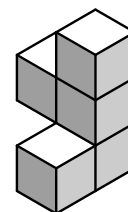
C is wrong: this is a different shape: its cubes are not arranged the same way.

Set 1 · Questions 101 to 110

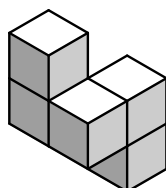
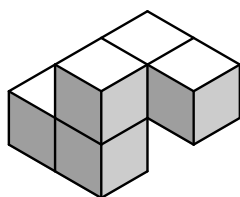
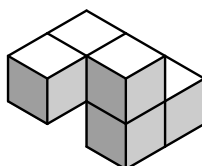
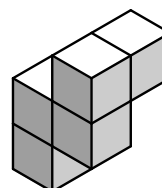
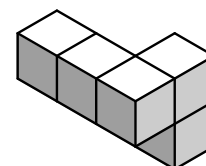
- 101** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

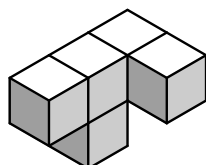
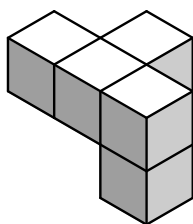
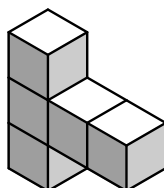
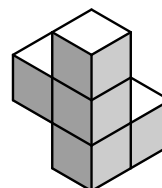
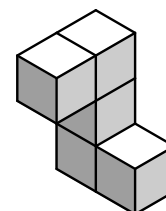
- 102** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

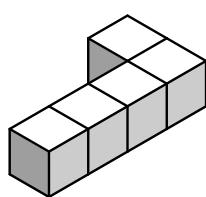
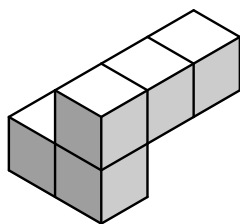
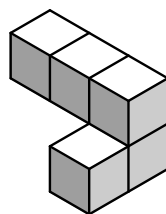
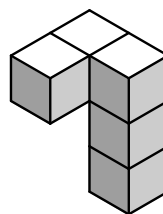
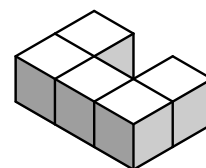
- 103** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

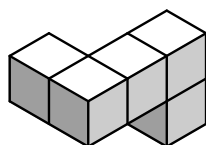
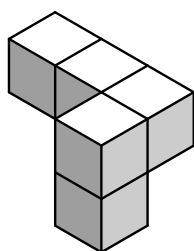
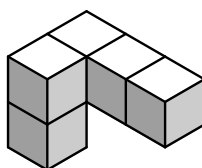
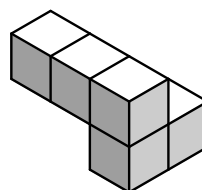
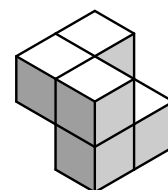
- 104** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

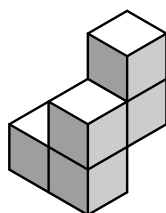
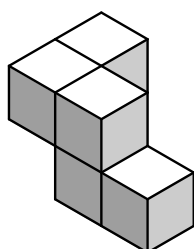
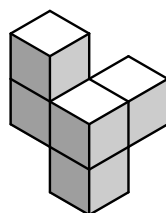
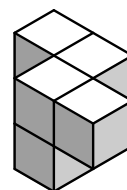
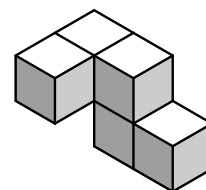
- 105** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

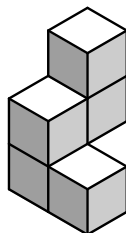
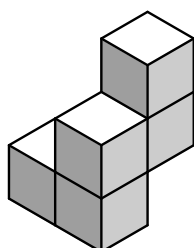
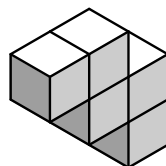
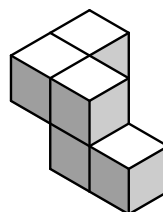
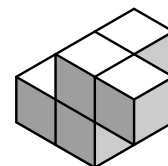
- 106** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

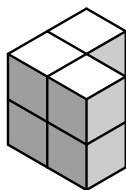
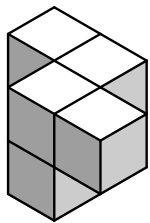
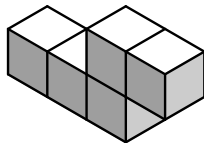
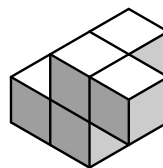
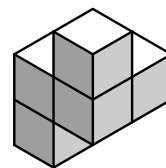
- 107** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

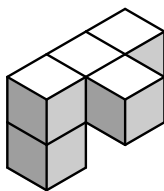
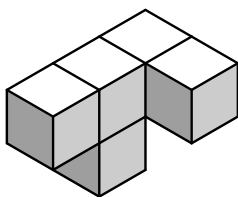
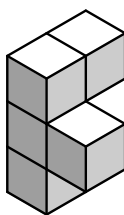
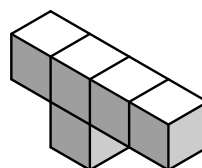
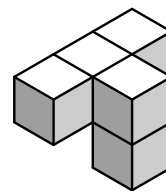
- 108** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

- 109** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

- 110** Which shape is the first shape turned around? All the shapes are made of 5 cubes joined face to face.

**A****B****C****D**

Score: _____ out of 10

SECTION 4

Paper folding

What to do

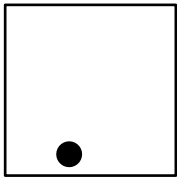
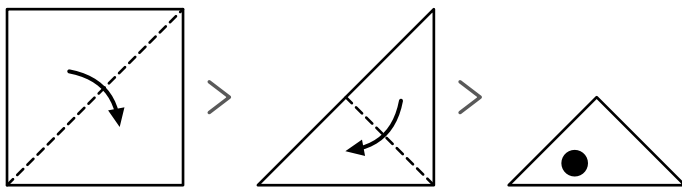
A square of paper is folded as shown, then a hole is punched through all the layers. Find the paper as it looks when it is opened out flat.

How to solve it

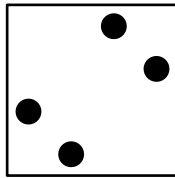
1. Open the folds one at a time, starting with the last one.
2. Each time you open a fold, every hole is copied to its mirror position across the fold line.
3. Count the holes. A punch through 2 layers makes 2 holes; through 4 layers it makes 4.

Worked example 1

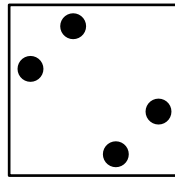
Ex. A square of paper is folded twice as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?



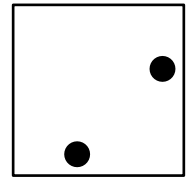
A



B



C



D

Answer B. The punch goes through 4 layers, so the open sheet has 4 holes in this pattern.

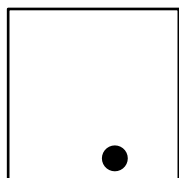
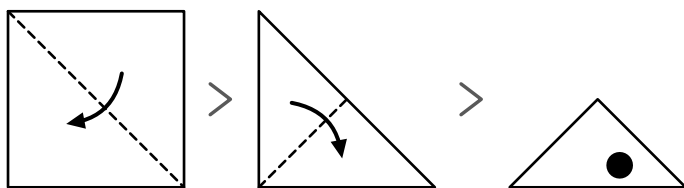
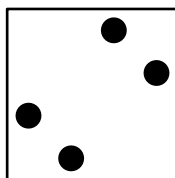
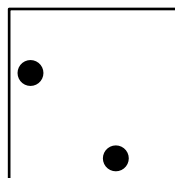
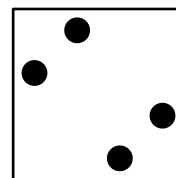
A is wrong: this shows only where the punch went in, before any fold is opened.

C is wrong: this is the right pattern reflected.

D is wrong: this shows the paper with only 1 of the 2 folds opened out.

Worked example 2

Ex. A square of paper is folded twice as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****(D)**

Answer D. The punch goes through 4 layers, so the open sheet has 4 holes in this pattern.

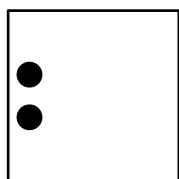
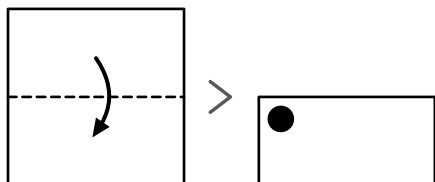
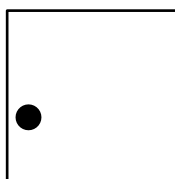
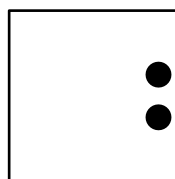
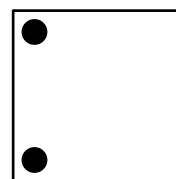
A is wrong: this shows only where the punch went in, before any fold is opened.

B is wrong: this is the right pattern reflected.

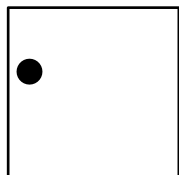
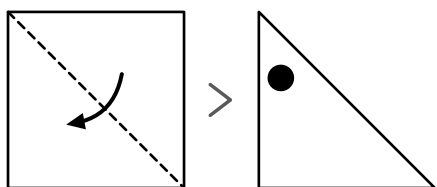
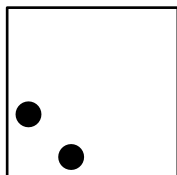
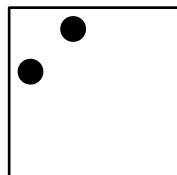
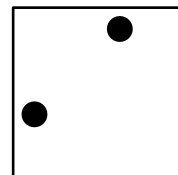
C is wrong: this shows the paper with only 1 of the 2 folds opened out.

Set 1 · Questions 151 to 160

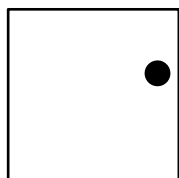
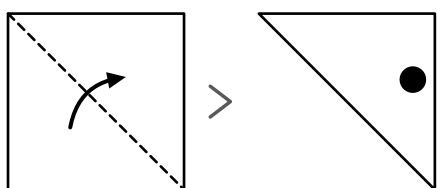
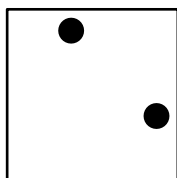
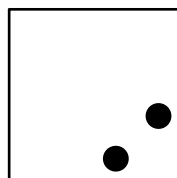
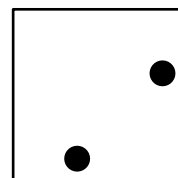
151 A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****D**

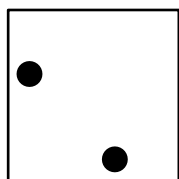
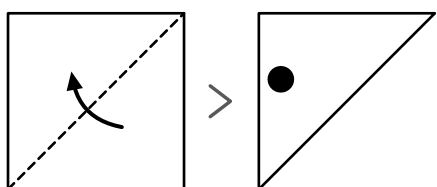
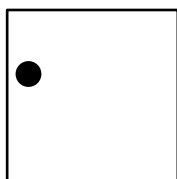
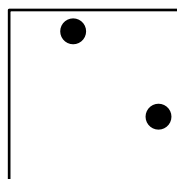
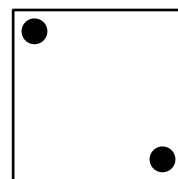
- 152** A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****D**

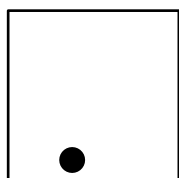
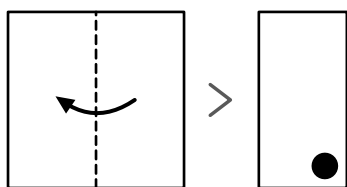
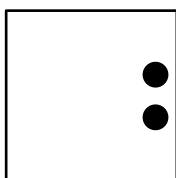
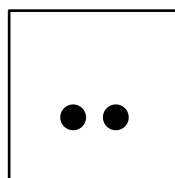
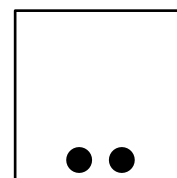
- 153** A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****D**

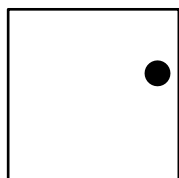
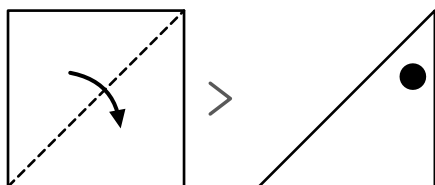
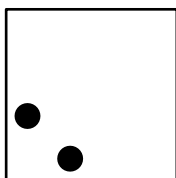
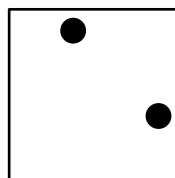
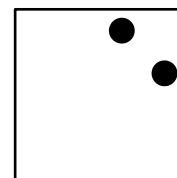
- 154** A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****D**

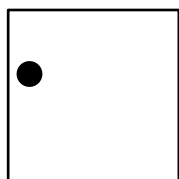
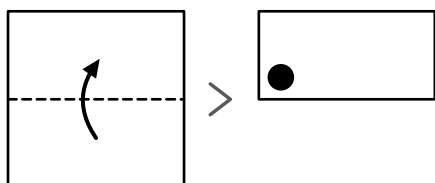
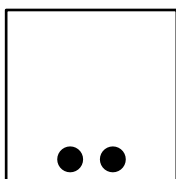
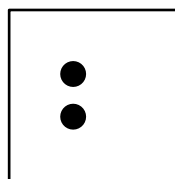
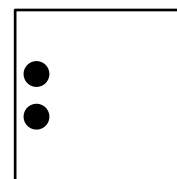
- 155** A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****D**

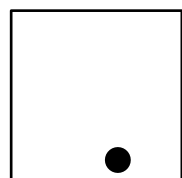
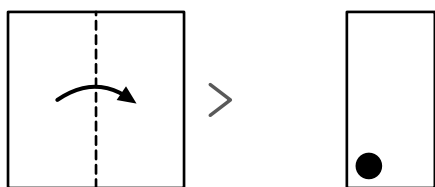
- 156** A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****D**

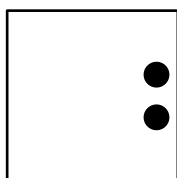
- 157** A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?

**A****B****C****D**

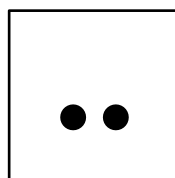
- 158** A square of paper is folded once as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?



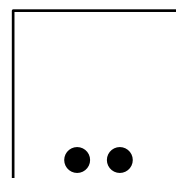
A



B

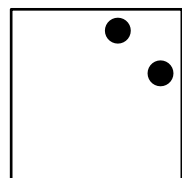
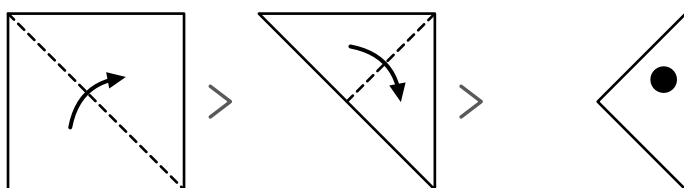


C

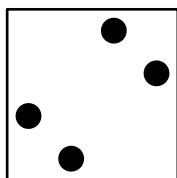


D

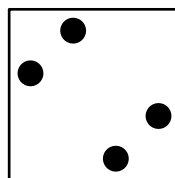
- 159** A square of paper is folded twice as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?



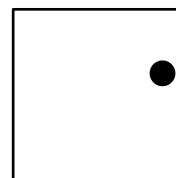
A



B

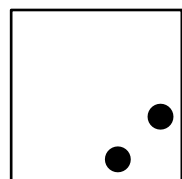
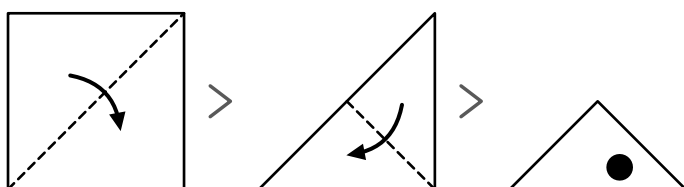


C

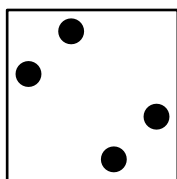


D

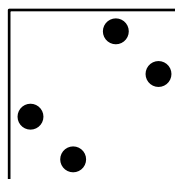
- 160** A square of paper is folded twice as shown, then a hole is punched through all the layers. Which shows the paper when it is opened out?



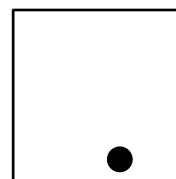
A



B



C



D

Score: _____ out of 10

Quick answer key

The letter of the right answer to every question, for quick marking. Each row is one set of 10 questions. Why each answer is right, and why the others are wrong, is explained from page 21.

Section 1: Cube nets

Set 1	1	D	2	B	3	A	4	D	5	A	6	A	7	A	8	D	9	B	10	D
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Section 2: Views of 3D shapes

Set 1	51	B	52	C	53	A	54	A	55	A	56	A	57	B	58	A	59	C	60	D
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Section 3: Turning 3D shapes

Set 1	101	D	102	C	103	A	104	A	105	B	106	C	107	A	108	C	109	D	110	A
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Section 4: Paper folding

Set 1	151	A	152	C	153	D	154	A	155	D	156	D	157	D	158	D	159	B	160	B
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Answers and explanations

Section 1: Cube nets

- 1 **D The four dots, diamond and cross meet at one corner of the folded cube in this order.**
 A: These faces are next to each other on the cube, but in mirror-image order.
 B: The four dots and the square are on opposite faces, so they cannot be seen together.
 C: The diamond and the circle are on opposite faces, so they cannot be seen together.
- 2 **B The four dots, diamond and star meet at one corner of the folded cube in this order.**
 A: These faces are next to each other on the cube, but in mirror-image order.
 C: The diamond and the cross are on opposite faces, so they cannot be seen together.
 D: The circle and the star are on opposite faces, so they cannot be seen together.
- 3 **A The circle, cross and square meet at one corner of the folded cube in this order.**
 B: These faces are next to each other on the cube, but in mirror-image order.
 C: The star and the square are on opposite faces, so they cannot be seen together.
 D: The circle and the diamond are on opposite faces, so they cannot be seen together.
- 4 **D The four dots, star and diamond meet at one corner of the folded cube in this order.**
 A: These faces are next to each other on the cube, but in mirror-image order.
 B: The four dots and the square are on opposite faces, so they cannot be seen together.
 C: The cross and the star are on opposite faces, so they cannot be seen together.
- 5 **A The cross, square and star meet at one corner of the folded cube in this order.**
 B: These faces are next to each other on the cube, but in mirror-image order.
 C: The four dots and the star are on opposite faces, so they cannot be seen together.
 D: The cross and the diamond are on opposite faces, so they cannot be seen together.
- 6 **A The diamond, star and four dots meet at one corner of the folded cube in this order.**
 B: These faces are next to each other on the cube, but in mirror-image order.
 C: The cross and the four dots are on opposite faces, so they cannot be seen together.
 D: The cross and the four dots are on opposite faces, so they cannot be seen together.
- 7 **A The square, circle and star meet at one corner of the folded cube in this order.**
 B: These faces are next to each other on the cube, but in mirror-image order.
 C: The four dots and the star are on opposite faces, so they cannot be seen together.
 D: The four dots and the star are on opposite faces, so they cannot be seen together.
- 8 **D The star, cross and four dots meet at one corner of the folded cube in this order.**
 A: These faces are next to each other on the cube, but in mirror-image order.
 B: The circle and the four dots are on opposite faces, so they cannot be seen together.
 C: The square and the cross are on opposite faces, so they cannot be seen together.
- 9 **B The four dots, cross and circle meet at one corner of the folded cube in this order.**
 A: These faces are next to each other on the cube, but in mirror-image order.
 C: The cross and the square are on opposite faces, so they cannot be seen together.
 D: The diamond and the circle are on opposite faces, so they cannot be seen together.
- 10 **D The star, square and diamond meet at one corner of the folded cube in this order.**
 A: These faces are next to each other on the cube, but in mirror-image order.
 B: The circle and the diamond are on opposite faces, so they cannot be seen together.
 C: The circle and the diamond are on opposite faces, so they cannot be seen together.

Section 2: Views of 3D shapes

- 51 **B This is the view from the front.**
 A: This is the view from above.
 C: This is the view from the side.
 D: This is missing a square.

- 52 C This is the view from the front.**
 A: This is the right view reversed, left to right.
 B: This is the view from above.
 D: This is the view from the side.
- 53 A This is the view from above.**
 B: This is the right view reversed, left to right.
 C: This is the view from the front.
 D: This is the right view turned round.
- 54 A This is the view from the front.**
 B: This is the right view reversed, left to right.
 C: This is the view from above.
 D: This is the view from the side.
- 55 A This is the view from above.**
 B: This is the right view reversed, left to right.
 C: This is the view from the front.
 D: This is the view from the side.
- 56 A This is the view from the front.**
 B: This is the view from above.
 C: This is the view from the side.
 D: This has a square too many.
- 57 B This is the view from the front.**
 A: This is the view from above.
 C: This is the view from the side.
 D: This has a square too many.
- 58 A This is the view from above.**
 B: This is the right view reversed, left to right.
 C: This is the view from the front.
 D: This is the right view turned round.
- 59 C This is the view from the front.**
 A: This is the right view reversed, left to right.
 B: This is the view from above.
 D: This is the view from the side.
- 60 D This is the view from above.**
 A: This is the view from the front.
 B: This is the view from the side.
 C: This is the right view turned round.

Section 3: Turning 3D shapes

- 101 D This is the first shape, turned.**
 A: This is a mirror image of the first shape. No turn can make it match.
 B: This is a different shape: its cubes are not arranged the same way.
 C: This is a different shape: its cubes are not arranged the same way.
- 102 C This is the first shape, turned.**
 A: This is a different shape: its cubes are not arranged the same way.
 B: This is a different shape: its cubes are not arranged the same way.
 D: This is a mirror image of the first shape. No turn can make it match.
- 103 A This is the first shape, turned.**
 B: This is a mirror image of the first shape. No turn can make it match.
 C: This is a different shape: its cubes are not arranged the same way.
 D: This is a different shape: its cubes are not arranged the same way.

- 104 A This is the first shape, turned.**
 B: This is a different shape: its cubes are not arranged the same way.
 C: This is a mirror image of the first shape. No turn can make it match.
 D: This is a different shape: its cubes are not arranged the same way.
- 105 B This is the first shape, turned.**
 A: This is a different shape: its cubes are not arranged the same way.
 C: This is a mirror image of the first shape. No turn can make it match.
 D: This is a different shape: its cubes are not arranged the same way.
- 106 C This is the first shape, turned.**
 A: This is a different shape: its cubes are not arranged the same way.
 B: This is a mirror image of the first shape. No turn can make it match.
 D: This is a different shape: its cubes are not arranged the same way.
- 107 A This is the first shape, turned.**
 B: This is a different shape: its cubes are not arranged the same way.
 C: This is a different shape: its cubes are not arranged the same way.
 D: This is a mirror image of the first shape. No turn can make it match.
- 108 C This is the first shape, turned.**
 A: This is a mirror image of the first shape. No turn can make it match.
 B: This is a different shape: its cubes are not arranged the same way.
 D: This is a different shape: its cubes are not arranged the same way.
- 109 D This is the first shape, turned.**
 A: This is a different shape: its cubes are not arranged the same way.
 B: This is a different shape: its cubes are not arranged the same way.
 C: This is a mirror image of the first shape. No turn can make it match.
- 110 A This is the first shape, turned.**
 B: This is a mirror image of the first shape. No turn can make it match.
 C: This is a different shape: its cubes are not arranged the same way.
 D: This is a different shape: its cubes are not arranged the same way.

Section 4: Paper folding

- 151 A The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
 B: This shows only where the punch went in, before any fold is opened.
 C: This is the right pattern reflected.
 D: This is what a punch in a different place would give.
- 152 C The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
 A: This shows only where the punch went in, before any fold is opened.
 B: This is the right pattern reflected.
 D: This is what a punch in a different place would give.
- 153 D The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
 A: This shows only where the punch went in, before any fold is opened.
 B: This is the right pattern reflected.
 C: This is what a punch in a different place would give.
- 154 A The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
 B: This shows only where the punch went in, before any fold is opened.
 C: This is the right pattern turned round.
 D: This is what a punch in a different place would give.
- 155 D The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
 A: This shows only where the punch went in, before any fold is opened.
 B: This is the right pattern turned round.
 C: This is what a punch in a different place would give.

- 156 D The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
A: This shows only where the punch went in, before any fold is opened.
B: This is the right pattern turned round.
C: This is what a punch in a different place would give.
- 157 D The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
A: This shows only where the punch went in, before any fold is opened.
B: This is the right pattern turned round.
C: This is what a punch in a different place would give.
- 158 D The punch goes through 2 layers, so the open sheet has 2 holes in this pattern.**
A: This shows only where the punch went in, before any fold is opened.
B: This is the right pattern turned round.
C: This is what a punch in a different place would give.
- 159 B The punch goes through 4 layers, so the open sheet has 4 holes in this pattern.**
A: This shows the paper with only 1 of the 2 folds opened out.
C: This is the right pattern reflected.
D: This shows only where the punch went in, before any fold is opened.
- 160 B The punch goes through 4 layers, so the open sheet has 4 holes in this pattern.**
A: This shows the paper with only 1 of the 2 folds opened out.
C: This is the right pattern reflected.
D: This shows only where the punch went in, before any fold is opened.

How every answer was checked

Every question in this book was made by a computer program from exact geometry, then checked twice, by two methods written independently of each other. A question was printed only if both methods found exactly one correct option. Questions that failed were thrown away and replaced.

Cube nets.

The net is folded into a cube. Each option is compared with the folded cube in all 24 ways a cube can be turned, pattern by pattern.

Views of 3D shapes.

A drawing does not always settle a shape, because a cube can hide behind others. So the program searches every arrangement of the stated number of cubes, each sitting on the table or on another cube, that would be drawn exactly the same. A question was used only when there is just one such arrangement.

Turning 3D shapes.

The program lists every way of joining 5 cubes face to face (534 ways, counting each way round separately) and checks that each drawing could only show one shape. Only the correct option can be turned to match the first shape; mirror images never can.

Paper folding.

The paper is opened out on the computer, fold by fold, and every layer the punch went through gets its hole. The second method folds the drawn paper again from the dashed lines and arrows as printed, and checks that each picture is what the fold before it makes.

Checking the drawings.

The second method works from the finished drawings, the lines and shapes as printed, rather than from the program's own description of each question. If a drawing had differed from the question it was meant to show, the check would have failed.

While this book was being made, the program rejected 174 candidate questions that failed these checks or its rules for a fair question. It also caught all 803 faulty questions planted on purpose to test the checks.

Found something that looks wrong? Please write to support@bitygan.com.

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The full book

3D Spatial Reasoning, Book 1: Foundation

- 200 questions, 50 of each kind, in sets of 10 with a score box
- Every section starts with what to do, three tips and two worked examples
- A one-page quick answer key for all 200 questions
- Every answer explained: why the right answer is right, and why each wrong answer is wrong
- A score record to track progress, and how every answer was checked

In print, and as a PDF to print at home:

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