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UNATUM Test Prep

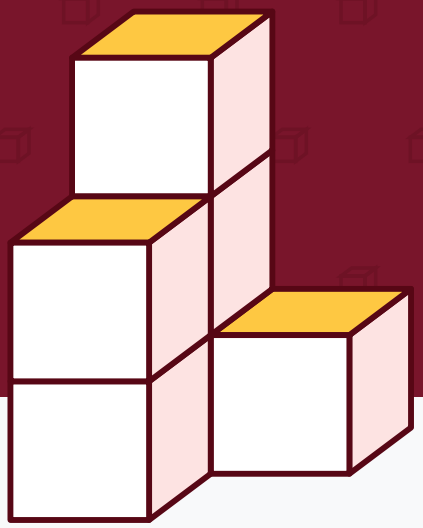
FULL-LENGTH
3
practice tests

DAT

Perceptual Ability

The complete PAT workbook

768 questions, every answer checked two ways



How many cubes have exactly two of their sides painted?

A real question from this book.
Turn over to try it.

3 full-length
practice tests

Every answer
checked two ways

A mistake finder
for every wrong option

Timed drills
and a timing plan

Apertures • View Recognition • Angles • Paper Folding • Cube Counting • Spatial Relations

Biggie Ganyo

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UNATUM TEST PREP

DAT Perceptual Ability

Free sample: the first topic of all six PAT question types, every answer checked two ways

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DAT Perceptual Ability: Free sample: the first topic of all six PAT question types, every answer checked two ways

Free sample, 2026

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The Dental Admission Test (DAT) is administered by the American Dental Association, which has not reviewed, sponsored or endorsed this book. All questions here are original.

Imprint: Independently published.

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All 768 questions in the full book were checked against their models and drawings before printing, and all 5,276 planted mistakes were caught. See Checked two ways in Start here. If you think you have found a mistake, please write to support@bitygan.com.

getunatum.com

About this sample

This free sample is the first topic of each of the book's six sections, exactly as printed. Each has a question to try first, the rules, one method, a worked example with every option explained, and practice. Every answer is at the back, with the mistake behind each wrong option. Print it, or work from the screen.

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Start here

This book is a training plan, not reading. Every page asks you to do something: try a question first, learn one method, practice it, then meet it again later, mixed with the rest. Spaced, mixed practice with feedback is what makes a spatial skill stick, and spatial skills do improve with training.

The Perceptual Ability Test in brief

- The PAT is the second of the DAT's four tests: 90 questions in 60 minutes, shown one at a time on screen. That is 40 seconds a question on average.
- It has six types of question: Apertures, View Recognition, Angle Discrimination, Paper Folding, Cube Counting, and Spatial Relations (also called 3D Form Development).
- Every ADA list gives the six types in that order. Prep guides report that the test does too, with 15 questions of each type. The ADA itself gives only the total.
- There is no penalty for guessing, so answer every question. Some questions are trial questions that are not scored, and they look the same as the rest.
- At the test center you get two note boards without graph lines, and two fine-tip markers. Magnifiers are not allowed.
- The Canadian Dental Aptitude Test and the Admission Test for Dental Hygiene (ATDH) have Perceptual Ability sections built from the same six types. This book prepares you for all three.

What a score means

DAT scores run from 200 to 600 in steps of 10. From March to December 2025, the average PAT score was about 407. In the ADA's percentile table, a PAT score of 470 is at the 88th percentile, and 500 is at the 94th.

This book does not turn your practice results into a predicted score. The ADA scores the test with a statistical model whose question values are not published, so no book can do that honestly. Use the practice tests to find what to practice next.

Three steps

1. **Check.** Start with the check-up before Section 1. Mark it with the answers at the back. Every question you get wrong, or only guessed, points to the topic to learn first.
2. **Learn.** Each topic starts with a question to try before you read. Then comes one method, a worked example with every option explained, and practice.
3. **Come back.** Review sets bring each topic back after a gap, mixed with the others. A timed drill ends each section, and three full practice tests end the book.

Sure or guessing

- **After each question, tick how sure you are:** sure, unsure or guess. A wrong answer you were sure of tells you the most.
- **Read every explanation,** not just the letter. Each wrong option is named with the mistake that usually leads to it, and the answers say which topic to go back to.
- **Keep a mistakes log** at the back, with a date to try that question again.

Checked two ways

Every question in this book was made and checked by a proprietary engine before it was printed. A question was printed only when all of these held:

- **Exactly one right answer.** Model and drawing checks agreed on a single answer under the rules printed in this book. Additional geometry tests check known failure cases, including the orientation of folded patterns.
- **The rules you read are the rules that were checked.** Each section's rule list is printed from the same record the checks use.
- **Large enough to judge by eye.** No question turns on a difference too small to see, such as two angles less than two degrees apart.
- **Every wrong option is a named mistake,** and no option gives the answer away by pattern alone.

To test the checks themselves, 5,276 faults were planted in this book's own questions, such as a second right answer or a line in the wrong place. The checks caught all of them. Along the way, 4,382 candidate questions failed a check and were replaced, never repaired.

> ✕ **WATCH OUT** What this book does not cover. Its View Recognition and Apertures objects are built from whole cubes, with flat faces at right angles. The real test also gives those types slanted faces and curves. Spatial Relations here includes wedges, pyramids and other sloped solids, but no curves. The methods taught here work for every shape.

WHERE THESE FACTS COME FROM

- American Dental Association, *DAT 2026 Candidate Guide* (updated August 2026): test sections, timing, scoring, note boards.
- American Dental Association, *DAT User's Manual* (2026): 2025 results.
- American Dental Association, *Understanding the New DAT Score Reporting Scale* (2025): score range and percentile ranks.
- Kaplan, *DAT 2016 Strategies, Practice and Review* (2016): questions per type.
- Uttal and others, "The malleability of spatial skills: a meta-analysis of training studies", *Psychological Bulletin*, 2013.
- Brunmair and Richter, "Similarity matters: a meta-analysis of interleaved learning", *Psychological Bulletin*, 2019.

SECTION ONE

1

Apertures

Apertures is the first type of PAT question, also called keyholes. A solid object is shown, then five openings. The object may be turned any way before it starts, but it must then pass straight through. So the right opening is exactly one of the object's outlines: the shape it shows when you look along the way it travels.

Your topic tracker

	Topic	Page	Check-up right	Learned	Reviewed	Secure
1.1	Three outlines	2	☐	☐	☐	☐

Secure means right, and sure, in two review sets a week or more apart.

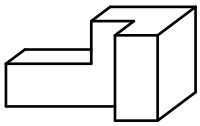
1.1 Three outlines

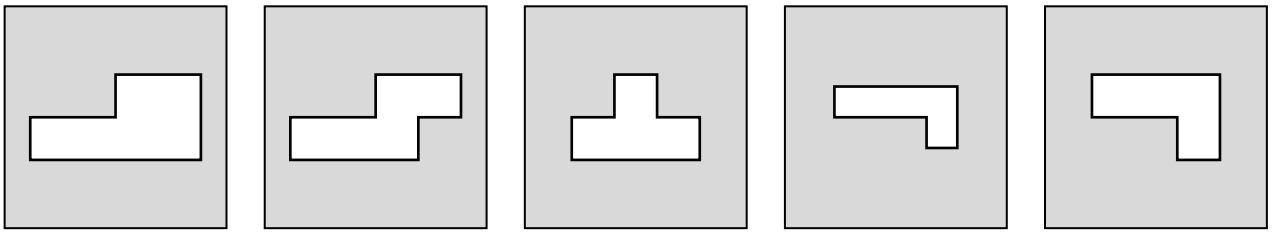
TRY THIS FIRST Try this one first. The page then shows the method.

Answer at the back

☐ sure ☐ unsure ☐ guess

Which opening would the object pass through, with the right side first?





A B C D E

An object pushed straight through an opening fills it with its outline, seen along the way it moves. Every object here has three such outlines: front to back, top to bottom, and side to side.

THE RULES

1. Each question shows a solid object and five openings.
2. Before the object goes through, you may turn it any way, and start it through a side you cannot see.
3. Once it has started, it cannot be turned or twisted, and it must pass all the way through. The right opening is exactly the shape of the object's outline from the side that goes first.
4. The object and the openings are drawn to the same scale, so an opening can be the right shape but too small. Every difference is large enough to see.
5. Hidden parts of the object hold no surprises: they are as plain as the parts you can see suggest.
6. Exactly one opening is right.

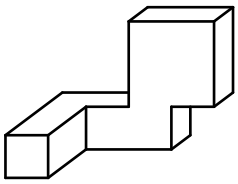
HOW TO WORK IT

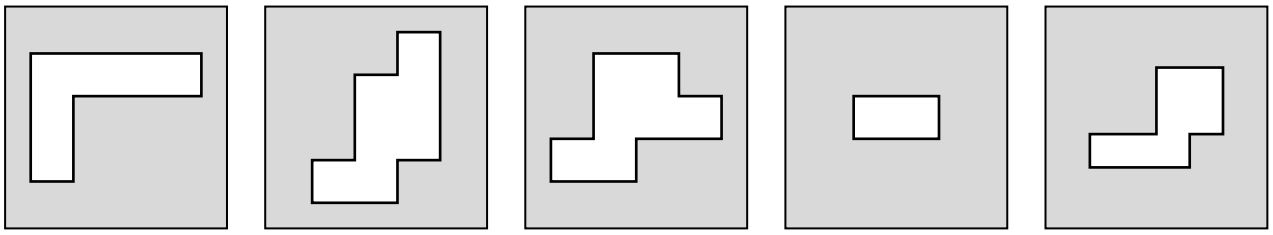
1. **Find the three outlines.** Picture the object seen from the front, from the top and from the side. Seen from the back, the bottom or the other side, each outline is only flipped over. The object may be turned first, so a flipped outline still fits.
2. **Measure in cubes.** The objects are built from cubes. Count the cubes along each edge of each outline, so you check lengths as well as shapes.
3. **Sketch them small.** Draw the three outlines on your note board, a square of the grid for each cube.
4. **Match square for square.** Compare each opening with your sketches. The right opening is exactly one outline. Close is not exact.

× WATCH OUT Right shape, too small. The openings are drawn at the same scale as the object, so an opening can match an outline's shape and still be too small for it. Compare one length you can measure on both.

WORKED EXAMPLE ✓ **answer proven two ways**

Which opening would the object pass through, with the right side first?





A B C D E

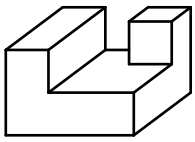
✓ **A is right.** This is the exact outline of the object seen straight from the top (or bottom): put that side through first.
B (almost another side's outline): This is close to the outline from another side, but one part does not match.
C (almost another side's outline): This is close to the outline from another side, but one part does not match.
D (almost another side's outline): This is close to the outline from another side, but one part does not match.
E (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.

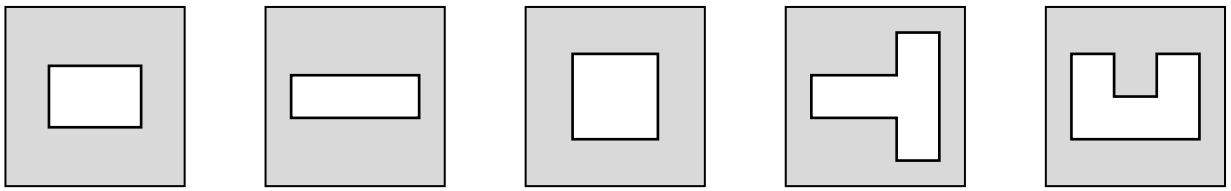
RECALL Cover the page, then answer from memory.

1 Why must the right opening be one of the object's outlines?
2 Which three outlines do you check?
3 Why does a flipped outline still fit?

Practice

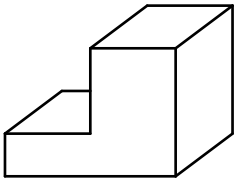
1 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

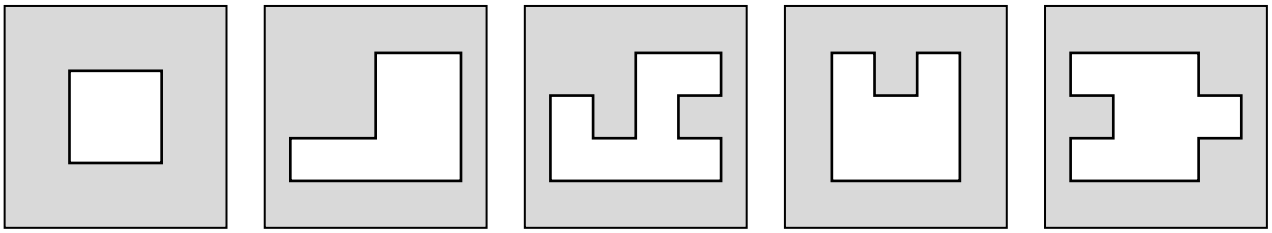




A B C D E

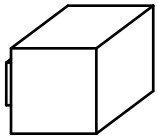
2 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

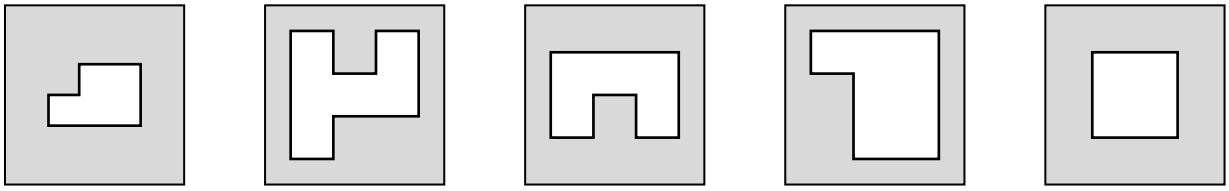




A **B** **C** **D** **E**

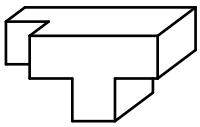
3 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

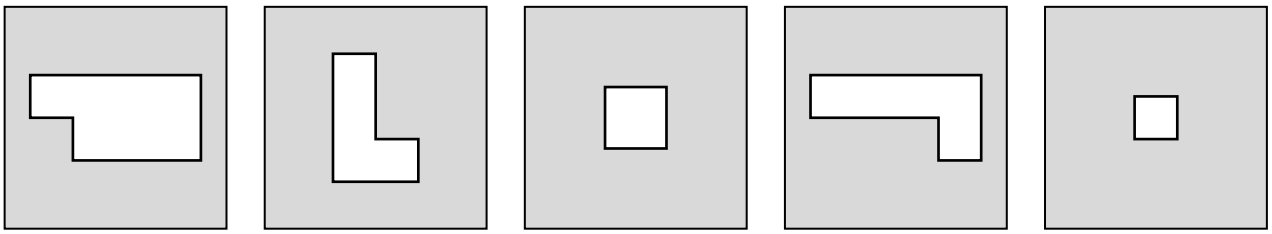




A **B** **C** **D** **E**

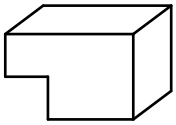
4 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

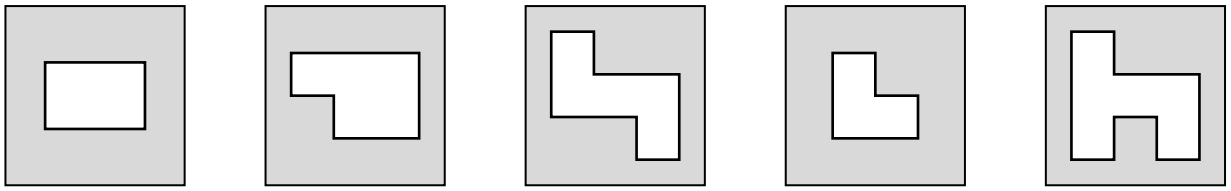




A **B** **C** **D** **E**

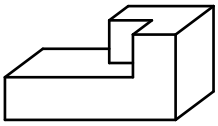
5 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

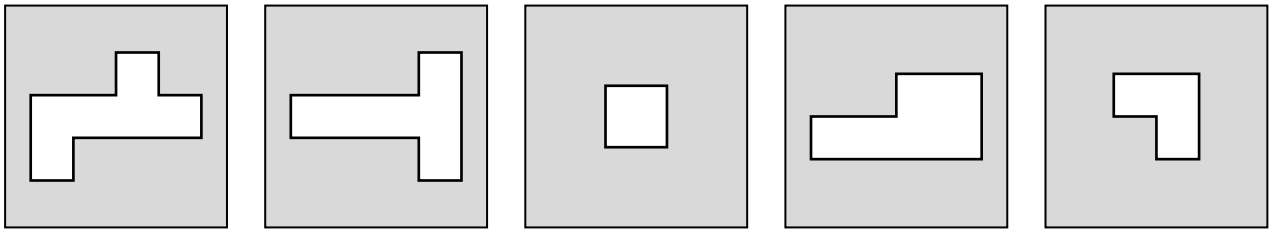




A B C D E

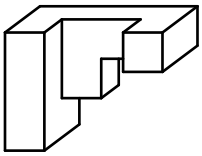
6 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

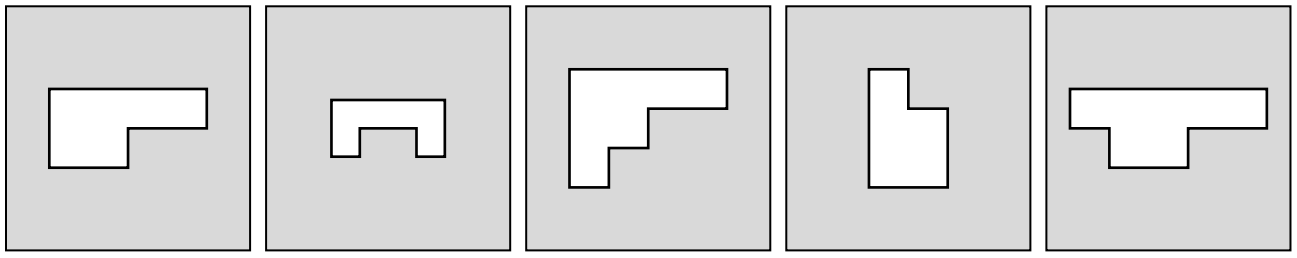




A B C D E

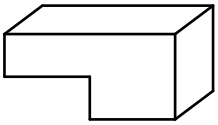
7 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

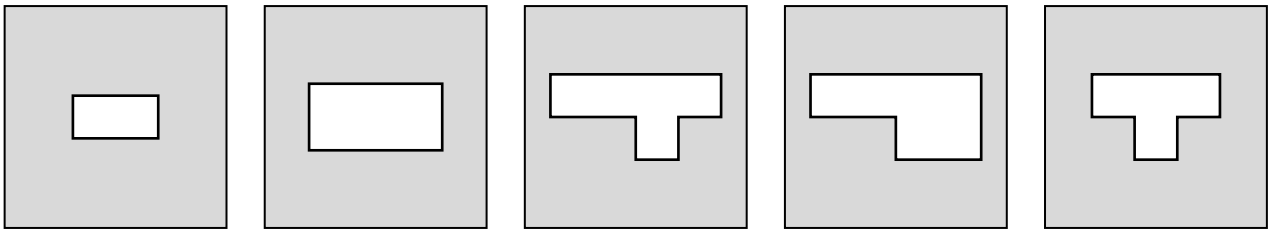




A B C D E

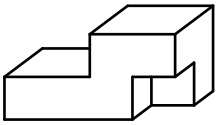
8 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

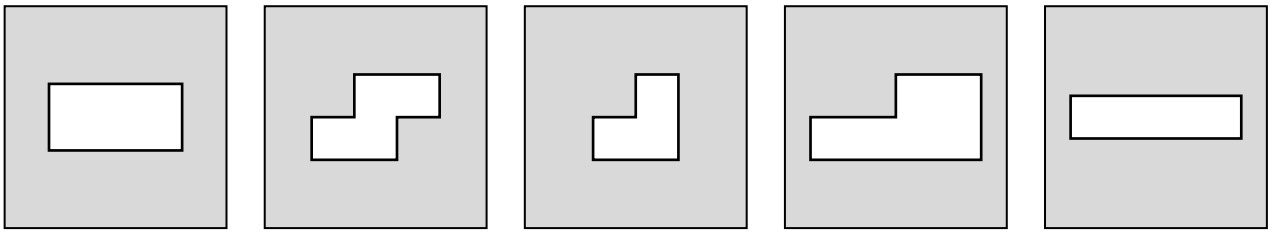




A **B** **C** **D** **E**

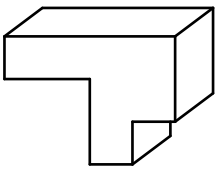
9 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

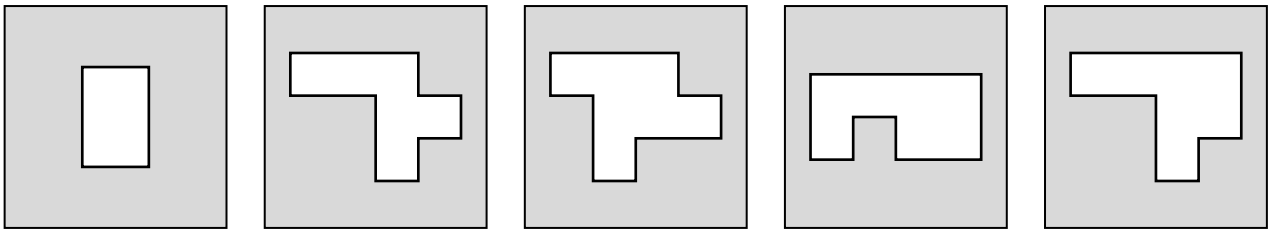




A **B** **C** **D** **E**

10 Which opening would the object pass through, with the right side first? ☐ sure ☐ unsure ☐ guess

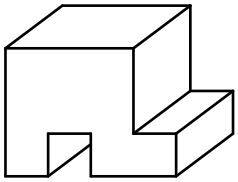


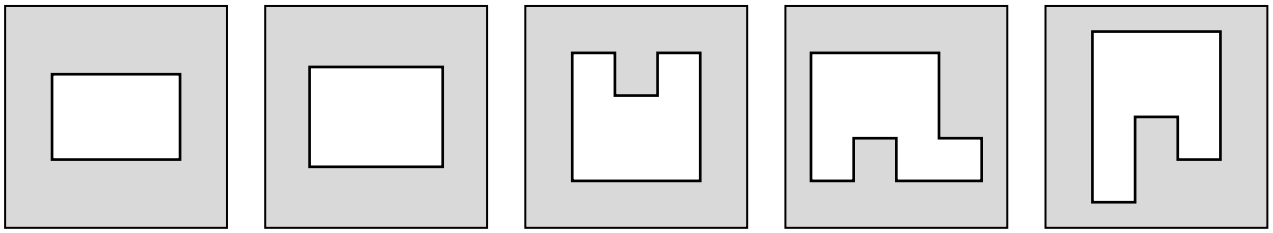


A **B** **C** **D** **E**

11 Which opening would the object pass through, with the right side first?

☐ sure ☐ unsure ☐ guess





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

COME BACK ON _____ _____ _____ Come back to this topic after a day, a week and three weeks.

Right first time: _____ of 11

SECTION TWO

2

View Recognition

View Recognition is the second type of PAT question, also called top-front-end. Two flat views of a solid object are shown, and you choose the missing third view. The views are drawn the way engineers draw them. Each one looks straight at a face of the object, and the three are laid out so that their edges line up.

Your topic tracker

	Topic	Page	Check-up right	Learned	Reviewed	Secure
2.1	The end view	9	☐	☐	☐	☐

Secure means right, and sure, in two review sets a week or more apart.

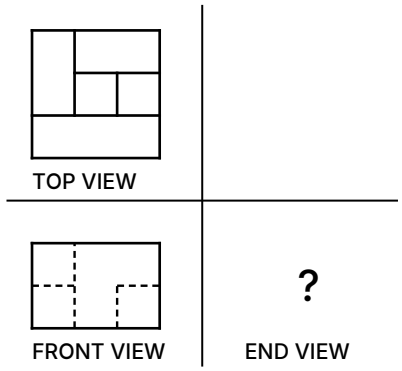
2.1 The end view

TRY THIS FIRST Try this one first. The page then shows the method.

Answer at the back

☐ sure ☐ unsure ☐ guess

Choose the correct END VIEW.





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

The top and front views are given, and you find the end view. The end view looks at the object from the right, so it shares the front view's heights and the top view's depths.

THE RULES

1. Each question shows two views of a solid object and asks for the third: the top, front or end view.
2. The views are drawn without perspective: you look straight at the object along parallel lines of sight.
3. The top view looks down on the object, the front view looks at its front, and the end view looks at it from the right.
4. The top view is always at the upper left, the front view at the lower left, and the end view at the lower right. Each view lines up with its neighbors.
5. Edges you could not see from that direction are drawn as broken lines.
6. Where a visible edge and a hidden edge fall on the same line, the solid line is drawn.

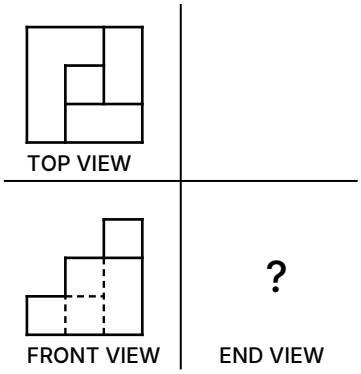
HOW TO WORK IT

1. **Heights come from the front view.** The end view sits beside the front view. Every horizontal line in the end view lines up with a horizontal line, solid or broken, in the front view.
2. **Depths come from the top view.** In the end view, the object's front is on the left, next to the front view. In the top view, the front is at the bottom, next to the front view.
3. **Turn the top view in your head.** Give it a quarter turn clockwise: its bottom edge goes to the left, and its depths line up with the end view's widths.
4. **Place each edge.** Find each edge of the object in the two views you have, then draw it where the end view would show it.

× WATCH OUT Viewed from the wrong side. A wrong option often shows the object from the left, a mirror image of the true end view. The front of the object is on the end view's left, next to the front view.

WORKED EXAMPLE ✓ **answer proven two ways**

Choose the correct END VIEW.





✓ **D is right.** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
A (an extra line): This has a line where the object has no edge.
B (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.
C (hidden line drawn solid): A line that is hidden from this side is drawn solid here. From the right it lies behind the object, so it must be broken.

RECALL Cover the page, then answer from memory.

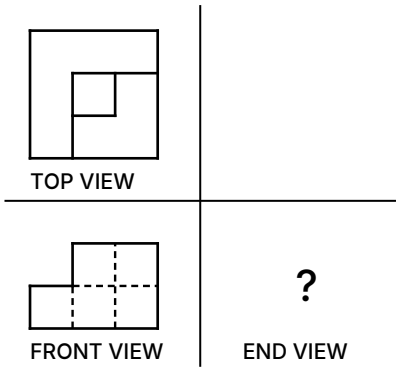
1 Which view gives the end view its heights?

2 On which side of the end view is the object's front?

3 Which way do you turn the top view?

Practice

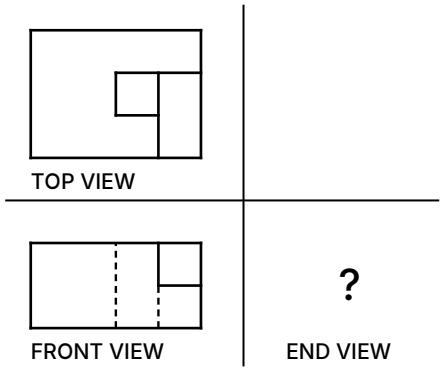
1 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





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

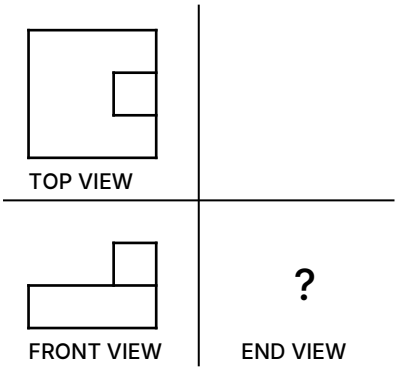
2 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





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

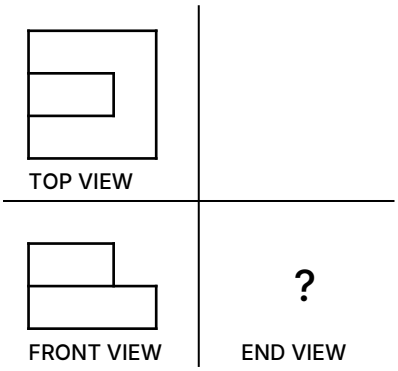
3 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





A B C D

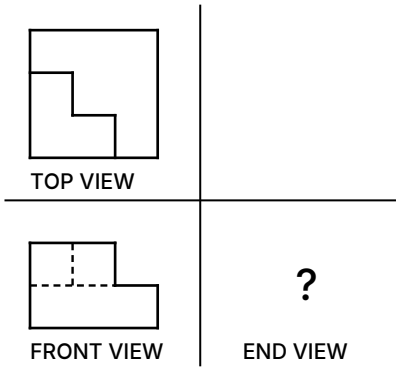
4 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





A B C D

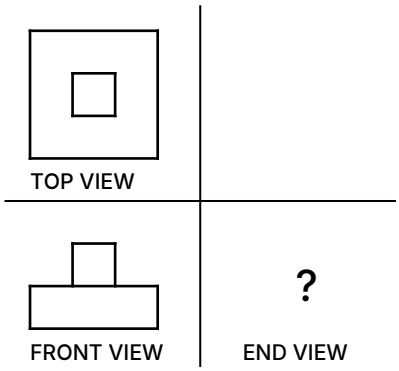
5 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





A B C D

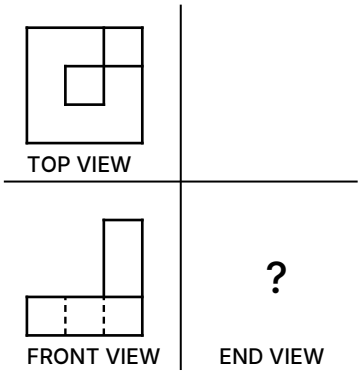
6 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





A B C D

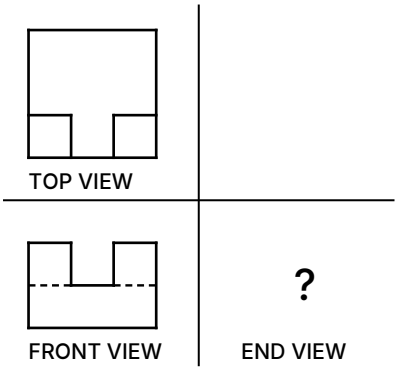
7 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





A B C D

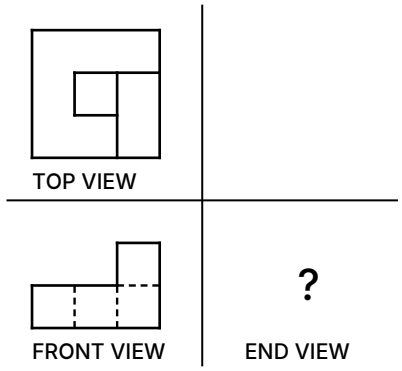
8 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





A B C D

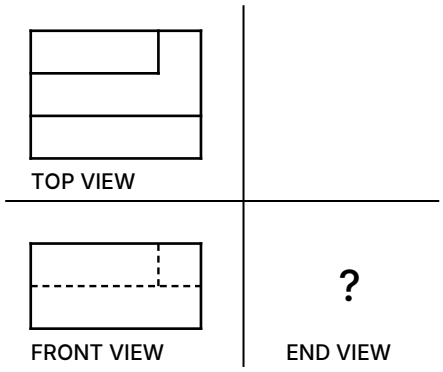
9 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess





A B C D

10 Choose the correct END VIEW. ☐ sure ☐ unsure ☐ guess

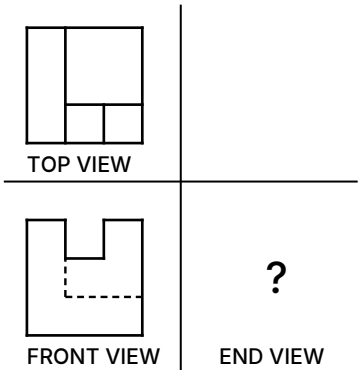




A B C D

11 Choose the correct END VIEW.

☐ sure ☐ unsure ☐ guess





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

COME BACK ON _____ _____ _____ Come back to this topic after a day, a week and three weeks.

Right first time: _____ of 11

SECTION THREE

3

Angle Discrimination

Angle Discrimination is the third type of PAT question, also called angle ranking. Four angles are shown, and you choose the option that puts them in order from the smallest to the largest. It is the fastest type on the test, and the one where a careful method saves the most points.

Your topic tracker

	Topic	Page	Check-up right	Learned	Reviewed	Secure
3.1	Clear gaps	18	☐	☐	☐	☐

Secure means right, and sure, in two review sets a week or more apart.

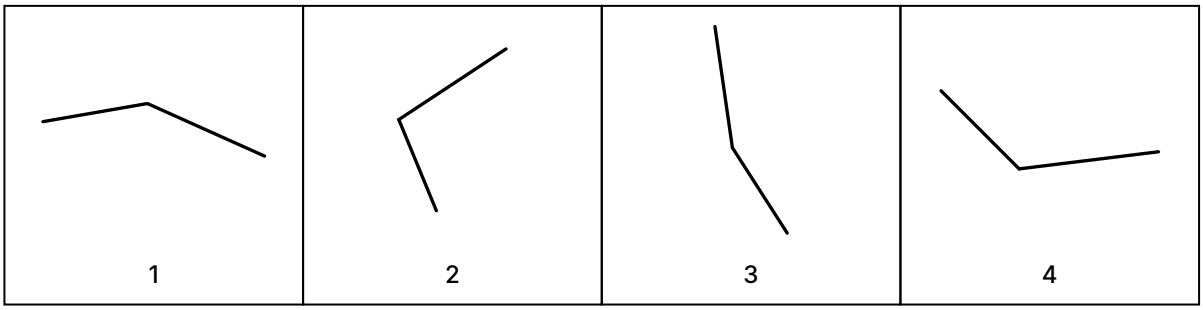
3.1 Clear gaps

TRY THIS FIRST Try this one first. The page then shows the method.

Answer at the back

☐ sure ☐ unsure ☐ guess

Rank the four angles from smallest to largest.



A	B	C	D
4-2-3-1	2-1-4-3	2-4-3-1	2-4-1-3

In this topic every angle differs from the others by at least eight degrees, enough to see at a glance. Learn the order of work here, while the judging is easy.

THE RULES

1. Each question shows four angles, numbered 1 to 4.
2. Judge the inside (interior) angle where the two arms meet: the opening between them.
3. Put the four angles in order from smallest to largest, and choose the option that gives that order.
4. The arms may be of any length and point any way. Only the opening counts.

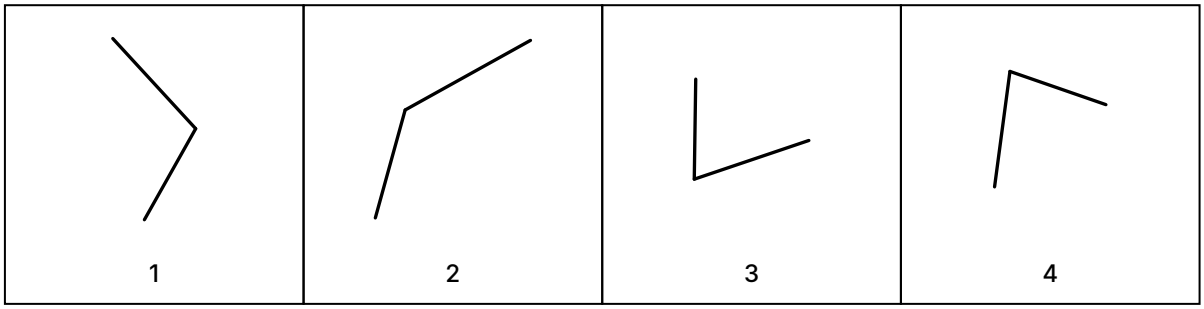
HOW TO WORK IT

1. **Sort by the right angle.** Compare each angle with a right angle, the corner of a page. Is it smaller or larger, and by a lot or a little?
2. **Find the smallest.** Cross out every option that does not start with it.
3. **Find the largest.** Cross out every option that does not end with it.
4. **Order the middle two.** Usually only one option is left by now. If two are left, they differ only in the middle pair: judge that pair alone.

× WATCH OUT Ranked largest to smallest. The options give the order from the smallest angle to the largest. Read each option left to right as smallest first.

WORKED EXAMPLE ✓ **answer proven two ways**

Rank the four angles from smallest to largest.



2-3-4-1	3-4-1-2	3-4-2-1	4-1-3-2
A	**B**	**C**	**D**

✓ **B is right.** Measured, angle 3 is 70.5°, angle 4 is 78.5°, angle 1 is 108°, angle 2 is 134.5°, so the order is 3-4-1-2.
A (one angle misplaced): This puts angle 2 before angle 1, but angle 2 (134.5°) is larger than angle 1 (108°).
C (neighbors swapped): This puts angle 2 before angle 1, but angle 2 (134.5°) is larger than angle 1 (108°).
D (one angle misplaced): This puts angle 4 before angle 3, but angle 4 (78.5°) is larger than angle 3 (70.5°).

RECALL Cover the page, then answer from memory.

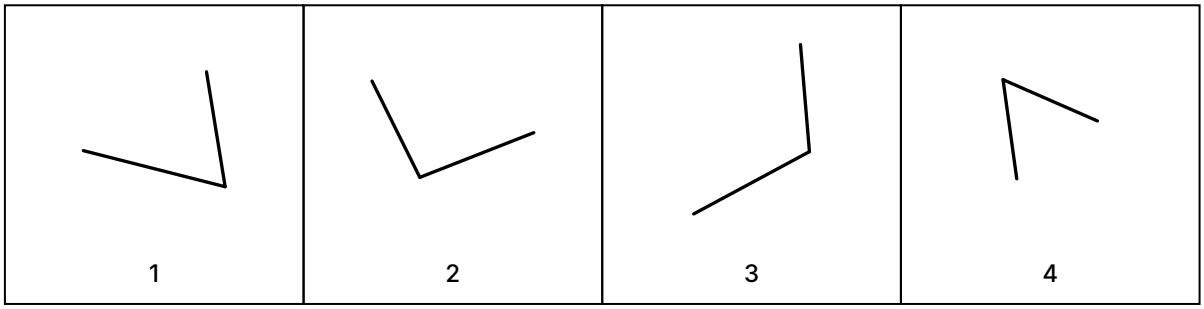
1 What do you compare every angle with first?

2 Which two angles do you find before the others?

3 Which way does each option read?

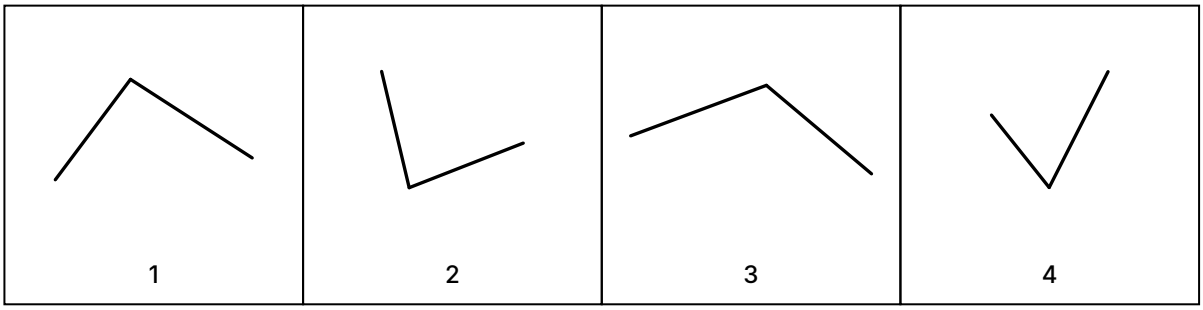
Practice

1 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



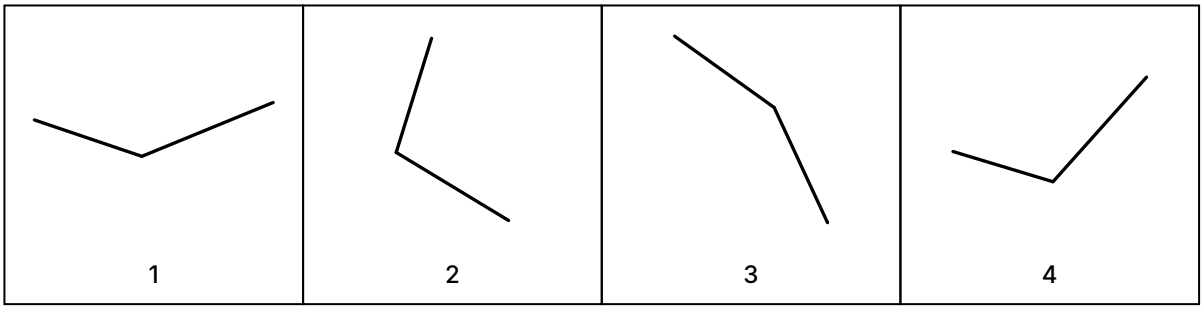
1-4-3-2	1-4-2-3	4-1-2-3	1-2-4-3
A	**B**	**C**	**D**

2 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



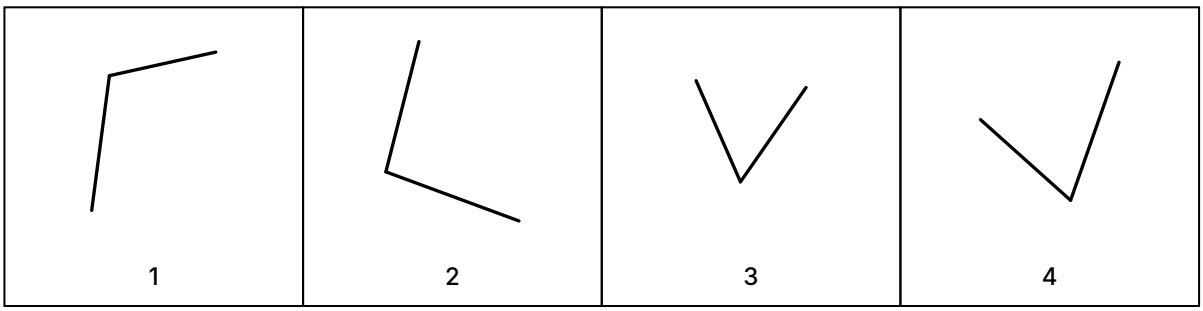
A	B	C	D
4-2-1-3	4-1-2-3	1-4-2-3	4-3-2-1

3 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



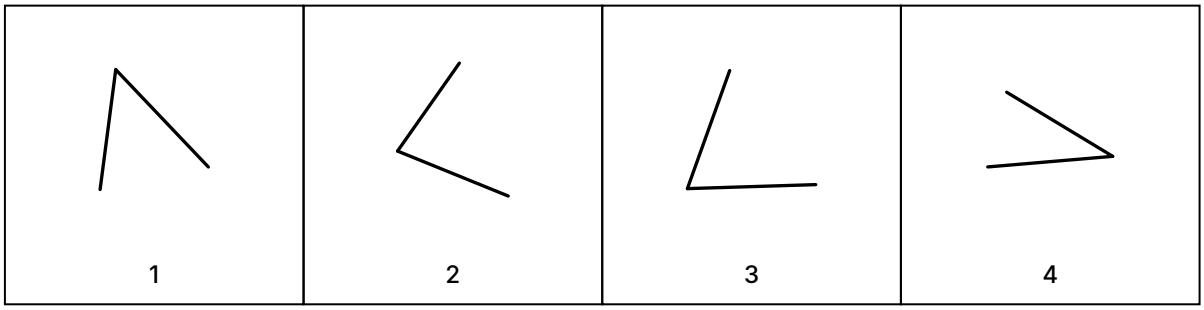
A	B	C	D
2-4-1-3	3-1-4-2	4-1-3-2	4-1-2-3

4 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



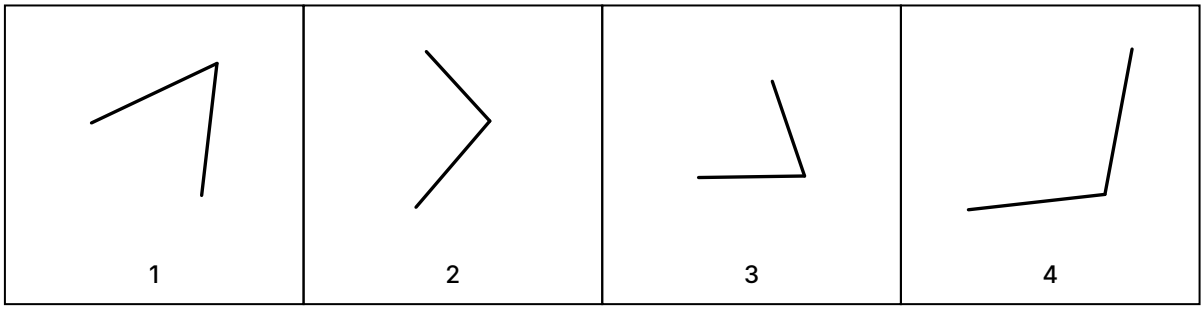
A	B	C	D
4-3-2-1	3-4-2-1	4-2-3-1	3-2-4-1

5 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



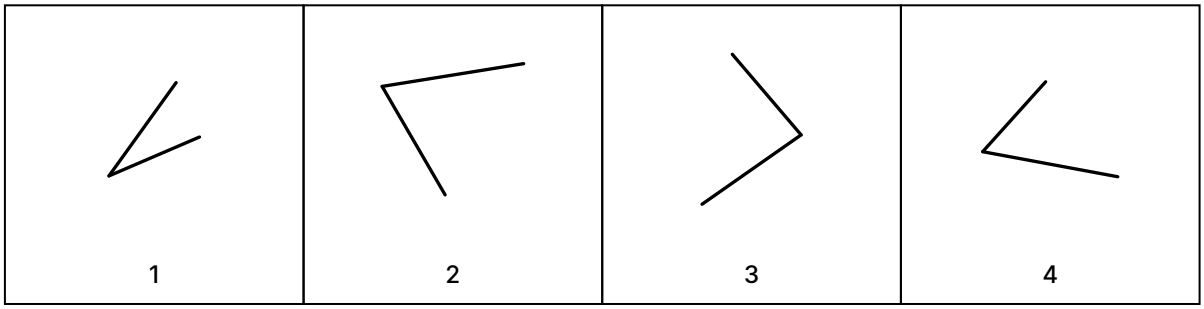
A	B	C	D
3-4-1-2	1-4-2-3	4-1-3-2	4-1-2-3

6 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



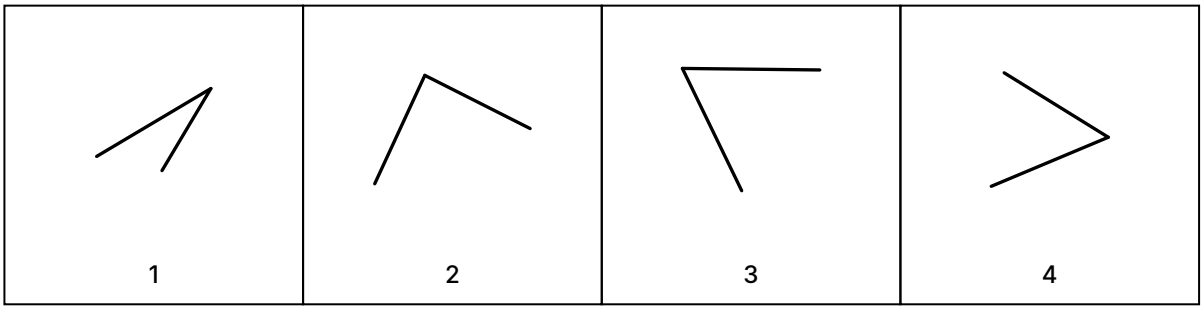
A	B	C	D
1-2-4-3	1-3-2-4	1-3-4-2	4-2-3-1

7 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



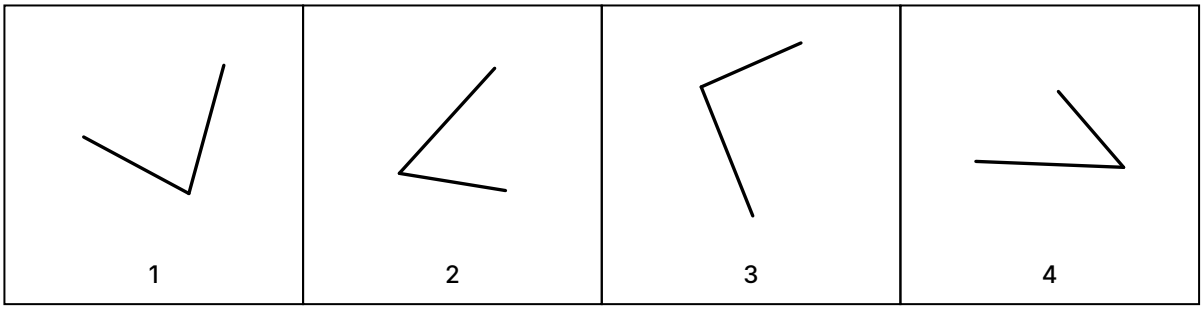
A	B	C	D
4-2-1-3	2-1-4-3	1-4-2-3	1-2-4-3

8 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



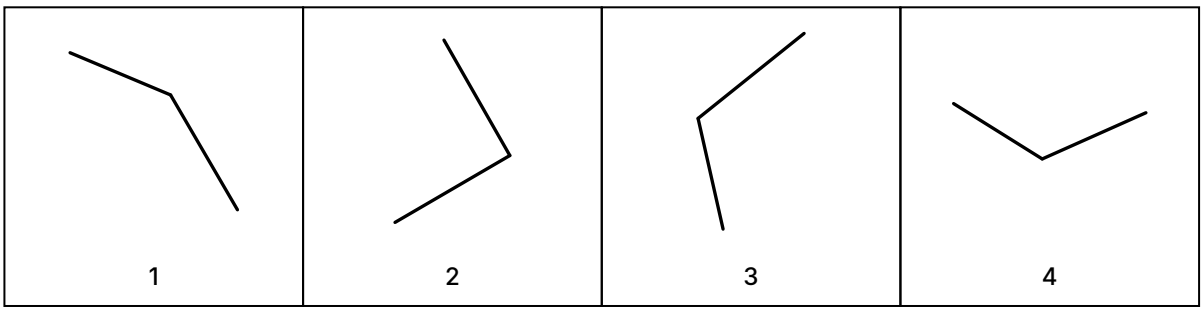
A	B	C	D
3-1-4-2	1-3-4-2	1-3-2-4	1-4-3-2

9 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



A	B	C	D
3-1-2-4	4-2-1-3	4-3-2-1	2-1-4-3

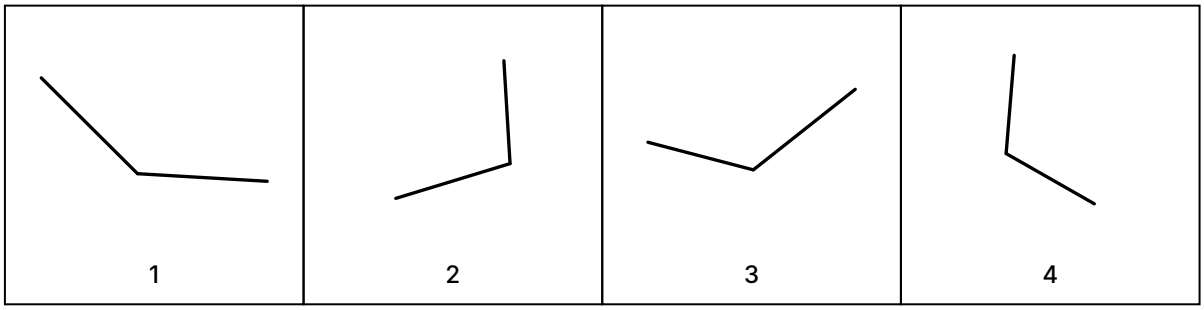
10 Rank the four angles from smallest to largest. ☐ sure ☐ unsure ☐ guess



A	B	C	D
2-3-1-4	2-4-3-1	2-4-1-3	2-3-4-1

11 Rank the four angles from smallest to largest.

☐ sure ☐ unsure ☐ guess



2-4-1-3	4-2-1-3	1-2-4-3	2-4-3-1
A	**B**	**C**	**D**

COME BACK ON _____ _____ _____ Come back to this topic after a day, a week and three weeks.

Right first time: _____ of 11

SECTION FOUR

4

Paper Folding

Paper Folding is the fourth type of PAT question, also called hole punching. A square sheet is folded, a hole is punched through it, and you choose the pattern of holes the sheet shows when it is opened flat. One method answers every question: count the layers under the punch, then open the folds one at a time, last fold first.

Your topic tracker

	Topic	Page	Check-up right	Learned	Reviewed	Secure
4.1	Reading the panels	25	☐	☐	☐	☐

Secure means right, and sure, in two review sets a week or more apart.

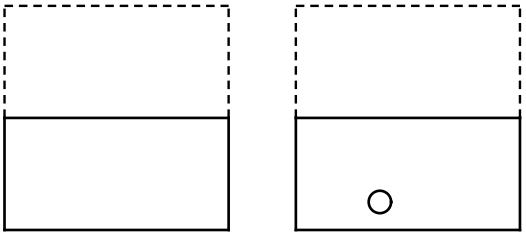
4.1 Reading the panels

TRY THIS FIRST Try this one first. The page then shows the method.

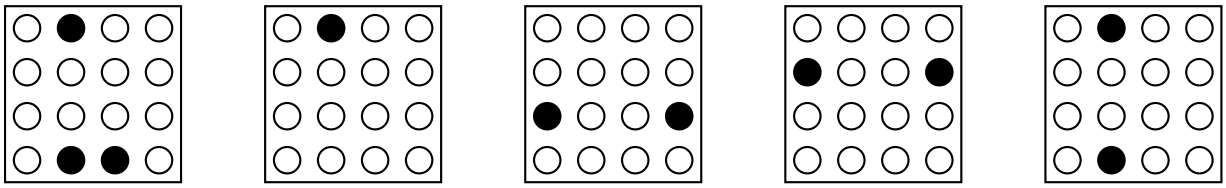
Answer at the back

☐ sure ☐ unsure ☐ guess

Choose the pattern of holes the paper shows when it is opened out.



Fold 1 Punch



A B C D E

Each question is a strip of panels, read left to right. Each panel shows the paper after one fold, and the last panel shows where the hole is punched. Below are five grids of sixteen circles, and the black circles show where the holes are once the sheet is opened. Test questions usually have two or more folds. This topic uses one, to learn the method.

THE RULES

1. A square sheet of paper is folded one or more times, then one hole is punched through it.
2. Broken lines show where the paper was before a fold. Solid lines show where the paper is after it.
3. The paper is never turned over or twisted, and it always stays inside the original square.
4. The hole goes through every layer of paper at the place it is punched.
5. Open the paper in your head. Choose the grid whose black circles show every hole in the opened sheet.

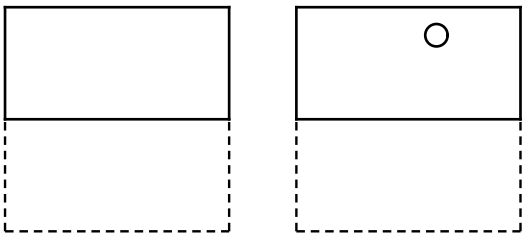
HOW TO READ A QUESTION

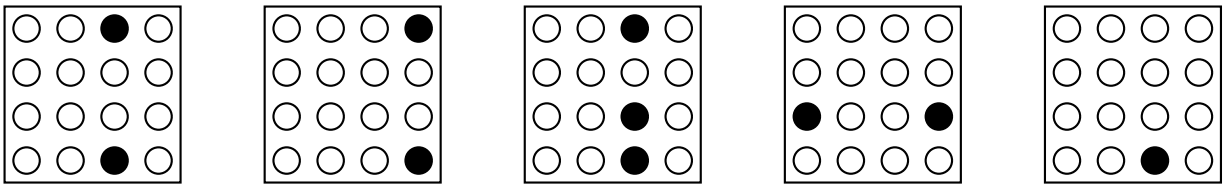
1. **Count the fold panels.** One panel for each fold, then the punch panel.
2. **Find each crease.** In each panel, look for the solid straight edge that was not there in the panel before. That is the crease. The part beyond it has been folded over toward you.
3. **Place the punch.** Find the punch's square on the four-by-four grid of the original sheet: which column, which row.
4. **Open the fold.** Copy the hole across the crease, the same distance on the other side, if folded paper lay under the punch.

✕ WATCH OUT Broken lines are the original sheet, not a fold. Every broken line runs along the edge of the original square, where paper used to be.

WORKED EXAMPLE ✓ answer proven two ways

Choose the pattern of holes the paper shows when it is opened out.





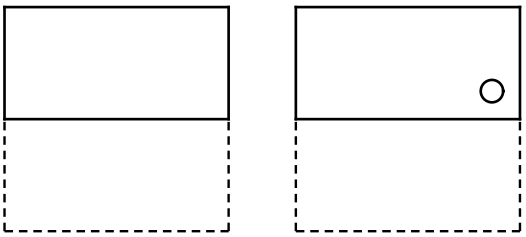
✓ **A is right.** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
B (holes moved one place): The holes are one place too far right. Follow the punch's exact place as each fold opens.
C (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
D (pattern flipped): This is the right pattern flipped across the other diagonal. The paper is never turned over.
E (one hole too few): One hole short: the paper was 2 layers thick at the punch, so there are 2 holes.

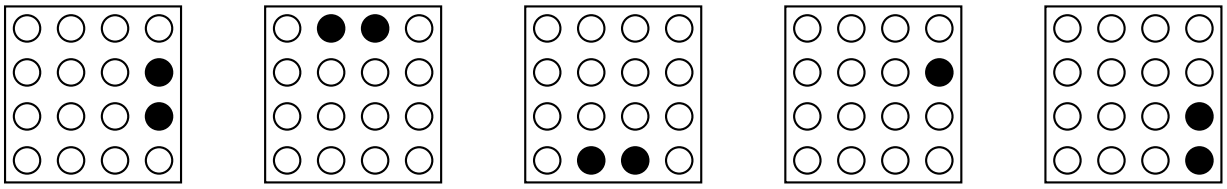
RECALL Cover the page, then answer from memory.

1 What do the broken lines show?
2 How do you find a fold's crease?
3 Where do you mark the punch before you open anything?

Practice

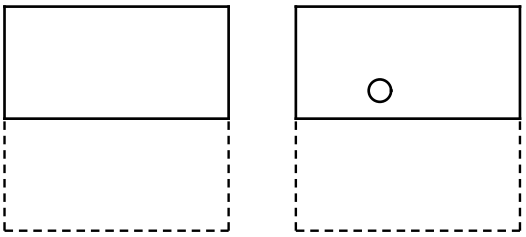
1 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

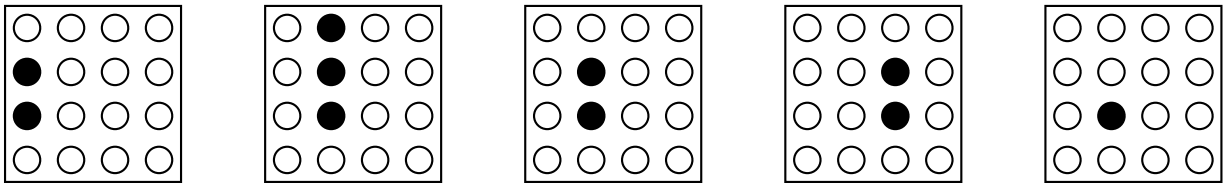




A B C D E

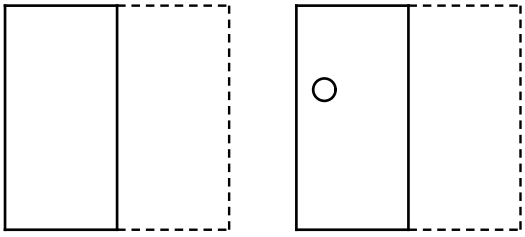
2 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

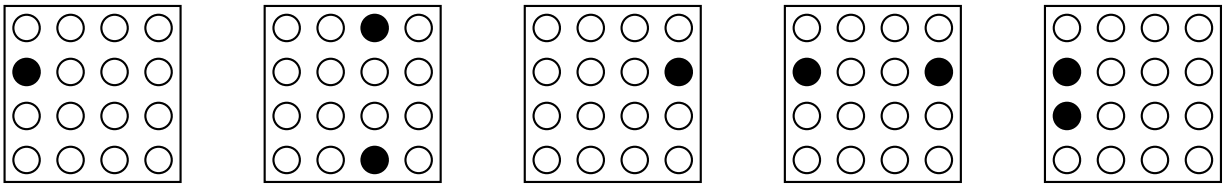




A B C D E

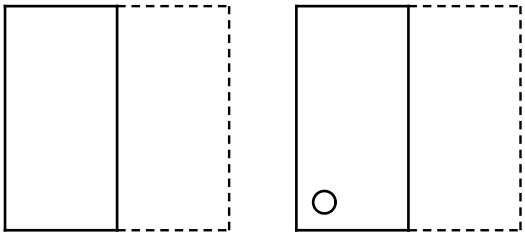
3 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

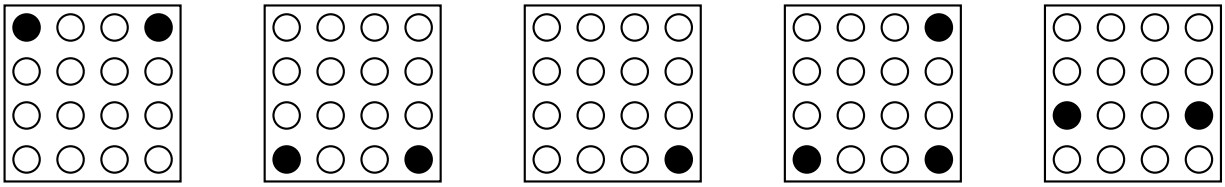




A B C D E

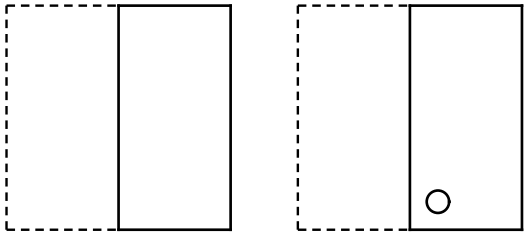
4 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

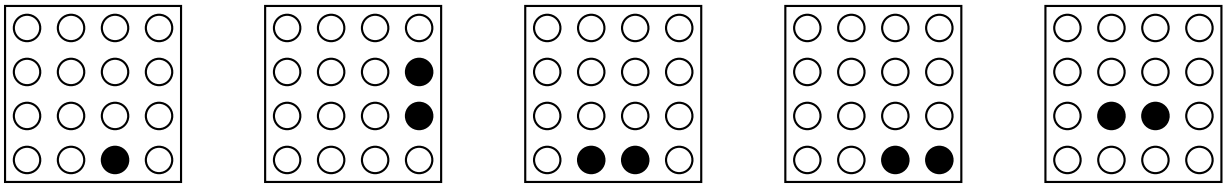




A B C D E

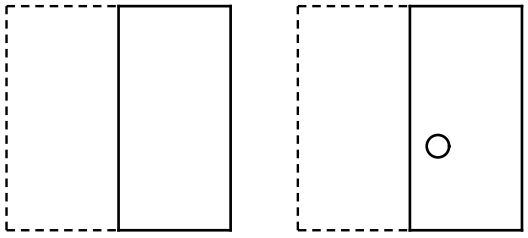
5 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

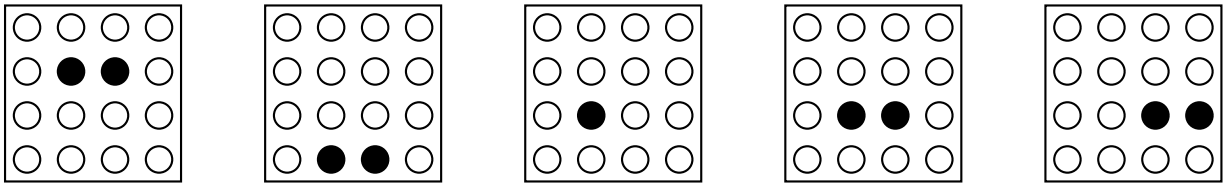




A B C D E

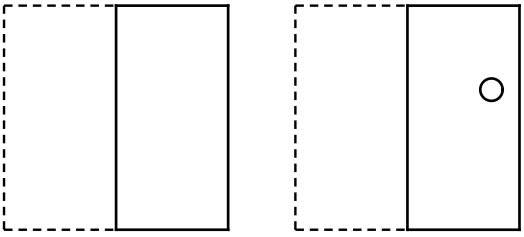
6 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

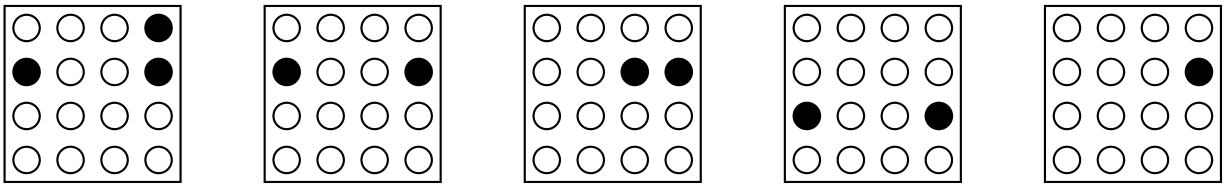




A B C D E

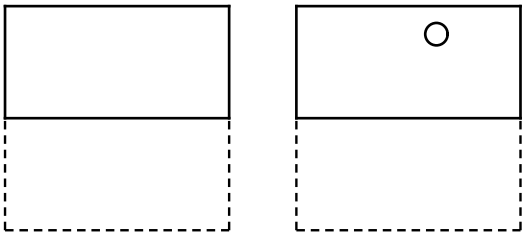
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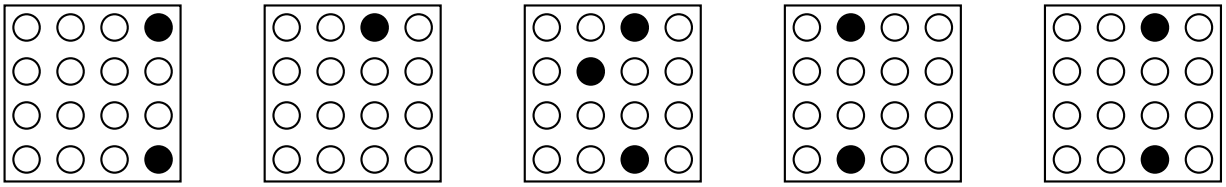




A B C D E

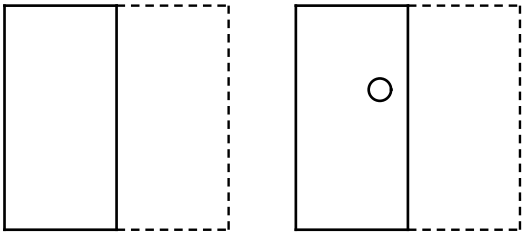
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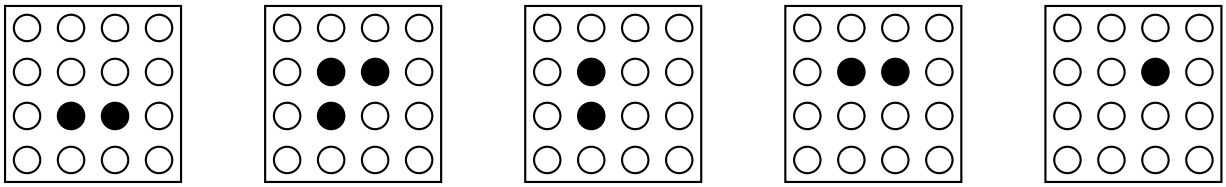




A B C D E

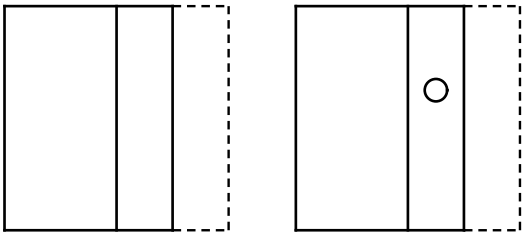
9 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

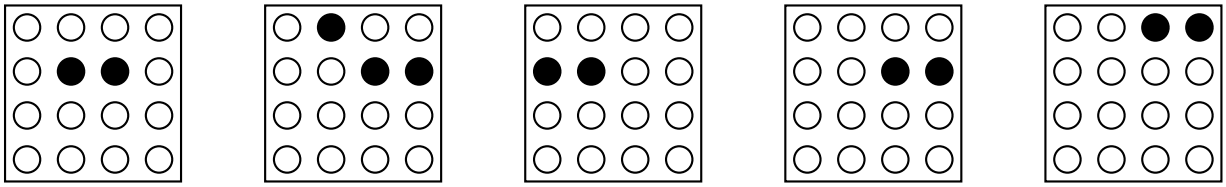




A B C D E

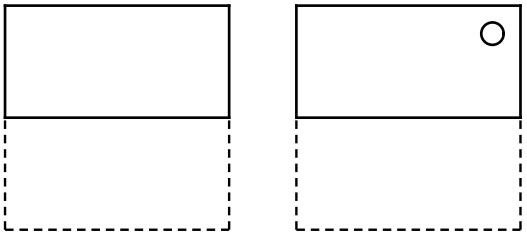
10 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess

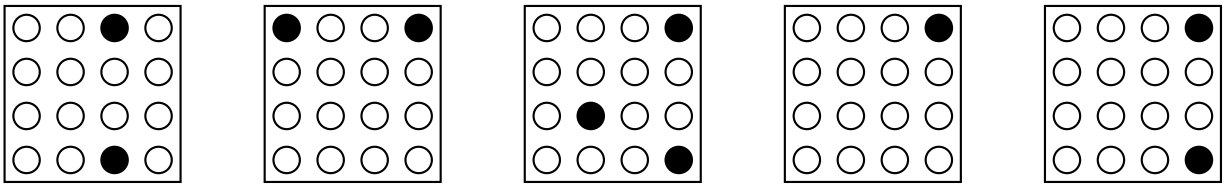




A B C D E

11 Choose the pattern of holes the paper shows when it is opened out. ☐ sure ☐ unsure ☐ guess





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

COME BACK ON _____ _____ _____ Come back to this topic after a day, a week and three weeks. **Right first time:** _____ of 11

SECTION FIVE

5

Cube Counting

Cube Counting is the fifth type of PAT question. A stack of cubes was painted on every outside side except the bottom, and each question asks how many cubes have a given number of painted sides. Prep guides report that several questions share each figure on the test. So the method is to count every cube once, in a tally, and answer all the figure's questions from it.

Your topic tracker

	Topic	Page	Check-up right	Learned	Reviewed	Secure
5.1	The tally	34	☐	☐	☐	☐

Secure means right, and sure, in two review sets a week or more apart.

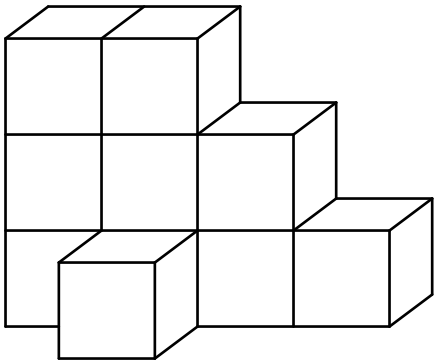
5.1 The tally

TRY THIS FIRST Try this one first. The page then shows the method.

Answer at the back

☐ sure ☐ unsure ☐ guess

How many cubes have exactly one of their sides painted?



1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

A cube's painted sides are the ones with nothing against them. That means its top, if no cube sits on it, and each of its four sides with no cube beside it. Its bottom never counts, so no cube has more than five.

THE RULES

1. Each figure is made of cubes of the same size, cemented together.
2. The whole figure was then painted on every outside side except the bottom it stands on.
3. The only hidden cubes are those needed to hold up cubes you can see.
4. Each question asks how many cubes have exactly a given number of sides painted.
5. Zero is never the right answer.

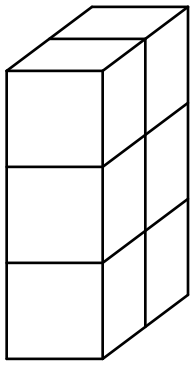
HOW TO WORK IT

1. **Write the tally.** Down the side of your note board, write one to five, one line each.
2. **Go column by column.** Take one cube at a time, from the back of the stack to the front, top cube first.
3. **Count its painted sides.** The top if nothing is on it, then each of the four sides with no cube against it, seen or not.
4. **Mark the tally.** Put a stroke on the line for that number of sides.
5. **Check the total.** The strokes add up to the number of cubes. Then answer every question about the figure from the tally.

× WATCH OUT Bottom painted. The bottom the stack stands on is never painted, and neither is a side with a cube against it. A cube alone on the floor has five painted sides, not six.

WORKED EXAMPLE ✓ answer proven two ways

How many cubes have exactly three of their sides painted?



1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	B	C	(D)	E

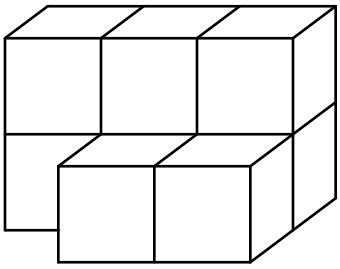
✓ **D is right.** Tally of painted sides for all 6 cubes: 3 sides: 4, 4 sides: 2.
A (counted only the sides you can see): This counts only the sides you can see (top, front, right). The back and left sides were painted too.
B (bottom painted): This paints the bottom of the cubes on the floor. The bottom is never painted.
C (lost count): Recount with a tally: exactly 4 cubes have 3 sides painted.
E (lost count): Recount with a tally: exactly 4 cubes have 3 sides painted.

RECALL Cover the page, then answer from memory.

1 Which sides of a cube can be painted?
2 Why does no cube have six painted sides?
3 How do you check the tally before you answer?

Practice

1 How many cubes have exactly one of their sides painted? ☐ sure ☐ unsure ☐ guess



1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	B	C	D	E

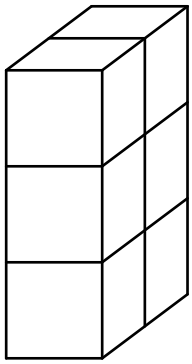
2 How many cubes have exactly three of their sides painted? ☐ sure ☐ unsure ☐ guess

1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	B	C	D	E

3 How many cubes have exactly four of their sides painted? ☐ sure ☐ unsure ☐ guess

1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	B	C	D	E

4 How many cubes have exactly three of their sides painted? ☐ sure ☐ unsure ☐ guess

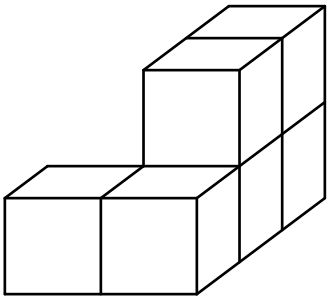


1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

5 How many cubes have exactly four of their sides painted? ☐ sure ☐ unsure ☐ guess

1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

6 How many cubes have exactly two of their sides painted? ☐ sure ☐ unsure ☐ guess



1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

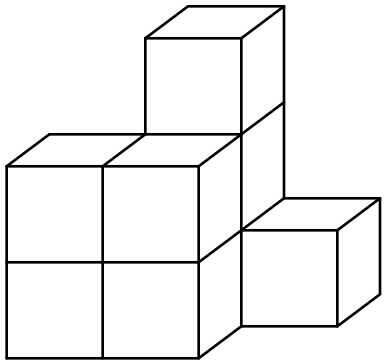
7 How many cubes have exactly three of their sides painted? ☐ sure ☐ unsure ☐ guess

1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

8 How many cubes have exactly four of their sides painted? ☐ sure ☐ unsure ☐ guess

1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

9 How many cubes have exactly two of their sides painted? ☐ sure ☐ unsure ☐ guess



1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

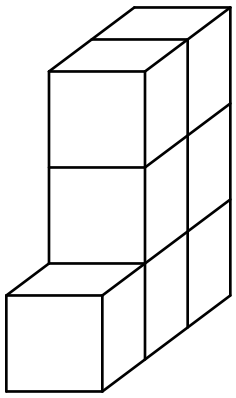
10 How many cubes have exactly four of their sides painted? ☐ sure ☐ unsure ☐ guess

1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

11 How many cubes have all five of their sides painted? ☐ sure ☐ unsure ☐ guess

1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

12 How many cubes have exactly four of their sides painted? ☐ sure ☐ unsure ☐ guess



1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

COME BACK ON _____ _____ _____ Come back to this topic after a day, a week and three weeks. **Right first time:** _____ of 12

SECTION SIX

6

Spatial Relations

Spatial Relations is the sixth type of PAT question, also called 3D Form Development or pattern folding. A flat pattern is shown, and you choose the solid it makes when folded. Each solid is drawn turned and seen from above and to one side, so you see three or more of its faces. The first three topics fold boxes; the last two fold solids with sloped faces, which are common on the test.

Your topic tracker

	Topic	Page	Check-up right	Learned	Reviewed	Secure
6.1	Cube patterns	39	☐	☐	☐	☐

Secure means right, and sure, in two review sets a week or more apart.

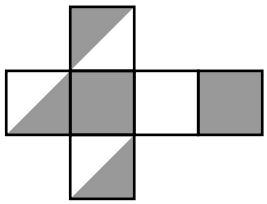
6.1 Cube patterns

TRY THIS FIRST Try this one first. The page then shows the method.

Answer at the back

☐ sure ☐ unsure ☐ guess

Which solid does the flat pattern make when it is folded?





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

A pattern of six squares folds into a cube. Its faces are plain, shaded, or shaded on one diagonal half. Four checks, in order, find the right solid without folding the whole pattern in your head.

THE RULES

1. Each question shows a flat pattern and four solids.
2. The pattern folds into exactly one of the solids. Fold it only along the lines drawn on it.
3. The pattern is the outside of the solid: its shading is on the outside.
4. Exactly one solid is right.

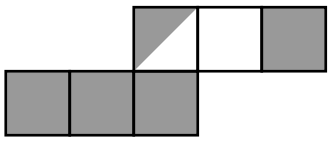
HOW TO WORK IT

1. **Find the opposite faces.** In a straight row of three squares, the first and third are opposite on the cube. Opposite faces can never be seen together, so cross out any solid that shows both.
2. **Fix one face.** Choose a face whose pattern you can place, such as a diagonal half. Find it on each solid left.
3. **Check its neighbors.** The faces that touch it on the pattern touch it on the solid, along the same edges.
4. **Check the corner.** Around the corner you see, the three faces come in a fixed order, turning one way. A mirror image turns the other way.

× WATCH OUT Mirror image. Folding never makes a mirror image, and a mirrored solid passes every check except the corner order. Check it last, every time.

WORKED EXAMPLE ✓ answer proven two ways

Which solid does the flat pattern make when it is folded?





A B C (D)

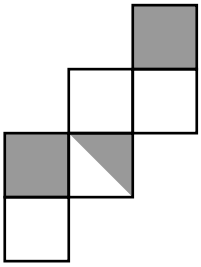
✓ **D is right.** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
B (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
C (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.

RECALL Cover the page, then answer from memory.

1 Which faces of a straight row of three are opposite?
2 Why can opposite faces never be seen together?
3 Which check catches a mirror image?

Practice

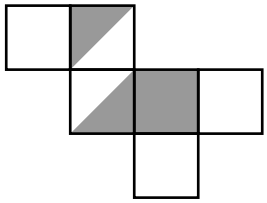
1 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





A B C D

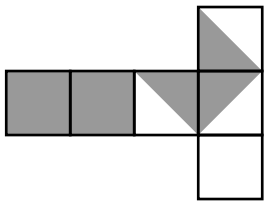
2 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





A B C D

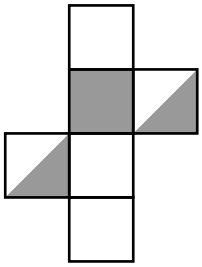
3 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





A B C D

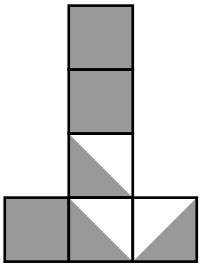
4 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess

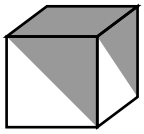




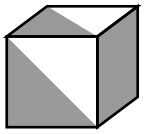
A B C D

5 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess

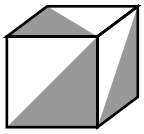




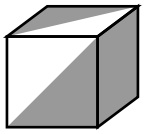
A



B

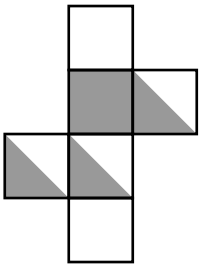


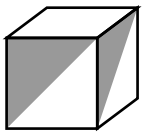
C



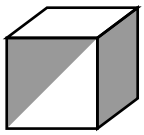
D

6 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess

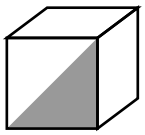




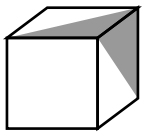
A



B

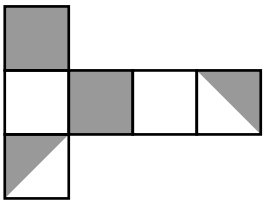


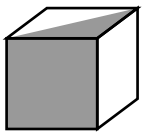
C



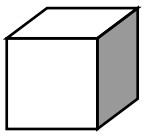
D

7 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess

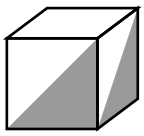




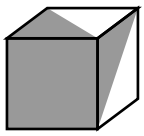
A



B

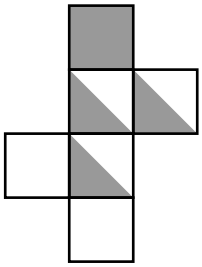


C



D

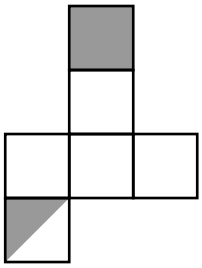
8 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





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

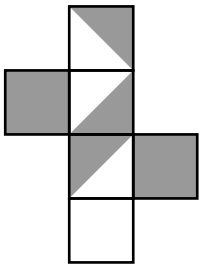
9 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





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

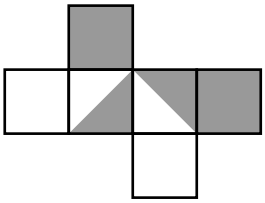
10 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





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

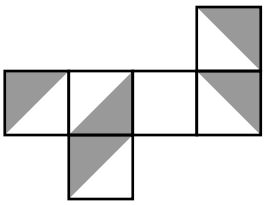
11 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





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

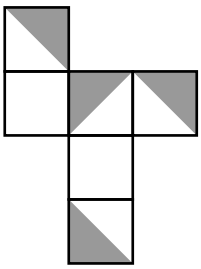
12 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





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

13 Which solid does the flat pattern make when it is folded? ☐ sure ☐ unsure ☐ guess





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

COME BACK ON _____ _____ _____ Come back to this topic after a day, a week and three weeks. **Right first time:** _____ of 13

Answers

Every answer was checked against its model and drawing before this book was printed. Under each practice answer, every wrong option is named with the mistake that usually leads to it. The practice tests have a shorter key: each wrong option's mistake, and the topic that fixes it. Write your mistakes in the log, then go back to the topic they name.

HOW SURE WERE YOU? Before you mark a set, count the answers you ticked sure. After marking, count the sure answers that were wrong. If that happens more than once in a set, slow down on that type: use the method's first step every time, before you look at the options.

Three outlines page 2

TRY THIS FIRST

→ **A** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose B (a part missing): This outline is missing a part the object has.
If you chose C (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose D (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose E (almost another side's outline): This is close to the outline from another side, but one part does not match.

PRACTICE

1 **E** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose B (too short): This outline is one cube too short in one direction.
If you chose C (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose D (a part in the wrong place): One square of this outline is in a different place from any outline of the object.

2 **B** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose C (a part in the wrong place): One square of this outline is in a different place from any outline of the object.
If you chose D (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose E (almost another side's outline): This is close to the outline from another side, but one part does not match.

3 **D** This is the exact outline of the object seen straight from the top (or bottom): put that side through first.
If you chose A (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose B (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose C (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose E (almost another side's outline): This is close to the outline from another side, but one part does not match.

4 **A** This is the exact outline of the object seen straight from the top (or bottom): put that side through first.
If you chose B (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose C (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose D (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose E (almost another side's outline): This is close to the outline from another side, but one part does not match.

5 **B** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose C (a part in the wrong place): One square of this outline is in a different place from any outline of the object.
If you chose D (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose E (almost another side's outline): This is close to the outline from another side, but one part does not match.

6 **D** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (a part in the wrong place): One square of this outline is in a different place from any outline of the object.
If you chose B (a part in the wrong place): One square of this outline is in a different place from any outline of the object.
If you chose C (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose E (almost another side's outline): This is close to the outline from another side, but one part does not match.

7 **C** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (a part missing): This outline is missing a part the object has.
If you chose B (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose D (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose E (a part in the wrong place): One square of this outline is in a different place from any outline of the object.

8 **D** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (too short): This outline is one cube too short in one direction.
If you chose B (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose C (a part missing): This outline is missing a part the object has.
If you chose E (almost another side's outline): This is close to the outline from another side, but one part does not match.

9 **D** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose B (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose C (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose E (too short): This outline is one cube too short in one direction.

10 **E** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose B (a part missing): This outline is missing a part the object has.
If you chose C (a part in the wrong place): One square of this outline is in a different place from any outline of the object.
If you chose D (almost another side's outline): This is close to the outline from another side, but one part does not match.

11 **D** This is the exact outline of the object seen straight from the front (or back): put that side through first.
If you chose A (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose B (right shape, too small): This is the outline of another side, but too small. Openings are drawn at the same scale as the object.
If you chose C (almost another side's outline): This is close to the outline from another side, but one part does not match.
If you chose E (a part in the wrong place): One square of this outline is in a different place from any outline of the object.

The end view page 9

TRY THIS FIRST

→ **D** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose A (viewed from the wrong side): This is the view from the opposite side (from the left), drawn back to front. The end view looks from the right.
If you chose B (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.
If you chose C (hidden line drawn solid): A line that is hidden from this side is drawn solid here. From the right it lies behind the object, so it must be broken.

PRACTICE

1 **A** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose B (hidden line drawn solid): A line that is hidden from this side is drawn solid here. From the right it lies behind the object, so it must be broken.
If you chose C (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.
If you chose D (hidden line drawn solid): A line that is hidden from this side is drawn solid here. From the right it lies behind the object, so it must be broken.

2 **A** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose B (hidden line drawn solid): A line that is hidden from this side is drawn solid here. From the right it lies behind the object, so it must be broken.
If you chose C (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.
If you chose D (visible line drawn broken): A line you can see from the right is drawn broken here. Nothing hides it, so it must be solid.

3 **D** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose A (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.
If you chose B (the view of a different object): This is the end view of a slightly different object. Check it edge by edge against the other two views.
If you chose C (viewed from the wrong side): This is the view from the opposite side (from the left), drawn back to front. The end view looks from the right.

4 **C** Every edge lines up with the other two views, and the end view shows no hidden edges.
If you chose A (an extra line): This has a line where the object has no edge.
If you chose B (viewed from the wrong side): This is the view from the opposite side (from the left), drawn back to front. The end view looks from the right.
If you chose D (visible line drawn broken): A line you can see from the right is drawn broken here. Nothing hides it, so it must be solid.

5 **C** Every edge lines up with the other two views, and the end view shows no hidden edges.
If you chose A (the view of a different object): This is the end view of a slightly different object. Check it edge by edge against the other two views.
If you chose B (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.
If you chose D (visible line drawn broken): A line you can see from the right is drawn broken here. Nothing hides it, so it must be solid.

6 **B** Every edge lines up with the other two views, and the end view shows no hidden edges.
If you chose A (visible line drawn broken): A line you can see from the right is drawn broken here. Nothing hides it, so it must be solid.
If you chose C (an extra line): This has a line where the object has no edge.
If you chose D (the view of a different object): This is the end view of a slightly different object. Check it edge by edge against the other two views.

7 **A** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose B (viewed from the wrong side): This is the view from the opposite side (from the left), drawn back to front. The end view looks from the right.
If you chose C (an extra line): This has a line where the object has no edge.
If you chose D (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.

8 **A** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose B (an extra line): This has a line where the object has no edge.
If you chose C (hidden line drawn solid): A line that is hidden from this side is drawn solid here. From the right it lies behind the object, so it must be broken.
If you chose D (viewed from the wrong side): This is the view from the opposite side (from the left), drawn back to front. The end view looks from the right.

9 **B** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose A (a line missing): A line is missing. Every edge of the object shows in the end view, solid if you can see it, broken if hidden.
If you chose C (viewed from the wrong side): This is the view from the opposite side (from the left), drawn back to front. The end view looks from the right.
If you chose D (the view of a different object): This is the end view of a slightly different object. Check it edge by edge against the other two views.

10 **A** Every edge lines up with the other two views, and the end view shows no hidden edges.
If you chose B (the view of a different object): This is the end view of a slightly different object. Check it edge by edge against the other two views.
If you chose C (viewed from the wrong side): This is the view from the opposite side (from the left), drawn back to front. The end view looks from the right.
If you chose D (visible line drawn broken): A line you can see from the right is drawn broken here. Nothing hides it, so it must be solid.

11 **C** Every edge lines up with the other two views, and the end view shows its hidden edges as broken lines.
If you chose A (an extra line): This has a line where the object has no edge.
If you chose B (a line out of place): One line is a square out of place. Line it up with the same edge in the other views.
If you chose D (hidden line drawn solid): A line that is hidden from this side is drawn solid here. From the right it lies behind the object, so it must be broken.

Clear gaps page 18

TRY THIS FIRST

→ **D** Measured, angle 2 is 101°, angle 4 is 128°, angle 1 is 146°, angle 3 is 155.5°, so the order is 2-4-1-3.
If you chose A (two pairs swapped): This puts angle 3 before angle 1, but angle 3 (155.5°) is larger than angle 1 (146°).
If you chose B (neighbors swapped): This puts angle 1 before angle 4, but angle 1 (146°) is larger than angle 4 (128°).
If you chose C (closest pair swapped): This puts angle 3 before angle 1, but angle 3 (155.5°) is larger than angle 1 (146°).

PRACTICE

1 **C** Measured, angle 4 is 58.5°, angle 1 is 66.5°, angle 2 is 95°, angle 3 is 113.5°, so the order is 4-1-2-3.
If you chose A (two pairs swapped): This puts angle 1 before angle 4, but angle 1 (66.5°) is larger than angle 4 (58.5°).
If you chose B (closest pair swapped): This puts angle 1 before angle 4, but angle 1 (66.5°) is larger than angle 4 (58.5°).
If you chose D (one angle misplaced): This puts angle 1 before angle 4, but angle 1 (66.5°) is larger than angle 4 (58.5°).

2 **A** Measured, angle 4 is 65.5°, angle 2 is 82°, angle 1 is 94°, angle 3 is 119.5°, so the order is 4-2-1-3.
If you chose B (closest pair swapped): This puts angle 1 before angle 2, but angle 1 (94°) is larger than angle 2 (82°).
If you chose C (one angle misplaced): This puts angle 1 before angle 2, but angle 1 (94°) is larger than angle 2 (82°).
If you chose D (one angle misplaced): This puts angle 3 before angle 1, but angle 3 (119.5°) is larger than angle 1 (94°).

3 **A** Measured, angle 2 is 104°, angle 4 is 115°, angle 1 is 139°, angle 3 is 150.5°, so the order is 2-4-1-3.
If you chose B (ranked largest to smallest): This puts angle 4 before angle 2, but angle 4 (115°) is larger than angle 2 (104°).
If you chose C (one angle misplaced): This puts angle 4 before angle 2, but angle 4 (115°) is larger than angle 2 (104°).
If you chose D (one angle misplaced): This puts angle 4 before angle 2, but angle 4 (115°) is larger than angle 2 (104°).

4 **B** Measured, angle 3 is 58.5°, angle 4 is 67.5°, angle 2 is 96°, angle 1 is 110°, so the order is 3-4-2-1.
If you chose A (closest pair swapped): This puts angle 4 before angle 3, but angle 4 (67.5°) is larger than angle 3 (58.5°).
If you chose C (one angle misplaced): This puts angle 4 before angle 3, but angle 4 (67.5°) is larger than angle 3 (58.5°).
If you chose D (neighbors swapped): This puts angle 2 before angle 4, but angle 2 (96°) is larger than angle 4 (67.5°).

5 **C** Measured, angle 4 is 36°, angle 1 is 51°, angle 3 is 68.5°, angle 2 is 77°, so the order is 4-1-3-2.
If you chose A (one angle misplaced): This puts angle 3 before angle 1, but angle 3 (68.5°) is larger than angle 1 (51°).
If you chose B (two pairs swapped): This puts angle 2 before angle 3, but angle 2 (77°) is larger than angle 3 (68.5°).
If you chose D (closest pair swapped): This puts angle 2 before angle 3, but angle 2 (77°) is larger than angle 3 (68.5°).

6 **B** Measured, angle 1 is 58°, angle 3 is 72°, angle 2 is 97°, angle 4 is 107°, so the order is 1-3-2-4.
If you chose A (one angle misplaced): This puts angle 2 before angle 3, but angle 2 (97°) is larger than angle 3 (72°).
If you chose C (closest pair swapped): This puts angle 4 before angle 2, but angle 4 (107°) is larger than angle 2 (97°).
If you chose D (ranked largest to smallest): This puts angle 4 before angle 2, but angle 4 (107°) is larger than angle 2 (97°).

7 **C** Measured, angle 1 is 31°, angle 4 is 58.5°, angle 2 is 69°, angle 3 is 84.5°, so the order is 1-4-2-3.
If you chose A (one angle misplaced): This puts angle 4 before angle 1, but angle 4 (58.5°) is larger than angle 1 (31°).
If you chose B (one angle misplaced): This puts angle 2 before angle 4, but angle 2 (69°) is larger than angle 4 (58.5°).
If you chose D (closest pair swapped): This puts angle 2 before angle 4, but angle 2 (69°) is larger than angle 4 (58.5°).

8 **D** Measured, angle 1 is 28.5°, angle 4 is 54.5°, angle 3 is 63.5°, angle 2 is 88°, so the order is 1-4-3-2.
If you chose A (one angle misplaced): This puts angle 3 before angle 4, but angle 3 (63.5°) is larger than angle 4 (54.5°).
If you chose B (closest pair swapped): This puts angle 3 before angle 4, but angle 3 (63.5°) is larger than angle 4 (54.5°).
If you chose C (one angle misplaced): This puts angle 3 before angle 4, but angle 3 (63.5°) is larger than angle 4 (54.5°).

9 **B** Measured, angle 4 is 47°, angle 2 is 57°, angle 1 is 77°, angle 3 is 92°, so the order is 4-2-1-3.
If you chose A (ranked largest to smallest): This puts angle 2 before angle 4, but angle 2 (57°) is larger than angle 4 (47°).
If you chose C (one angle misplaced): This puts angle 3 before angle 1, but angle 3 (92°) is larger than angle 1 (77°).
If you chose D (one angle misplaced): This puts angle 2 before angle 4, but angle 2 (57°) is larger than angle 4 (47°).

10 **D** Measured, angle 2 is 90.5°, angle 3 is 116°, angle 4 is 124°, angle 1 is 143°, so the order is 2-3-4-1.
If you chose A (neighbors swapped): This puts angle 1 before angle 4, but angle 1 (143°) is larger than angle 4 (124°).
If you chose B (closest pair swapped): This puts angle 4 before angle 3, but angle 4 (124°) is larger than angle 3 (116°).
If you chose C (one angle misplaced): This puts angle 4 before angle 3, but angle 4 (124°) is larger than angle 3 (116°).

11 **D** Measured, angle 2 is 103.5°, angle 4 is 115°, angle 3 is 127°, angle 1 is 138.5°, so the order is 2-4-3-1.
If you chose A (neighbors swapped): This puts angle 1 before angle 3, but angle 1 (138.5°) is larger than angle 3 (127°).
If you chose B (two pairs swapped): This puts angle 4 before angle 2, but angle 4 (115°) is larger than angle 2 (103.5°).
If you chose C (one angle misplaced): This puts angle 1 before angle 3, but angle 1 (138.5°) is larger than angle 3 (127°).

Reading the panels page 25

TRY THIS FIRST

→ **E** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose B (one hole too few): One hole short: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose C (pattern flipped): This is the right pattern flipped corner to corner. The paper is never turned over.
If you chose D (pattern flipped): This is the right pattern flipped across the other diagonal. The paper is never turned over.

PRACTICE

1 **A** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose B (pattern flipped): This is the right pattern flipped corner to corner. The paper is never turned over.
If you chose C (pattern flipped): This is the right pattern flipped across the other diagonal. The paper is never turned over.
If you chose D (opened across the wrong line): This opens fold 1 across a line one step below its crease. Each hole is copied across the crease of the fold being opened.
If you chose E (holes moved one place): The holes are one place too far down. Follow the punch's exact place as each fold opens.

2 **C** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (holes moved one place): The holes are one place too far left. Follow the punch's exact place as each fold opens.
If you chose B (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose D (holes moved one place): The holes are one place too far right. Follow the punch's exact place as each fold opens.
If you chose E (one hole too few): One hole short: the paper was 2 layers thick at the punch, so there are 2 holes.

3 **D** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (opened across the wrong line): This opens fold 1 across a line one step to the right of its crease. Each hole is copied across the crease of the fold being opened.
If you chose B (pattern flipped): This is the right pattern flipped corner to corner. The paper is never turned over.
If you chose C (one hole too few): One hole short: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose E (opened across the wrong line): This opens fold 1 across a line at right angles to its crease. Each hole is copied across the crease of the fold being opened.

4 **B** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (pattern flipped): This is the right pattern flipped top to bottom. The paper is never turned over.
If you chose C (one hole too few): One hole short: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose D (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose E (holes moved one place): The holes are one place too far up. Follow the punch's exact place as each fold opens.

5 **C** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (opened across the wrong line): This opens fold 1 across a line one step to the left of its crease. Each hole is copied across the crease of the fold being opened.
If you chose B (pattern flipped): This is the right pattern flipped across the other diagonal. The paper is never turned over.
If you chose D (opened across the wrong line): This opens fold 1 across a line one step to the right of its crease. Each hole is copied across the crease of the fold being opened.
If you chose E (holes moved one place): The holes are one place too far up. Follow the punch's exact place as each fold opens.

6 **D** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (holes moved one place): The holes are one place too far up. Follow the punch's exact place as each fold opens.
If you chose B (holes moved one place): The holes are one place too far down. Follow the punch's exact place as each fold opens.
If you chose C (one hole too few): One hole short: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose E (opened across the wrong line): This opens fold 1 across a line one step to the right of its crease. Each hole is copied across the crease of the fold being opened.

7 **B** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose C (opened across the wrong line): This opens fold 1 across a line one step to the right of its crease. Each hole is copied across the crease of the fold being opened.
If you chose D (holes moved one place): The holes are one place too far down. Follow the punch's exact place as each fold opens.
If you chose E (opened across the wrong line): This opens fold 1 across a line one step to the left of its crease. Each hole is copied across the crease of the fold being opened.

8 **E** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (holes moved one place): The holes are one place too far right. Follow the punch's exact place as each fold opens.
If you chose B (opened across the wrong line): This opens fold 1 across a line one step below its crease. Each hole is copied across the crease of the fold being opened.
If you chose C (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose D (holes moved one place): The holes are one place too far left. Follow the punch's exact place as each fold opens.

9 **D** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (holes moved one place): The holes are one place too far down. Follow the punch's exact place as each fold opens.
If you chose B (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose C (opened across the wrong line): This opens fold 1 across a line at right angles to its crease. Each hole is copied across the crease of the fold being opened.
If you chose E (one hole too few): One hole short: the paper was 2 layers thick at the punch, so there are 2 holes.

10 **D** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (opened across the wrong line): This opens fold 1 across a line one step to the left of its crease. Each hole is copied across the crease of the fold being opened.
If you chose B (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose C (pattern flipped): This is the right pattern flipped left to right. The paper is never turned over.
If you chose E (holes moved one place): The holes are one place too far up. Follow the punch's exact place as each fold opens.

11 **E** The punch goes through 2 layers, so the open sheet has 2 holes. Open the folds last first. Fold 1 takes 1 hole to 2.
If you chose A (holes moved one place): The holes are one place too far left. Follow the punch's exact place as each fold opens.
If you chose B (opened across the wrong line): This opens fold 1 across a line at right angles to its crease. Each hole is copied across the crease of the fold being opened.
If you chose C (one hole too many): One hole too many: the paper was 2 layers thick at the punch, so there are 2 holes.
If you chose D (opened across the wrong line): This opens fold 1 across a line one step below its crease. Each hole is copied across the crease of the fold being opened.

The tally page 34

TRY THIS FIRST

→ **A** Tally of painted sides for all 10 cubes, 1 of them a hidden support: 1 side: 1, 2 sides: 2, 3 sides: 2, 4 sides: 5.
If you chose B (missed a touching side): This is how many cubes have 2 sides painted. A side counts as painted only if no cube touches it.
If you chose C (lost count): Recount with a tally: exactly 1 cube has 1 side painted.
If you chose D (counted only the sides you can see): This counts only the sides you can see (top, front, right). The back and left sides were painted too.
If you chose E (lost count): Recount with a tally: exactly 1 cube has 1 side painted.

PRACTICE

1 **A** Tally of painted sides for all 8 cubes, 1 of them a hidden support: 1 side: 1, 2 sides: 1, 3 sides: 4, 4 sides: 2.
If you chose B (counted only the sides you can see): This counts only the sides you can see (top, front, right). The back and left sides were painted too.
If you chose C (lost count): Recount with a tally: exactly 1 cube has 1 side painted.
If you chose D (lost count): Recount with a tally: exactly 1 cube has 1 side painted.
If you chose E (lost count): Recount with a tally: exactly 1 cube has 1 side painted.

2 **D** Tally of painted sides for all 8 cubes, 1 of them a hidden support: 1 side: 1, 2 sides: 1, 3 sides: 4, 4 sides: 2.
If you chose A (counted a side as touching): This is how many cubes have 2 sides painted. A side touching another cube is not painted; one side too many was counted as touching.
If you chose B (counted only the sides you can see): This counts only the sides you can see (top, front, right). The back and left sides were painted too.
If you chose C (lost count): Recount with a tally: exactly 4 cubes have 3 sides painted.
If you chose E (lost count): Recount with a tally: exactly 4 cubes have 3 sides painted.

3 **B** Tally of painted sides for all 8 cubes, 1 of them a hidden support: 1 side: 1, 2 sides: 1, 3 sides: 4, 4 sides: 2.
If you chose A (lost count): Recount with a tally: exactly 2 cubes have 4 sides painted.
If you chose C (lost count): Recount with a tally: exactly 2 cubes have 4 sides painted.
If you chose D (counted a side as touching): This is how many cubes have 3 sides painted. A side touching another cube is not painted; one side too many was counted as touching.
If you chose E (bottom painted): This paints the bottom of the cubes on the floor. The bottom is never painted.

4 **D** Tally of painted sides for all 6 cubes: 3 sides: 4, 4 sides: 2.
If you chose A (counted only the sides you can see): This counts only the sides you can see (top, front, right). The back and left sides were painted too.
If you chose B (bottom painted): This paints the bottom of the cubes on the floor. The bottom is never painted.
If you chose C (lost count): Recount with a tally: exactly 4 cubes have 3 sides painted.
If you chose E (lost count): Recount with a tally: exactly 4 cubes have 3 sides painted.

5 **B** Tally of painted sides for all 6 cubes: 3 sides: 4, 4 sides: 2.
If you chose A (lost count): Recount with a tally: exactly 2 cubes have 4 sides painted.
If you chose C (lost count): Recount with a tally: exactly 2 cubes have 4 sides painted.
If you chose D (bottom painted): This paints the bottom of the cubes on the floor. The bottom is never painted.
If you chose E (lost count): Recount with a tally: exactly 2 cubes have 4 sides painted.

6 **A** Tally of painted sides for all 6 cubes: 2 sides: 1, 3 sides: 2, 4 sides: 3.
If you chose B (counted only the sides you can see): This counts only the sides you can see (top, front, right). The back and left sides were painted too.
If you chose C (lost count): Recount with a tally: exactly 1 cube has 2 sides painted.
If you chose D (lost count): Recount with a tally: exactly 1 cube has 2 sides painted.
If you chose E (lost count): Recount with a tally: exactly 1 cube has 2 sides painted.

7 **B** Tally of painted sides for all 6 cubes: 2 sides: 1, 3 sides: 2, 4 sides: 3.
If you chose A (bottom painted): This paints the bottom of the cubes on the floor. The bottom is never painted.
If you chose C (missed a touching side): This is how many cubes have 4 sides painted. A side counts as painted only if no cube touches it.
If you chose D (lost count): Recount with a tally: exactly 2 cubes have 3 sides painted.
If you chose E (lost count): Recount with a tally: exactly 2 cubes have 3 sides painted.

8 **C** Tally of painted sides for all 6 cubes: 2 sides: 1, 3 sides: 2, 4 sides: 3.
If you chose A (lost count): Recount with a tally: exactly 3 cubes have 4 sides painted.
If you chose B (counted a side as touching): This is how many cubes have 3 sides painted. A side touching another cube is not painted; one side too many was counted as touching.
If you chose D (bottom painted): This paints the bottom of the cubes on the floor. The bottom is never painted.
If you chose E (lost count): Recount with a tally: exactly 3 cubes have 4 sides painted.

9 **B** Tally of painted sides for all 8 cubes, 1 of them a hidden support: 2 sides: 2, 3 sides: 3, 4 sides: 2, 5 sides: 1.
If you chose A (hidden supports left out): This leaves out the hidden cubes. 1 cube is hidden, holding up cubes you can see, and it is painted too.
If you chose C (missed a touching side): This is how many cubes have 3 sides painted. A side counts as painted only if no cube touches it.
If you chose D (lost count): Recount with a tally: exactly 2 cubes have 2 sides painted.
If you chose E (lost count): Recount with a tally: exactly 2 cubes have 2 sides painted.

10 **B** Tally of painted sides for all 8 cubes, 1 of them a hidden support: 2 sides: 2, 3 sides: 3, 4 sides: 2, 5 sides: 1.
If you chose A (missed a touching side): This is how many cubes have 5 sides painted. A side counts as painted only if no cube touches it.
If you chose C (counted a side as touching): This is how many cubes have 3 sides painted. A side touching another cube is not painted; one side too many was counted as touching.
If you chose D (lost count): Recount with a tally: exactly 2 cubes have 4 sides painted.
If you chose E (lost count): Recount with a tally: exactly 2 cubes have 4 sides painted.

11 **A** Tally of painted sides for all 8 cubes, 1 of them a hidden support: 2 sides: 2, 3 sides: 3, 4 sides: 2, 5 sides: 1.
If you chose B (bottom painted): This paints the bottom of the cubes on the floor. The bottom is never painted.
If you chose C (lost count): Recount with a tally: exactly 1 cube has 5 sides painted.
If you chose D (lost count): Recount with a tally: exactly 1 cube has 5 sides painted.
If you chose E (lost count): Recount with a tally: exactly 1 cube has 5 sides painted.

12 **C** Tally of painted sides for all 7 cubes: 2 sides: 1, 3 sides: 3, 4 sides: 3.
If you chose A (lost count): Recount with a tally: exactly 3 cubes have 4 sides painted.
If you chose B (lost count): Recount with a tally: exactly 3 cubes have 4 sides painted.
If you chose D (lost count): Recount with a tally: exactly 3 cubes have 4 sides painted.
If you chose E (lost count): Recount with a tally: exactly 3 cubes have 4 sides painted.

Cube patterns page 39

TRY THIS FIRST

→ **A** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose B (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

PRACTICE

1 **B** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.

2 **A** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose B (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

3 **D** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose B (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.
If you chose C (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.

4 **C** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose B (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.

5 **D** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose B (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose C (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.

6 **B** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

7 **C** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose B (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

8 **A** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose B (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

9 **D** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose B (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose C (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.

10 **C** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose B (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

11 **A** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose B (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (pattern turned): One face's pattern is turned the wrong way. Check which edge its diagonal or band runs along.

12 **B** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose A (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

13 **A** Fold the pattern with the shading outside: this is the box it makes, turned to show these three faces.
If you chose B (mirror image): This is the mirror image of the box the pattern makes. Folding never turns a pattern into its mirror.
If you chose C (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.
If you chose D (faces swapped): Two faces have traded patterns. Find a face you know and check its neighbors on the pattern.

Mistake finder

Every wrong option in this book is a particular, common mistake, built in on purpose. If the answers keep naming the same one, read its fix here, then go back to the topic it names and try that topic's practice again.

Angle Discrimination

Neighbors swapped Two angles next to each other in size were put the wrong way round. Compare each neighboring pair in your order before you choose.

Closest pair swapped Leave the two closest angles until last. Judge only the opening: imagine laying one angle on the other, vertex on vertex and one arm on one arm, and see which other arm lies outside.

One angle misplaced One angle sits two or more places from where it belongs. Find the smallest and the largest first, then place the middle two. Go back to 3.1 , page 18.

Ranked largest to smallest The order asked for runs from the smallest angle to the largest. Go back to 3.1 , page 18.

Two pairs swapped Two neighboring pairs are reversed. Find the smallest and largest first, then settle each pair.

Apertures

A part missing An outline includes every part that sticks out, even when another part is behind it. Go back to 1.1 , page 2.

A part in the wrong place Find the object's three outlines first: front, top and side. Then compare each opening square by square with the outline it looks like.

Almost another side's outline Close is not exact. The right opening matches one outline square for square.

Too long Count the cubes along each side of the object and check the opening's lengths against them. Go back to 1.1 , page 2.

Too short Count the cubes along each side of the object and check the opening's lengths against them. Go back to 1.1 , page 2.

Right shape, too small Openings are drawn at the object's scale. Compare a length you can measure on both. Go back to 1.1 , page 2.

Cube Counting

Bottom painted The bottom the figure stands on is never painted. A cube alone on the floor has five painted sides, not six. Go back to 5.1 , page 34.

Lost count Make a tally before you answer: for each cube, count the top and four sides that nothing touches, and mark it under 1 to 5. The tally answers every question about the figure. Go back to 5.1 , page 34.

Hidden supports left out A cube that holds up a cube you can see is there, even when you cannot see it, and its open sides are painted. Put the hidden supports in your tally.

Counted a side as touching A side is unpainted only where another cube covers it. Check each side of the cube you counted. Go back to 5.1 , page 34.

Missed a touching side A side with a cube against it is not painted. Check above and on all four sides. Go back to 5.1 , page 34.

Counted only the sides you can see The back and left sides were painted too. Count every side with no cube against it, seen or not. Go back to 5.1 , page 34.

Paper Folding

One hole too many The open sheet has one hole for each layer the punch went through. Count the layers first.

Opened only the last fold Open every fold, last first. Each fold you open copies the holes across its crease wherever paper was folded over them.

One hole too few The open sheet has one hole for each layer the punch went through. Count the layers first.

Pattern flipped The paper is never turned over, so the pattern never flips as a whole. Open one fold at a time. Go back to 4.1 , page 25.

Skipped a fold Count the fold panels and open each one in turn, last first. Tick each panel as you open it.

Doubled at every fold A fold adds holes only where folded paper lay under the punch. Count the layers at the punch before you double anything.

Holes moved one place Fix the punch's exact square on the 4 × 4 grid before you open anything, then follow that square. Go back to 4.1 , page 25.

Opened across the wrong line Each fold opens across its own crease. Copy each hole across that crease, the same distance on the other side.

Spatial Relations

Mirror image Folding never makes a mirror image. Pick a corner where three faces meet and check their order. Go back to 6.1 , page 39.

Opposite faces shown together Faces opposite each other on the folded solid can never be seen at once. Go back to 6.1 , page 39.

Wrong proportions Match each face's length and width on the pattern with the edges of the solid.

Slope in the wrong place Find the sloped face on the pattern and the faces that meet it along an edge. On the solid, the same faces must meet it.

Pattern turned Check which edge a diagonal or band runs along, on the pattern and on the solid. Go back to 6.1 , page 39.

Faces swapped Find a face you are sure of on the pattern, then check which faces touch it. Go back to 6.1 , page 39.

View Recognition

Hidden line drawn solid Ask of each line whether something stands between it and you. If so, it must be broken.

An extra line Each line must come from an edge you can find in the other two views. Go back to 2.1 , page 9.

A line missing Every edge shows in every view, solid or broken. Line up each edge with the other two views. Go back to 2.1 , page 9.

A line out of place Project each edge across from the neighboring view, square by square.

The view of a different object Check every line, not just the outline: one cube more or less changes a single line.

Viewed from the wrong side The end view looks from the right, the top view from above, the front view from the front. Keep the view's edges lined up with its neighbors. Go back to 2.1 , page 9.

Visible line drawn broken A line you can see from that side is solid, even if a hidden line lies on it too.

The full book

The full workbook has everything in this sample, and more:

- 768 questions, every one checked against its model and drawing before printing
- A check-up that shows which of the 21 topics to start with
- Spaced review sets that bring every topic back, and a timed drill for each type
- 3 full-length practice tests: 90 questions each, 15 of each type
- A timing plan, a 10-week study plan, a mistakes log and a test-day method card
- Every answer explained, with a mistake finder for every wrong option

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Train for the PAT with questions you can trust.

The Perceptual Ability Test asks ninety spatial questions of six types in one hour. This workbook teaches each type with one clear method, then builds speed in stages: worked examples, practice that climbs from easy to test-hard, spaced reviews, a timed drill for every type and three full-length practice tests.

- 768 questions in 21 topics, from first steps to test-hard, with spaced reviews
- 3 full-length practice tests: 90 questions, 15 of each type, in test order
- A check-up that shows where to start, and a timed drill for every type
- Every option explained: each wrong one named with the mistake behind it
- A timing plan, a 10-week study plan and a one-page method card for test day

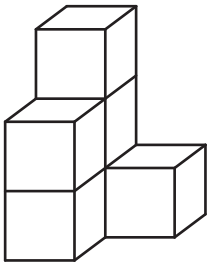
Every question has exactly one right answer.

Every question here was checked against its model and drawing before printing. Additional geometry tests check known failure cases. The checking itself was tested with 5,276 planted faults, and it caught every one.

Try the question on the front

As printed inside: the check-up, question 21, page 9.

How many cubes have exactly two of their sides painted?



1 cube	2 cubes	3 cubes	4 cubes	5 cubes
A	**B**	**C**	**D**	**E**

Answer: A, 1 cube. Tally of painted sides for all 6 cubes, 1 of them a hidden support: 2 sides: 1, 3 sides: 2, 4 sides: 2, 5 sides: 1. B: missed a touching side. C: lost count. D: lost count. E: lost count.

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Black-and-white interior, drawn like the on-screen test. US Letter, 448 pages. The Dental Admission Test (DAT) is administered by the American Dental Association, which has not reviewed, sponsored or endorsed this book. All questions are original.