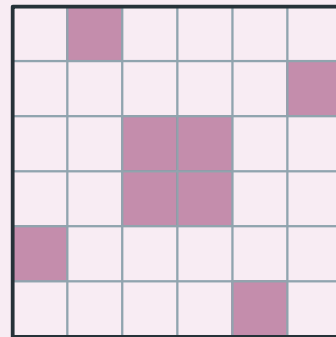
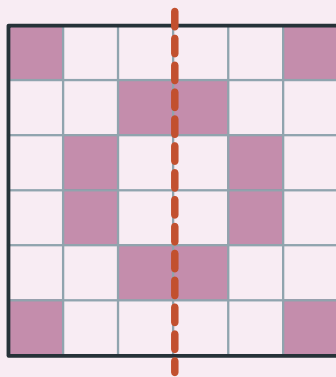


Symmetry & Pattern Art Studio

6 construction investigations, each with a worked answer.



HOW TO USE

1. Read the task and look closely at the grid or template.
2. Fold, trace or draw to test mirror lines and turns.
3. Explain how you know your design works.
4. Try the new design at the bottom of the page.

6 activities • 3 answer pages • From the 24-activity collection

11 US Letter pages • Print at 100% / Actual Size

Original Bobotemp educational printable • Fictional names, places and prices

BEFORE YOU START

Studio Toolkit

Three tools you will use on every page: cell names, the fold test for mirror lines and the tracing test for turns.

1. How cells are named

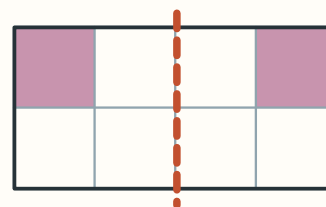
A cell is named by its row and then its column. Rows count down from the top: row 1 is the top row. Columns count from left to right: col 1 is the left column. So “row 2 col 3” means row 2, column 3. The grids on the activity pages have no numbers, so count from the top-left corner.

CELL NAMES

	col 1	col 2	col 3	col 4
row 1				
row 2			row 2 col 3	
row 3				

2. Test a mirror line by folding

1. Fold the page, or a tracing of the design, along the dashed mirror line.
2. Hold it up to the light. Every shaded cell must land exactly on a shaded cell.
3. A cell and its image are the same distance from the mirror, on opposite sides. Below, row 1 col 1 and row 1 col 4 match across the mirror.



3. Test a turn by tracing

1. Trace the design on tracing paper or thin paper, including its outline.
2. Press a pencil point on the center so the tracing can spin.
3. Turn the tracing slowly. Count every position where it matches the design underneath, until it is back where it started. The start position counts once, after the full 360° turn.
4. That count is the order of rotational symmetry.

MATERIALS

Predict first, then check. You need a pencil, a ruler, tracing paper or thin paper, and colored pencils if you like. Scissors are optional for the folding and cutting pages; use classroom scissors. No special kits are needed.

Name _____ Date _____

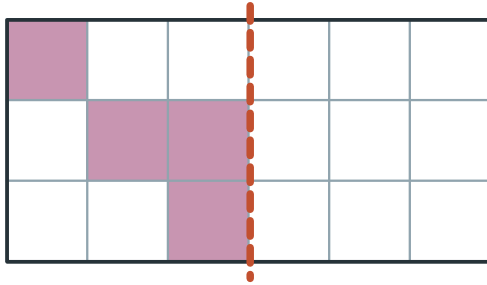
LEVEL 1



Use the construction grid. The dashed mirror line runs between column 3 and column 4.

Shade the right half so the tile is symmetric across the mirror line. How many cells are shaded in the finished tile?

CONSTRUCTION GRID: ROW 1 IS THE TOP ROW, COL 1 THE LEFT COLUMN



EVIDENCE TO USE

- Grid: 3 rows by 6 columns
- Mirror line: vertical, between col 3 and col 4
- Row 1 left half shaded: col 1
- Row 2 left half shaded: col 2, col 3
- Row 3 left half shaded: col 3
- Mirror rule: column c reflects to column $7 - c$

1. List the right-half cells you shade in each row.

2. Count all shaded cells in the finished tile.

[illegible]

3. Explain why col 3 reflects to col 4.

TRY IT • On the same grid, the cell row 2 col 1 is added to the left half. Which cell do you shade on the right?

Name _____ Date _____

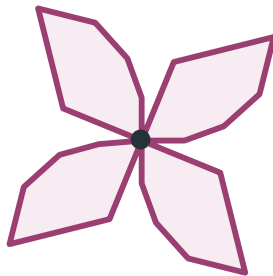
LEVEL 1



Trace the pinwheel on tracing paper. Pin it at the center and turn it until it matches again.

The pinwheel has 4 identical blades all curving the same way. What is its order of rotational symmetry, and what is the smallest turn that makes it match?

PINWHEEL TO TRACE



pin at the center dot

EVIDENCE TO USE

- Design: 4 identical blades, evenly spaced, same curl direction
- Full turn = 360°
- Order = number of matching positions in one full turn
- Smallest matching turn = $360^\circ \div \text{order}$

1. Count the matching positions in a full turn.

2. Compute the smallest matching turn.

[illegible]

3. Explain whether the pinwheel has a mirror line.

TRY IT • A pinwheel has 5 identical blades. What is the smallest matching turn?

Name _____ Date _____

LEVEL 1



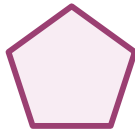
Each tile is a regular polygon. Copies tile a floor only if their corner angles meet to make exactly 360° with no gaps.

Which single tile shape covers a floor with exactly 4 tiles meeting at every corner?

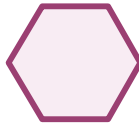
TILE TRAY



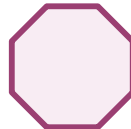
triangle 60°

square 90° 

pentagon 108°



hexagon 120°



octagon 135°

EVIDENCE TO USE

- Equilateral triangle corner: 60°
- Square corner: 90°
- Regular pentagon corner: 108°
- Regular hexagon corner: 120°
- Regular octagon corner: 135°
- Corners around a point must total 360°

1. Cross out tiles whose angle does not divide 360 evenly.

2. Find how many of each remaining tile meet at a point.

[illegible]

3. Name the tile that meets 4 at a corner.

[illegible]

TRY IT • How many regular hexagons meet at each corner of a hexagon floor?

Name _____ Date _____

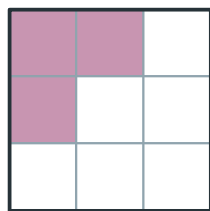
Quarter Turn on a 3-by-3 Tile

LEVEL 2

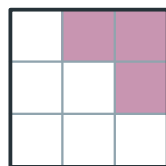


Turn the whole 3-by-3 tile 90° clockwise about its center cell. Predict first, then check with tracing paper.

Which answer grid shows the tile after a 90° clockwise turn?



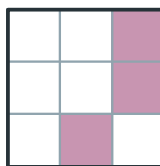
Start tile



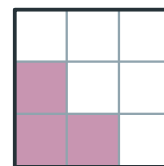
Option A



Option B



Option C



Option D

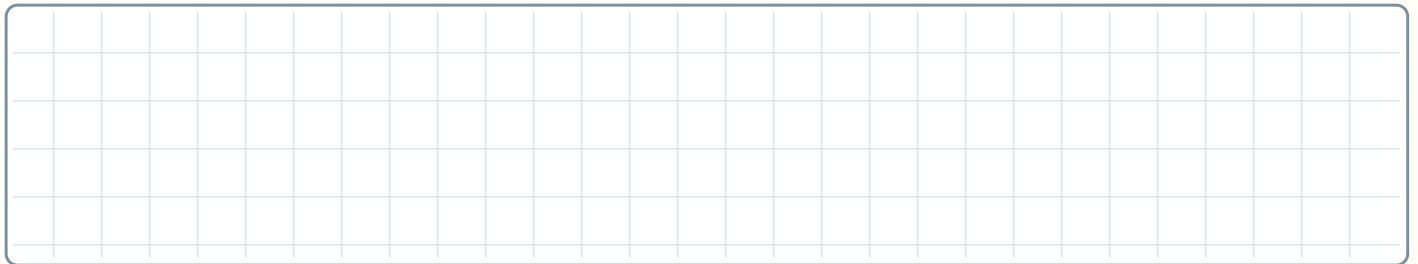
Clockwise rule

Row r , col c moves to
row c , col $4 - r$

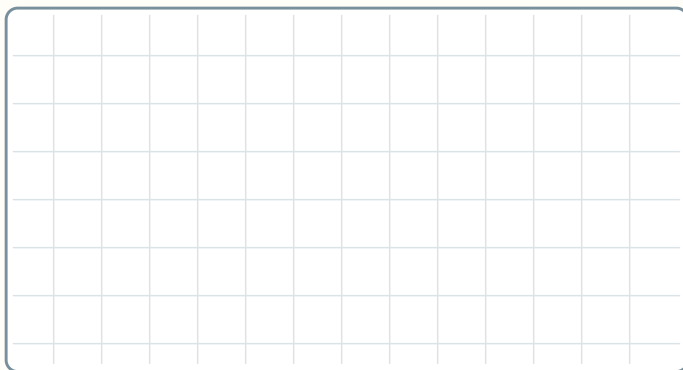
Counting

Row 1 is the top row;
col 1 is the left column

1. Use the rule to move row 1 col 1 and row 2 col 1.



2. Cross out options that miss those images.



3. Explain where row 1 col 2 lands.

TRY IT • Where does row 3 col 3 go after a 90° clockwise turn of the 3-by-3 tile? Explain how you know.

Quadrilateral Mirror Lab



Which quadrilateral has exactly 2 lines of symmetry that both run corner to corner?



kite

- Square: 4 equal sides, 4 right angles
- Rectangle (not square): 4 right angles
- Rhombus (not square): 4 equal sides
- Parallelogram: opposite sides parallel, no right angles, not a rhombus
- Isosceles trapezoid: 1 pair of parallel sides, 2 equal legs
- Kite (not rhombus): two pairs of equal neighboring sides

[illegible][illegible]

Name _____ Date _____

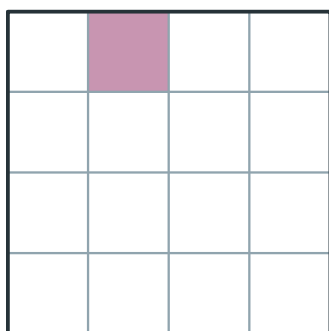
Full-Symmetry Square Tile

LEVEL 3



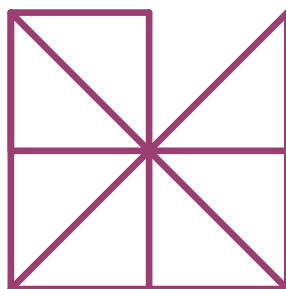
On a 4-by-4 grid, one cell is shaded. Add the fewest cells so the tile has all 4 square mirror lines and order-4 turn symmetry.

Which cells must you add, and how many cells are shaded in the finished tile?



Row 1: top row • col 1: left column

MIRRORS TO TEST

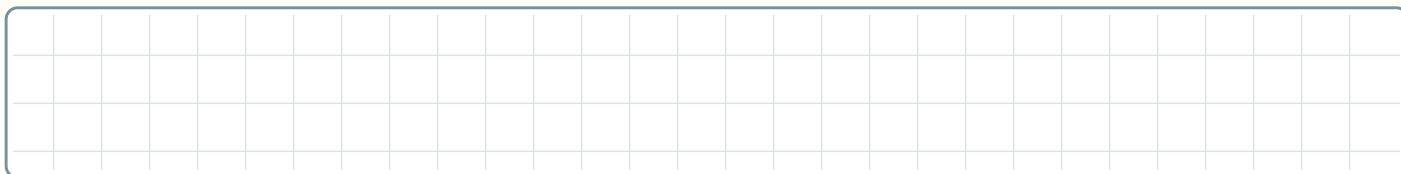


vertical, horizontal, both diagonals

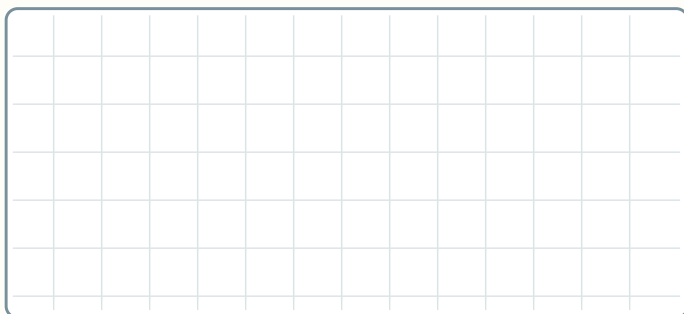
EVIDENCE TO USE

- Grid: 4 rows by 4 columns
- Starting cell: row 1 col 2
- Vertical mirror: col c becomes col $5 - c$
- Horizontal mirror: row r becomes row $5 - r$
- Main diagonal mirror: swap the row and col numbers
- Required: vertical, horizontal, and both diagonal mirror lines

1. Reflect row 1 col 2 across each mirror line and keep reflecting the new cells.



2. List all cells you add.



3. Explain why the tile also has order-4 turn symmetry.



TRY IT • Starting with only row 1 col 1 on the 4-by-4 grid, how many cells are in the full-symmetry tile?

1. Finish the Mirror Tile

LEVEL 1

Shade row 1: col 6. Shade row 2: col 4 and col 5. Shade row 3: col 4. The finished tile has 8 shaded cells.

WORKED REASONING • Each cell lands the same distance from the mirror on the other side. Col 1 is 3 cells from the mirror, so it reflects to col 6. Col 2 reflects to col 5 and col 3 reflects to col 4. There are 4 shaded cells on the left, and 4 reflected cells are added, so $4 \times 2 = 8$.

WATCH FOR • Some students copy the left half by sliding it 3 columns to the right. That shades row 1 col 4, row 2 col 5, row 2 col 6, and row 3 col 6 (columns 4, 5, 6, 6) instead of the correct row 1 col 6, row 2 col 4, row 2 col 5, and row 3 col 4. Sliding keeps the same order, but a reflection reverses the order across the mirror.

TRANSFER • Row 2 col 6, because column 1 reflects to column $7 - 1 = 6$.

4. Pinwheel Turn Test

LEVEL 1

Order 4. The smallest matching turn is 90° . It has no line of symmetry because the blades all curl the same way.

WORKED REASONING • The tracing matches at 90° , 180° , 270° , and 360° , which is 4 positions. $360 \div 4 = 90^\circ$. A mirror would flip the curl direction, so no line of symmetry works.

WATCH FOR • Some students say the order is 3 because they do not count the full 360° return. The starting position reached again after a full turn counts as one of the matches.

TRANSFER • 72° , because $360 \div 5 = 72$.

8. Which Tile Covers the Floor?

LEVEL 1

The square. $360 \div 90 = 4$.

WORKED REASONING • $360 \div 60 = 6$, $360 \div 90 = 4$, and $360 \div 120 = 3$, so the triangle, square, and hexagon tile alone. $360 \div 108$ and $360 \div 135$ are not whole numbers, so the pentagon and octagon leave gaps. Only the square has exactly 4 tiles at each corner.

WATCH FOR • Students may think any regular shape tiles because it looks neat. Pentagons leave a 36° gap: $3 \times 108 = 324$, which falls short of 360.

TRANSFER • 3

11. Quarter Turn on a 3-by-3 Tile

LEVEL 2

Option A: row 1 col 2, row 1 col 3, row 2 col 3

WORKED REASONING • Row 1 col 1 moves to row 1, col $4 - 1 = 3$, which is row 1 col 3, so only A and C remain. Row 2 col 1 moves to row 1, col $4 - 2 = 2$, which is row 1 col 2, so only A remains. Row 1 col 2 moves to row 2, col $4 - 1 = 3$, which is row 2 col 3, and that is also in A.

WATCH FOR • Some students turn only one cell or turn counterclockwise. A clockwise quarter turn sends the top-left corner to the top-right corner.

TRANSFER • Row 3 col 1 (bottom-right moves to bottom-left).

13. Quadrilateral Mirror Lab

LEVEL 2

The rhombus (not a square)

WORKED REASONING • Exactly 2 lines leaves the rectangle and the rhombus. A rectangle's lines cut through the midpoints of opposite sides. Folding a rectangle on its diagonal does not match the halves. A rhombus folds evenly on both diagonals, so it is the answer.

WATCH FOR • Many students believe a rectangle's diagonals are mirror lines. Folding a paper rectangle corner to corner shows the flaps do not line up.

TRANSFER • The parallelogram.

19. Full-Symmetry Square Tile

LEVEL 3

Add row 1 col 3, row 2 col 1, row 3 col 1, row 2 col 4, row 3 col 4, row 4 col 2, row 4 col 3. That is 7 cells added, for a total of 8 shaded cells.

WORKED REASONING • The vertical mirror sends row 1 col 2 to row 1 col 3. The horizontal mirror sends row 1 col 2 and row 1 col 3 to row 4 col 2 and row 4 col 3. The diagonal mirror (swap) sends those four cells to row 2 col 1, row 3 col 1, row 2 col 4, and row 3 col 4. Reflecting again adds nothing new, so the set has 8 cells, and $8 - 1 = 7$ were added. Quarter-turn check: a 90° clockwise turn sends row r , col c to row c , col $5 - r$, so row 1 col 2 $\rightarrow$ row 2 col 4 $\rightarrow$ row 4 col 3 $\rightarrow$ row 3 col 1 $\rightarrow$ row 1 col 2 and row 1 col 3 $\rightarrow$ row 3 col 4 $\rightarrow$ row 4 col 2 $\rightarrow$ row 2 col 1 $\rightarrow$ row 1 col 3. Every shaded cell lands on a shaded cell, so quarter turns match and the tile has order 4.

WATCH FOR • Students stop after the vertical and horizontal mirrors and leave out the diagonal images. The tile then has only 2 lines of symmetry.

TRANSFER • 4 cells (the four corners), because row 1 col 1 lies on a diagonal mirror.