

Tactile Tangrams

GUIDEBOOK

by
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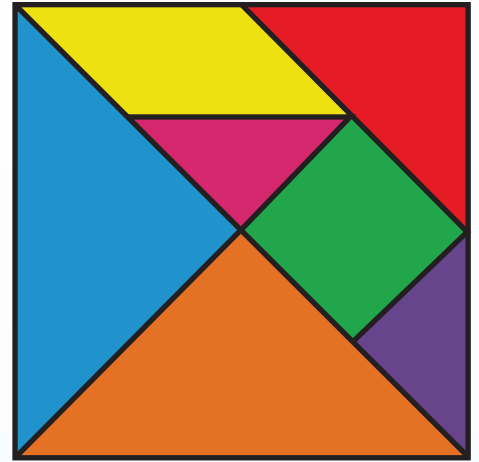


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introduction

The tangram puzzle is an ancient Chinese puzzle consisting of seven pieces in three different shapes: two large triangles, one medium triangle, two small triangles, a square, and a parallelogram. The materials and activities presented in **Tactile Tangrams** make this timeless and popular puzzle accessible to students and adults with visual impairments and blindness.



The use of tangram puzzles encourages the development and reinforcement of many educational and recreational skills including spatial reasoning, shape recognition, size comparison, pattern replication, and independent problem solving. Concepts such as congruence, symmetry, sides and angles, and fractions are also reinforced. Most notably, the use of tangram puzzles supports the following National Geometry Standards:

- Recognize, name, build, draw, compare, and sort two- and three-dimensional shapes
- Describe attributes and parts of two- and three-dimensional shapes
- Investigate and predict the results of putting together and taking apart two- and three-dimensional shapes

- Recognize and apply slides, flips, and turns
- Recognize and create shapes that have symmetry
- Recognize and represent shapes from different perspectives
- Relate ideas in geometry to ideas in numbers and measurement

The following expanded skills, especially important for tactile and low vision readers, are also addressed:

- Visual/tactile discrimination
- Visual/tactile memory
- Visual/tactile spatial orientation
- Parts of a whole understanding
- Recreational/leisure skills

Tactile Tangrams includes the following components:

- (2) Sets of 7 magnetic-backed tangram puzzle pieces (for use with a metal surface—e.g., APH's ALL-IN-ONE Board)
- (2) Sets of 7 translucent tangram puzzle pieces (for use with a light box)
- (2) Sets of 7 foam tangram puzzle pieces

- (26) Tactile/print “Silhouette Puzzle Frames”—raised outline images into which the puzzle pieces can be arranged
- (26) Tactile/print “Puzzle Solutions” showing a dissected view of each puzzle image
- (2) Magnetic strips for mounting frames to a metal surface
- (5) Tactile/print grid sheets
- (1) Tactile Tangrams Guidebook in large print
[Note: The braille version of this guidebook is available separately.]
- (1) CD with accessible versions of the guidebook

The activities in this guidebook are presented in an order that first acquaints a student with the tangram puzzle pieces, focusing specifically on geometry concepts (e.g., sides, angles, symmetry, etc.) before puzzle solving is introduced. These activities can be de-emphasized or omitted for the student or adult who prefers to focus exclusively on the task of solving the tangram puzzles. In this case, skip to **Activity 11** for puzzle solving instructions and game options.



A graphic for 'Activity 1' featuring a central orange diamond shape divided into four triangles. This diamond is surrounded by four red triangles, two pointing outwards and two pointing inwards, creating a larger, irregular shape. The word 'Activity' is written in a white, stylized font with a black outline, and the number '1' is written below it in the same style.

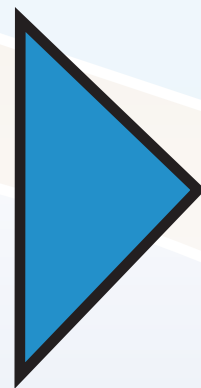
Activity 1

Puzzle Piece Comparisons

Explore and discuss the unique shapes of the tangram puzzle pieces. Focus on the overall shape, the number of sides, and the angles of each piece.

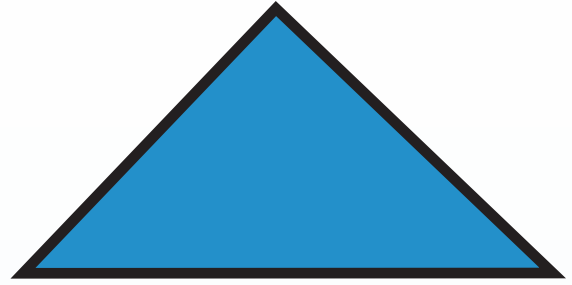
Small Triangle

- How many of the seven tangram puzzle pieces are small triangles? [2]
- How many sides does this shape have? [3]
- How many angles does this shape have? [3]



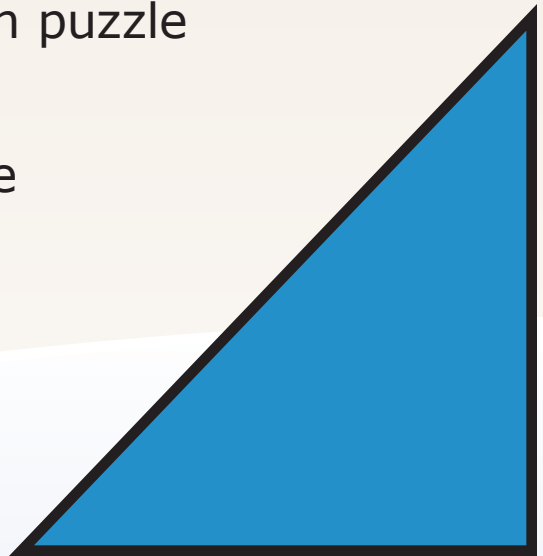
Medium Triangle

- How many of the seven tangram puzzle pieces are medium-sized triangles? [1]
- How many sides does this shape have? [3]
- How many angles does this shape have? [3]
- How many small triangles can cover this shape? [2]



Large Triangle

- How many of the seven tangram puzzle pieces are large triangles? [2]
- How many sides does this shape have? [3]
- How many angles does this shape have? [3]
- How many small triangles can cover this shape? [4]
- How many medium triangles can cover this shape? [2]



Suggested Questions for Triangle Pieces

- How are the small, medium, and large triangles the same? [shape, number of sides, number of angles, angle sizes]
- How are the small, medium, and large triangles different? [size, side length, area]

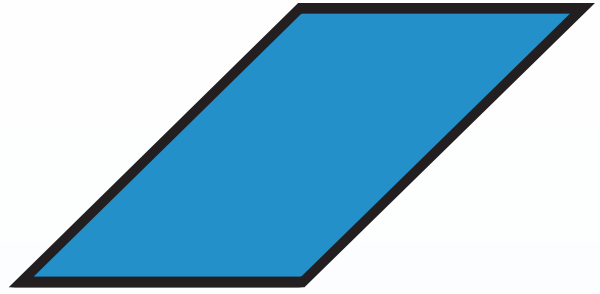
Square

- How many of the seven tangram puzzle pieces are squares? [1]
- How many sides does this shape have? [4]
- How many angles does this shape have? [4]
- Are the sides of the square of equal length? [yes]
- How many small triangles can cover this shape? [2]
- Are all the angles of the square the same? [yes]



Parallelogram

- How many of the seven tangram puzzle pieces are parallelograms? [1]
- How many sides does this shape have? [4]
- How many angles does this shape have? [4]
- How many small triangles can cover this shape? [2]

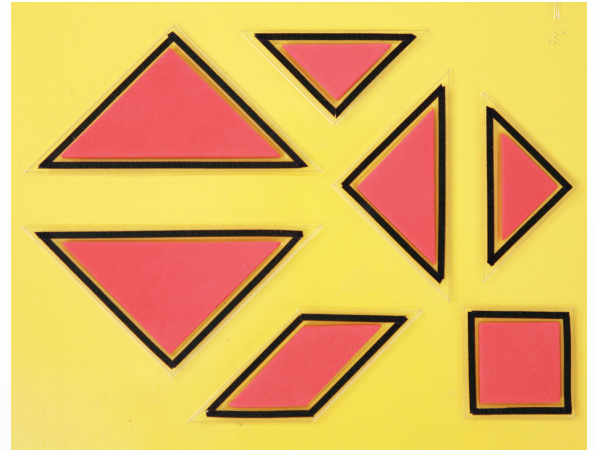


Suggested Questions for Square and Parallelogram

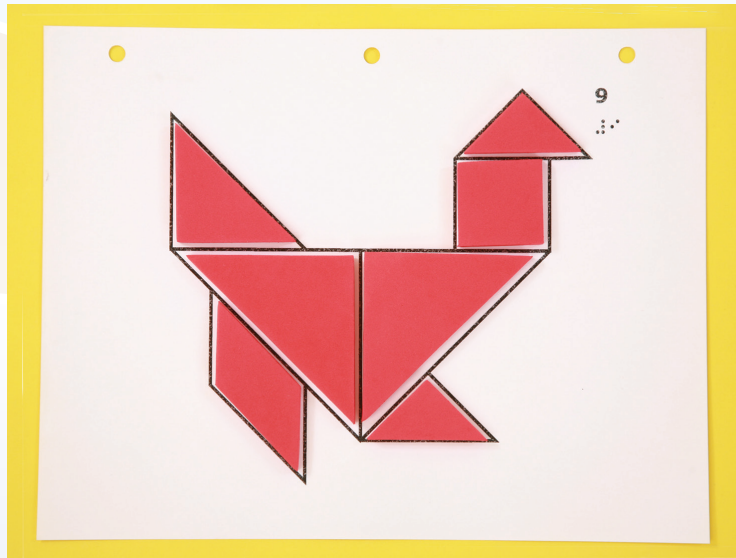
- How are the square and parallelogram the same? [Each has four sides and four angles.]
- How are the square and parallelogram different? [The sizes of their angles are different.]

PUZZLE PRACTICE

- 1) Using **Puzzle Frame #1**, have the student insert each puzzle piece into its corresponding puzzle frame. This is good practice for familiarizing the student with the concept of puzzles and how to insert the pieces within the raised frames.



- 2) Using any of the Puzzle Solutions, have the student place each tangram puzzle piece within the corresponding outline shape.







Types of Angles

Review types of angles using the seven tangram puzzle pieces.

Right Angle

Measures exactly 90 degrees

Acute Angle

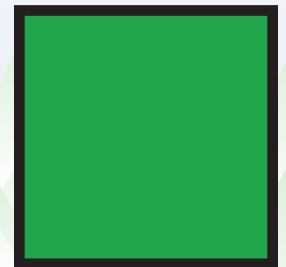
Measures less than 90 degrees

Obtuse Angle

Measures greater than 90 degrees but less than 180 degrees

Square

Present the square tangram puzzle piece to the student and ask the following questions:



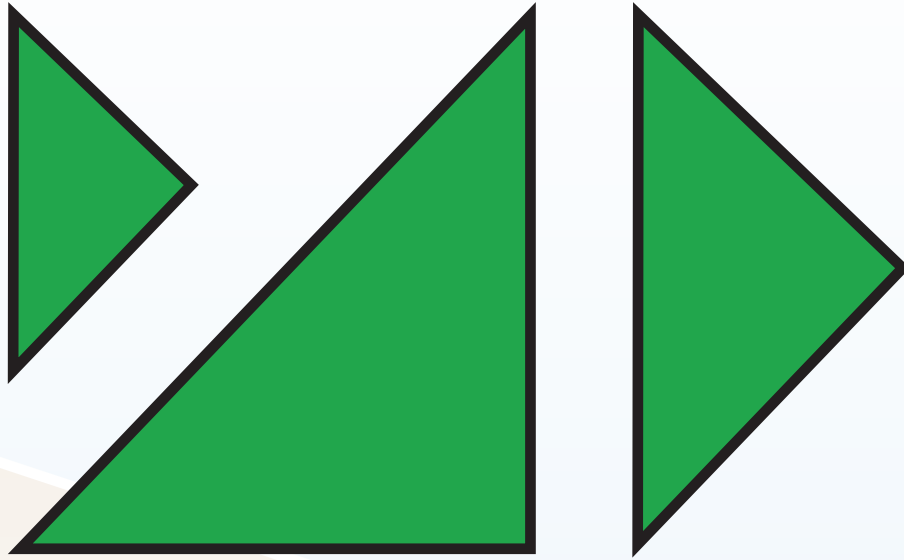
- How many angles does the square puzzle piece have? [4]
- Are all of the angles of the square the same? [yes]
- What types of angles does the square have? [4 right angles]
- What is the measurement of each angle of the square? [90 degrees]
- What is the sum of all the angles in the square? [360 degrees]

Triangles

Present all three sizes of triangle tangram puzzle pieces to the student and ask the following questions:

- Can you locate the right angle of each triangle puzzle piece?
- Is the right angle of each triangle piece smaller or larger than its other two angles? [larger]
- Find the two smallest angles of each triangle puzzle piece.
- What type of angle is each of the smaller angles of the triangle puzzle pieces. [acute]
- What is the measurement of each triangle's largest angle? [90 degrees]

- What is the measurement of the smallest angle of one triangle puzzle piece? [45 degrees].
- What is the sum of the two smallest angles of each triangle puzzle piece? [90 degrees]
- What is the sum of all the angle measures of each triangle puzzle piece? [180 degrees]



Parallelogram

Present the parallelogram tangram puzzle piece to the student and ask the following questions:

- Does the parallelogram puzzle piece have any right angles? [no]
- Are all the angles of the parallelogram of the same type? [no]
- How many acute angles does the parallelogram have? [2]



- How many obtuse angles does the parallelogram have? [2]
- What is the measurement of each smaller angle of the parallelogram? [45 degrees]
- What is the measurement of each larger angle of the parallelogram? [135 degrees]
- What is the sum of all the angle measures of the parallelogram? [360 degrees]



Flips, Turns, and Slides

Demonstrate three shape transformations using the tangram puzzle pieces.

Important: Non-magnetic tangram puzzle pieces are required for this activity so that the color and texture stay the same when shapes are flipped. Two sets of tangram puzzle pieces are needed so that duplicate square and parallelogram shapes are available.

Reflection

An object is flipped over an imaginary line, either vertically or horizontally. The object's size and shape remain the same.

Rotation

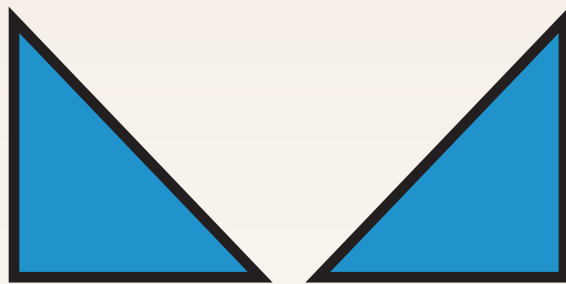
An object is turned around a fixed, center point (like the hands on a clock). The orientation of the object changes, but not its size or shape.

Translation

An object is moved or slid from its starting location in any direction without a change in shape, size, or orientation.

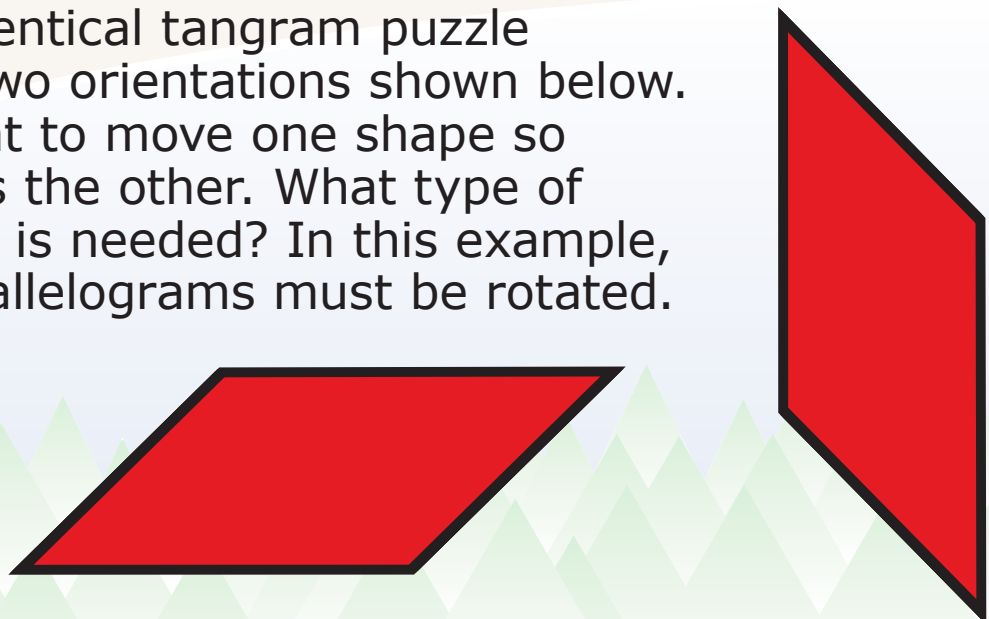
Example of Reflection

Present two identical tangram puzzle pieces in two different orientations shown below. Ask the student to move one shape so that it matches the other. What type of transformation is needed? In this example, one of the triangles must be flipped.



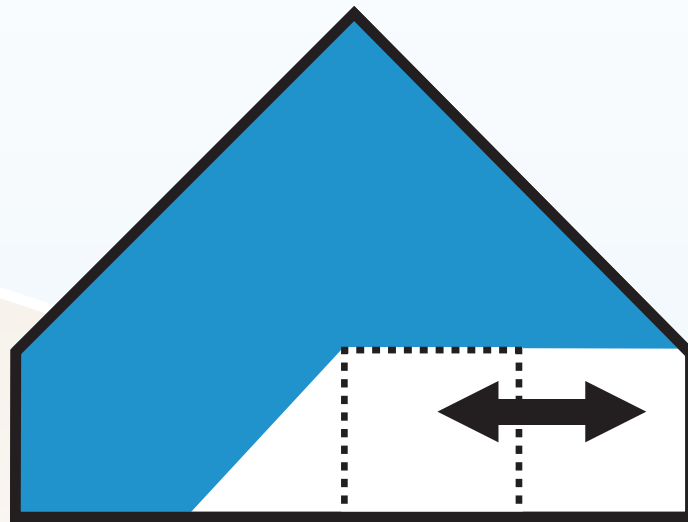
Example of Rotation

Present two identical tangram puzzle pieces in the two orientations shown below. Ask the student to move one shape so that it matches the other. What type of transformation is needed? In this example, one of the parallelograms must be rotated.



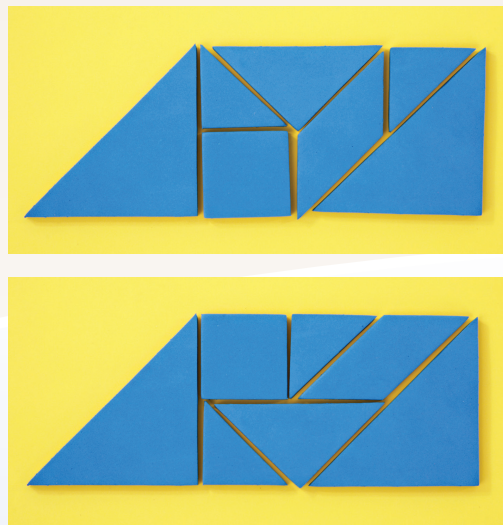
Example of Translation

Translation or sliding of a shape is frequently executed while solving a tangram puzzle. Practice sliding a tangram piece within a puzzle frame (with or without other tangram puzzle pieces in place). Can a prediction be made as to where the shape will fit? In this example, two possible locations for the square puzzle piece within the unsolved puzzle are illustrated by a sliding motion.



EXTENDED ACTIVITIES

- Encourage the student to describe the transformations being made while solving tangram puzzles.
- Have the student trace a tangram puzzle piece on a dry-erase board or APH's DRAFTSMAN: Tactile Drawing Board. Then flip, rotate, or slide it to another location on the board. Retrace the shape. Repeat several times until a number of different views are drawn.
- Discuss why some tangram puzzles have multiple solutions. [Depending on how the seven shapes are rotated or flipped, more than one solution is possible.]



- Try rotating, flipping, and sliding other images, pictures, or objects.



Congruent Polygons

Construct congruent polygons using two sets of tangram puzzle pieces included in **Tactile Tangrams**.

Congruent Polygons

Polygons are congruent if they are equal in all respects:

- Same number of sides
- All corresponding sides are the same length
- All corresponding interior angles are the same size

Examples

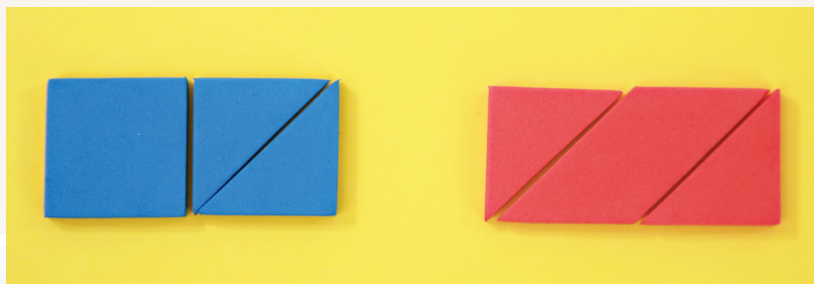
These squares are congruent.



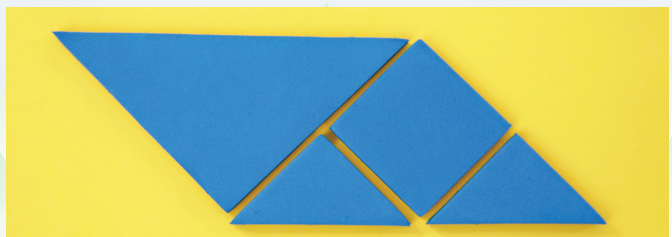
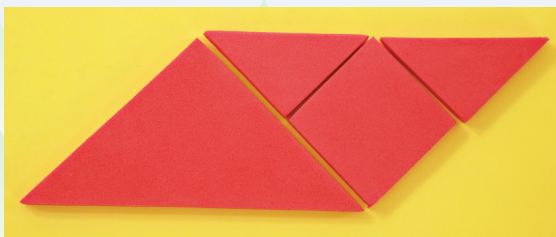
These triangles are congruent.



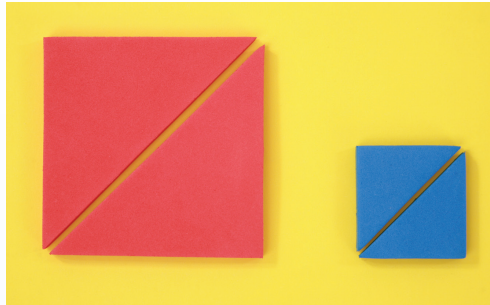
These rectangles are congruent.



These parallelograms are congruent but flipped or rotated in a different direction.



Discuss why some polygons are similar, but not congruent. For example, these two squares have the same number of sides and their angles are the same size, but their sides are not the same length.







Convex and Concave Puzzle Frames

Illustrate the differences between convex and concave polygons using the puzzle frames included in **Tactile Tangrams**.

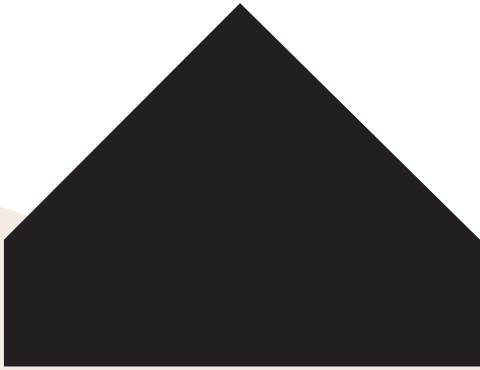
Convex Polygon

All vertices of a convex polygon point outward and away from the interior of the shape. All interior angles of a convex polygon measure less than 180 degrees.

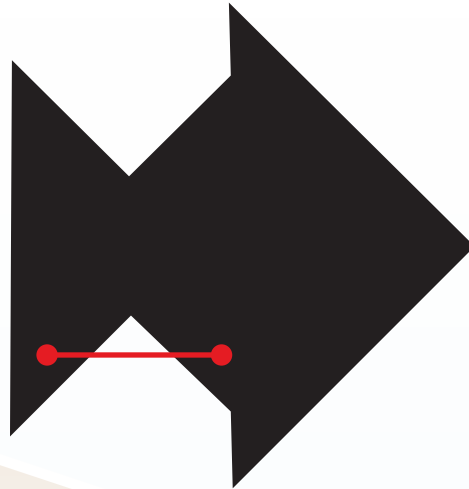
Concave Polygon

Some vertices of a concave polygon point inward, toward the interior of the shape. At least one interior angle measures greater than 180 degrees. At least one line exists between two points such that part of the line segment lies outside of the polygon.

Examples



**CONVEX
POLYGON**



**CONCAVE
POLYGON**

Sort the puzzle frames into two groups representing "Convex" and "Concave" polygons. The puzzle trays can be grouped like so:

Convex Puzzle Frames



#6



#11



#13



#15



#16



#17



#19



#25



#26

Concave Puzzle Frames



#5



#7



#8



#9



#10



#12



#14



#18



#20



#21



#22

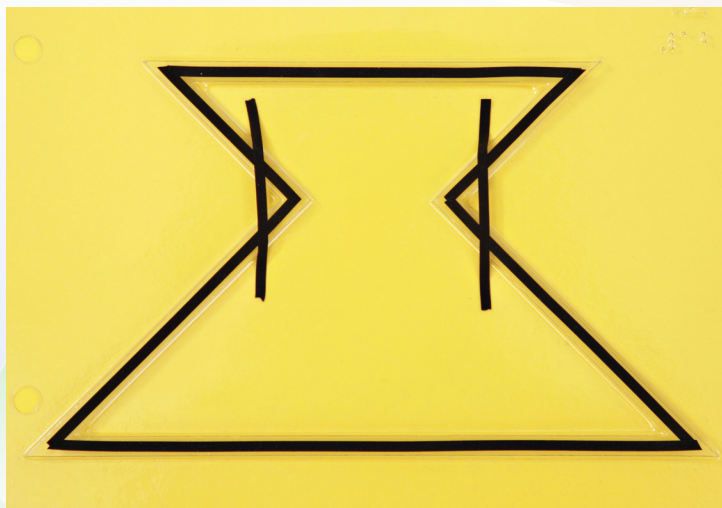


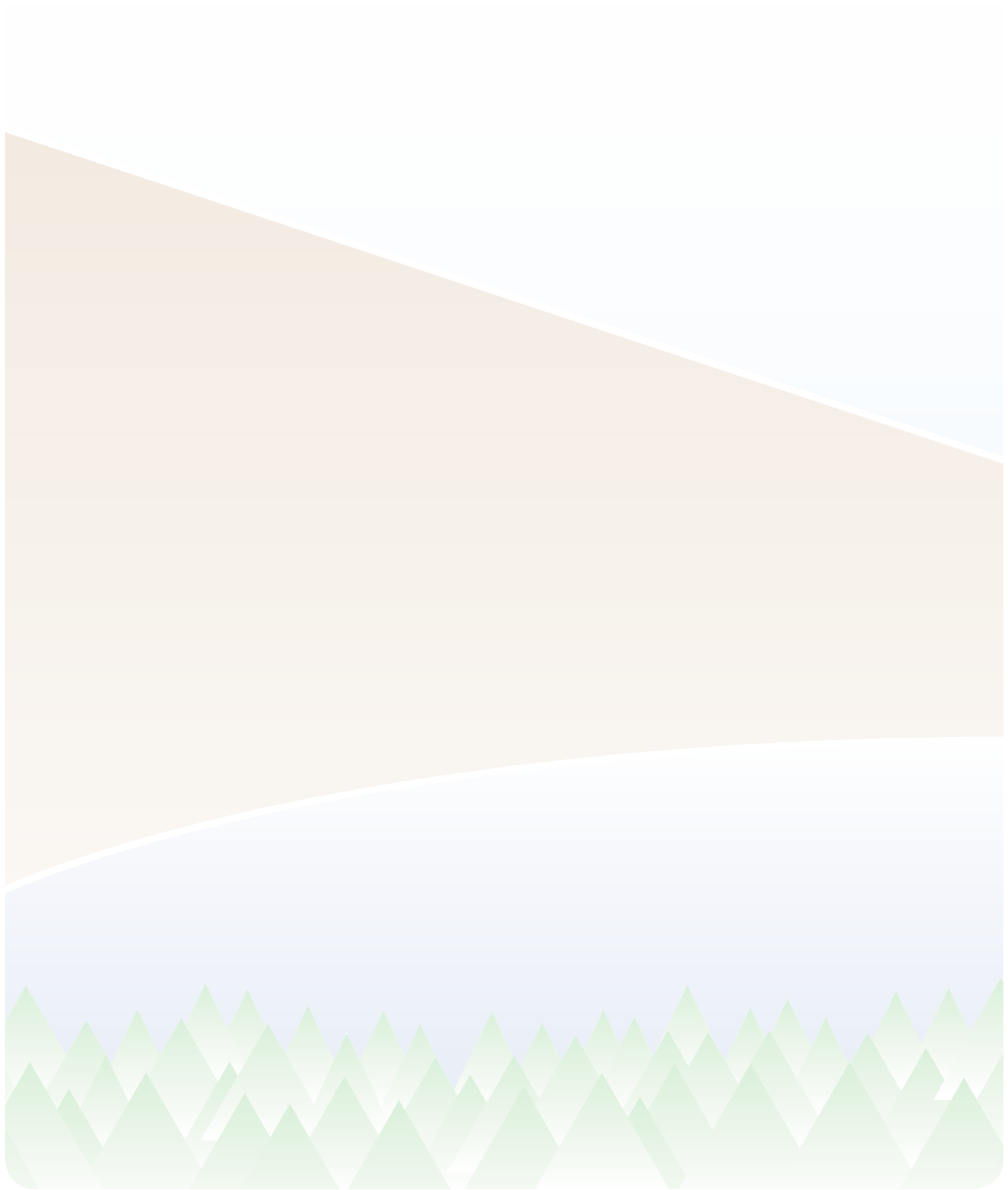
#23



#24

Temporary line segments can be drawn on the puzzle frames using Wikki Stix[®] or strips of APH's Graphic Art Tape to illustrate why a certain shape is a concave polygon.





Activity 6

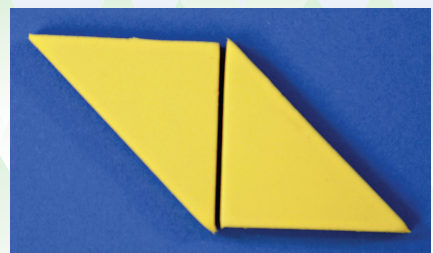
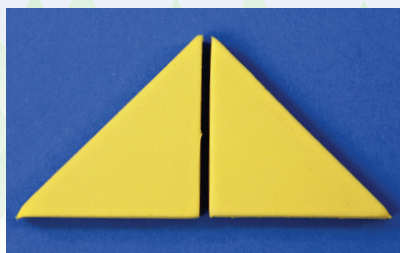
Making Convex and Concave Polygons

Construct a variety of convex and concave polygons using the tangram puzzle pieces. Alter the number and type of pieces used.

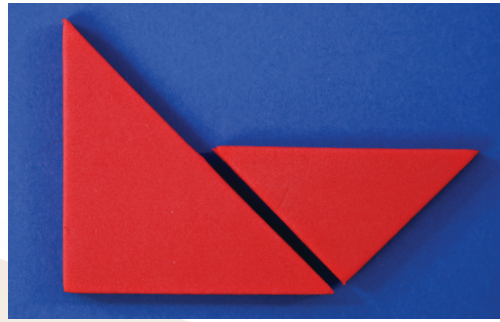
Note: Review the definitions of convex and concave polygons in Activity 5.

Examples

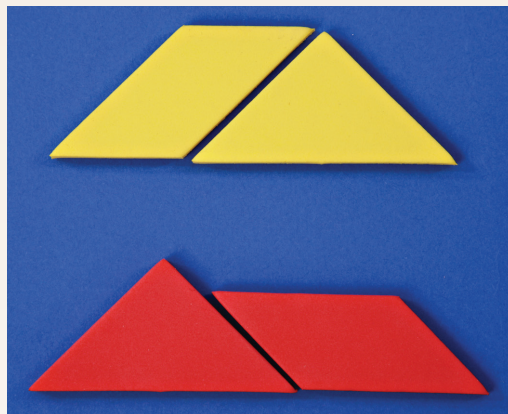
- Construct convex polygons using the two small triangles.



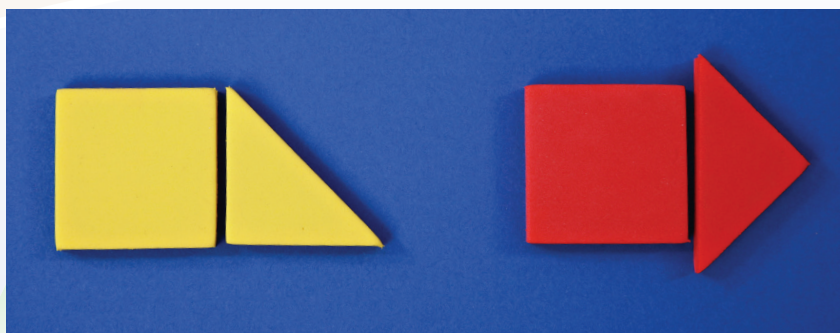
- Construct concave polygons using one small triangle and the medium triangle.



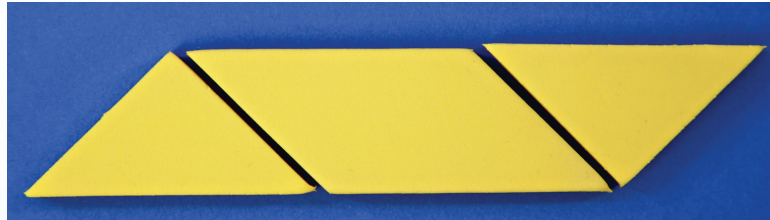
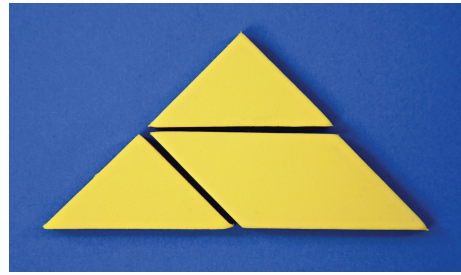
- Construct convex and concave polygons using the medium triangle and the parallelogram.



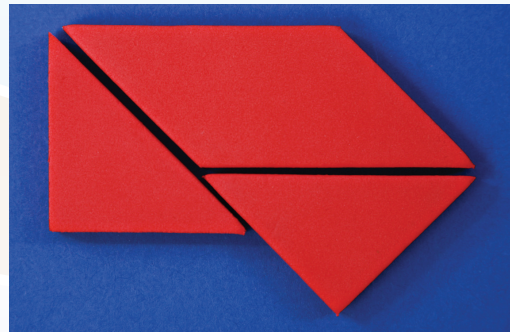
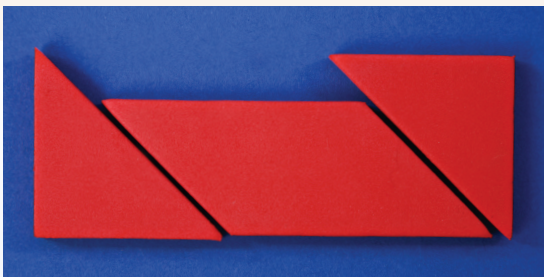
- Construct convex and concave polygons using the square and one small triangle.



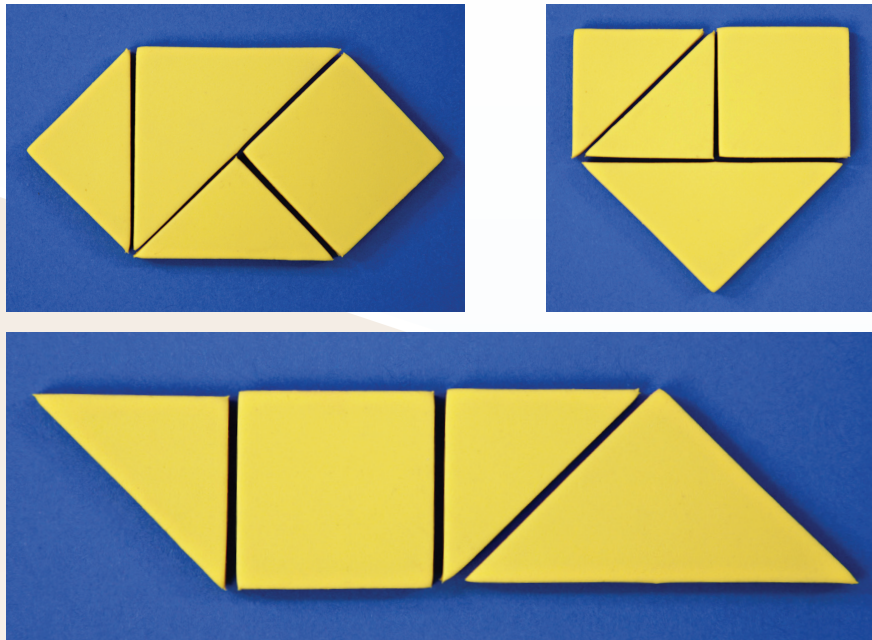
- Construct convex polygons using the parallelogram and the two small triangles.



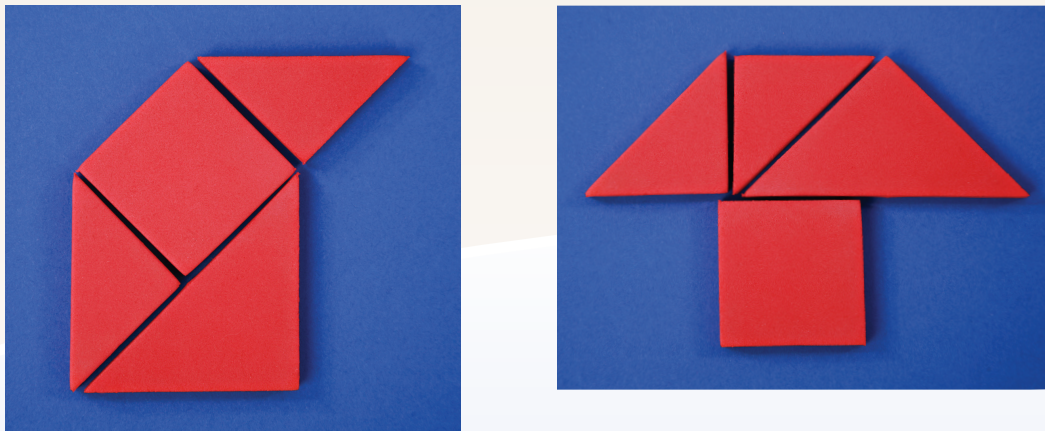
- Construct concave polygons using the parallelogram and the two small triangles.



- Construct convex polygons using the square, medium triangle, and two small triangles.



- Construct concave polygons using the square, medium triangle, and two small triangles.





Concept of Symmetry

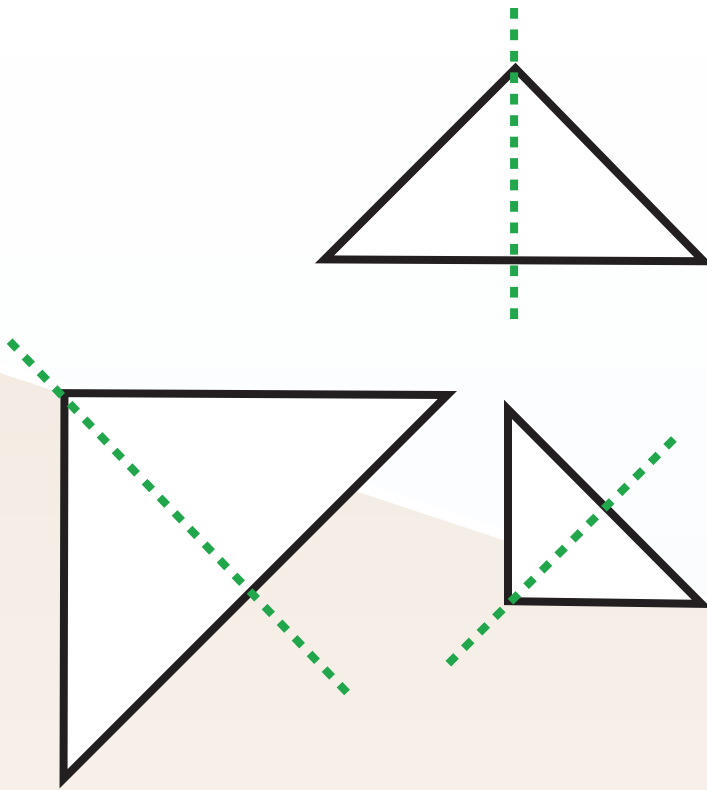
Introduce the concept of **symmetry** using the seven tangram puzzle pieces. Explore each shape separately and determine if it has lines of symmetry and, if so, how many lines of symmetry are present.

Symmetrical Shape

A shape is symmetrical if at least one fold line allows the shape to fold over on itself allowing the two halves to match up exactly. Some shapes have more than one line of symmetry. The fold lines are called "lines of symmetry."

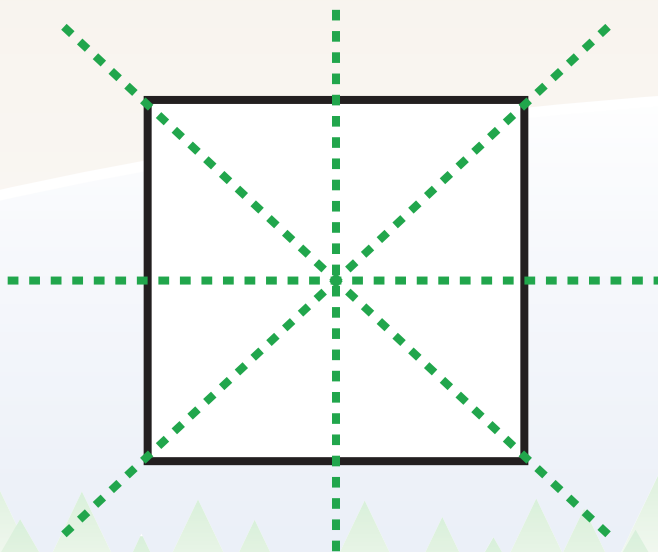
Triangles

- Each triangle puzzle piece, regardless of size, is symmetrical and has one line of symmetry.



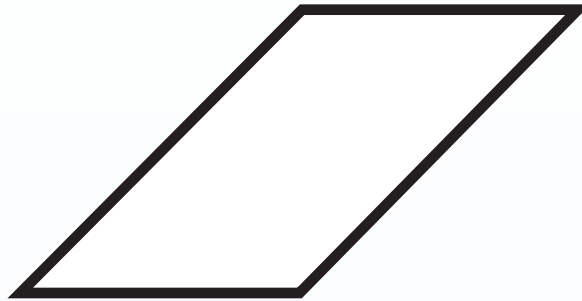
Square

- The square puzzle piece is symmetrical and has four lines of symmetry.



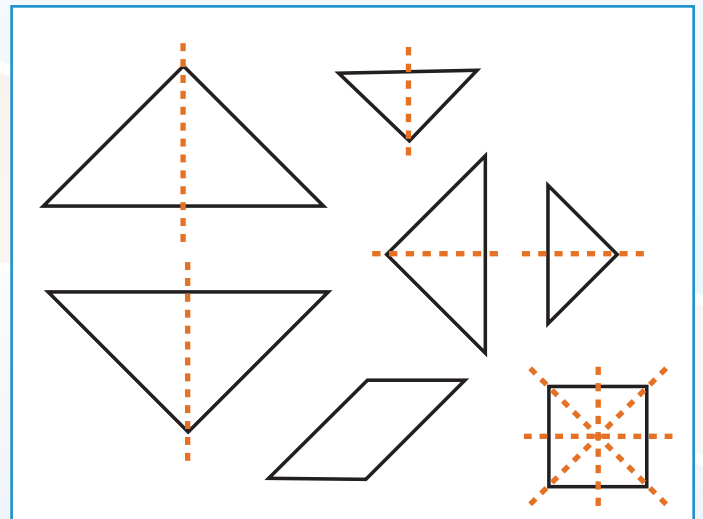
Parallelogram

- The parallelogram puzzle piece has no lines of symmetry.

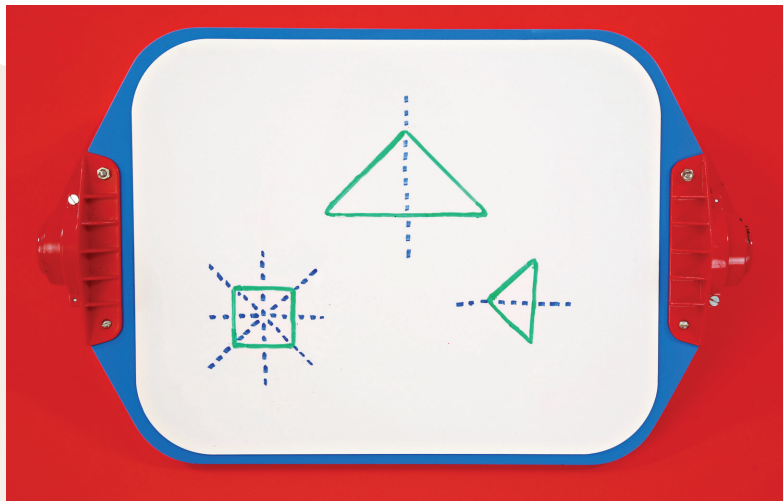


Demonstrate and identify the lines of symmetry of the tangram puzzle pieces in the following ways:

- 1) Provide paper cut-outs of the tangram puzzle pieces and fold the cut-out shapes along the line(s) of symmetry.
- 2) Using Puzzle Frame #1 from **Tactile Tangrams**, draw temporary lines of symmetry by directly applying Wikki Stix® or strips of APH's Graphic Art Tape to the puzzle frame shapes.



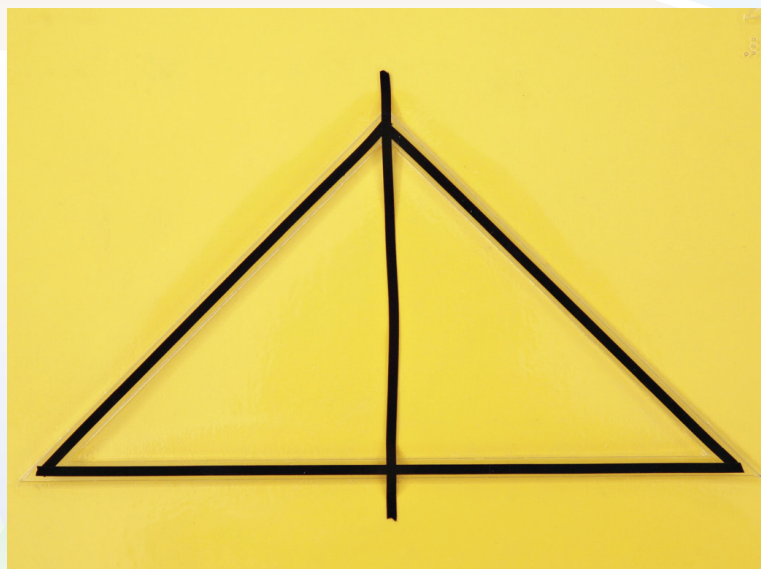
- 3) For low vision students, trace the tangram puzzle pieces onto a dry-erase surface (e.g., APH's ALL-IN-ONE Board) and draw dashed lines of symmetry (using a marker of a different color) on the outline shapes.



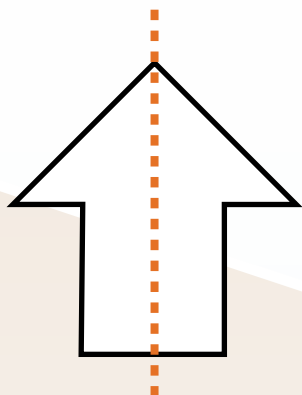


Symmetrical Puzzle Frames

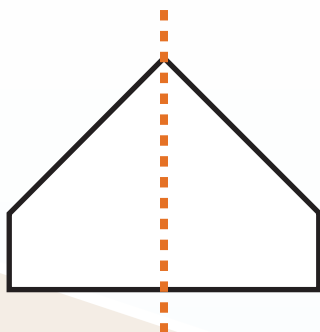
Identify lines of symmetry using the puzzle frames included in **Tactile Tangrams**. Which puzzle frames have one line of symmetry? Two? More than two? None? Draw the lines of symmetry on the puzzle frames by applying Wikki Stix® or strips of APH's Graphic Art Tape.



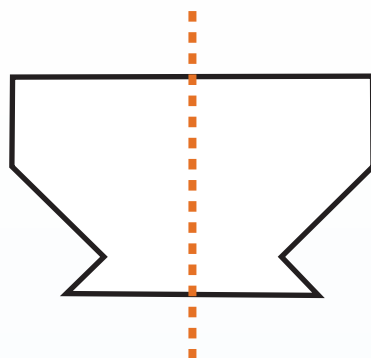
One Line of Symmetry



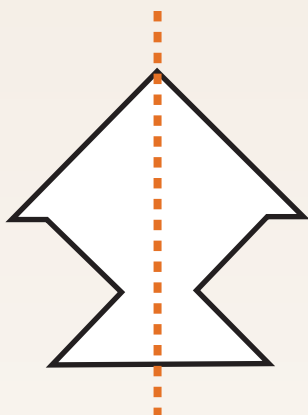
#5



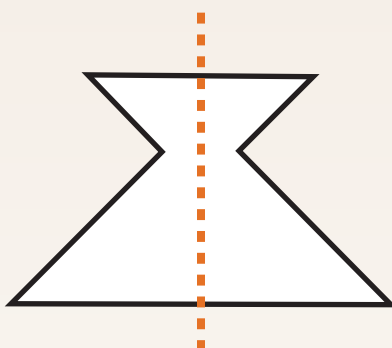
#6



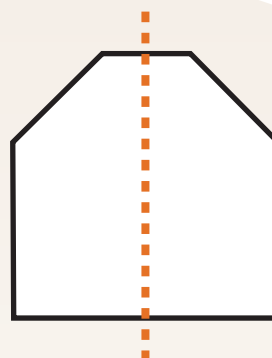
#8



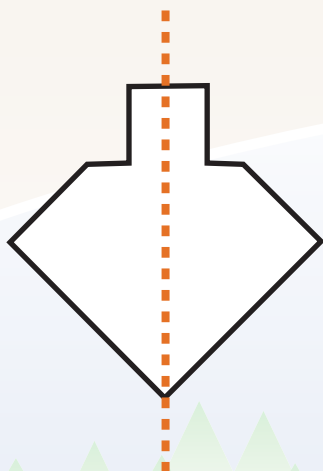
#10



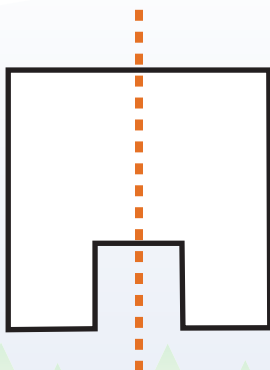
#12



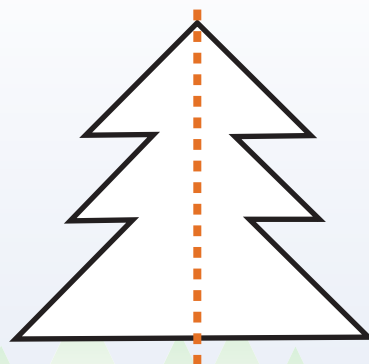
#13



#18

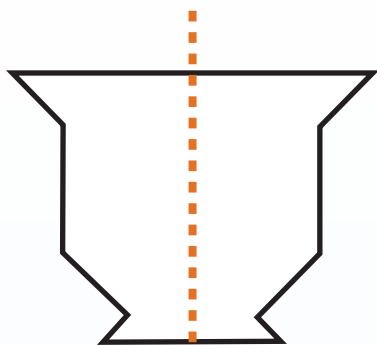


#21

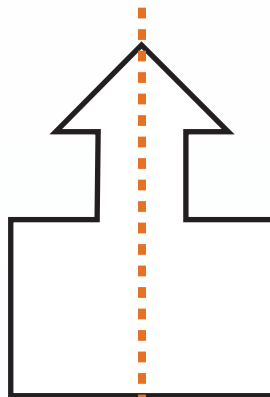


#22

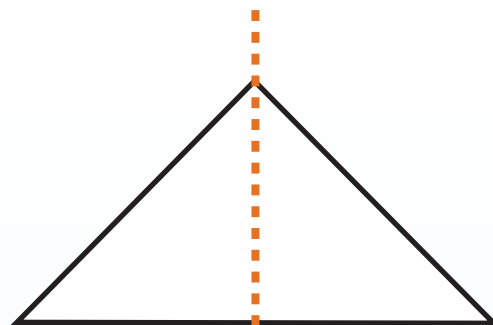
One Line of Symmetry (continued)



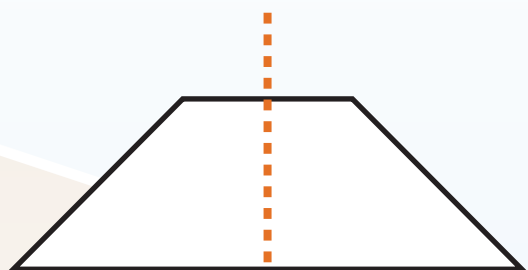
#23



#24

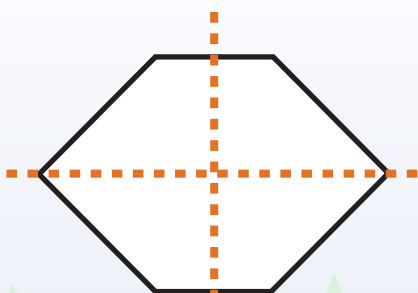


#25

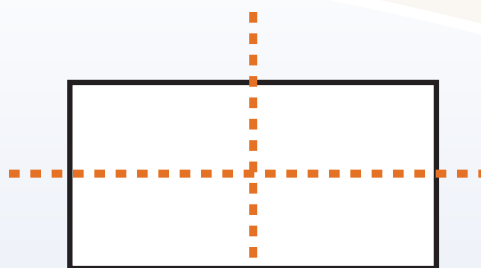


#26

Two Lines of Symmetry

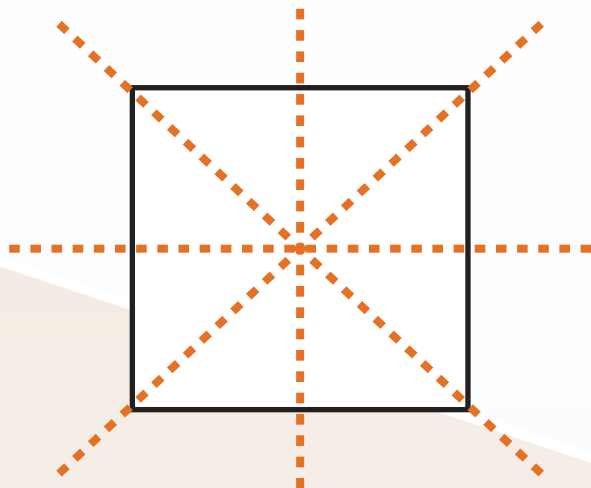


#11



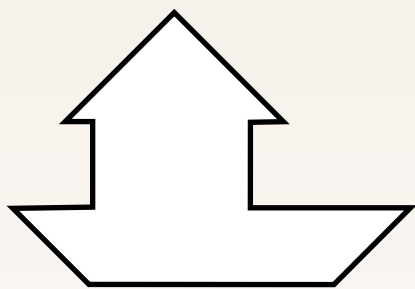
#17

More Than Two Lines of Symmetry

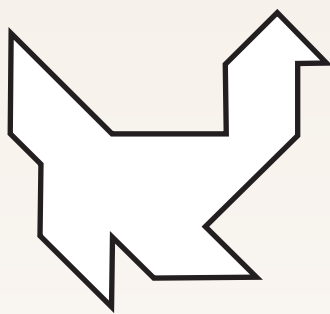


#19

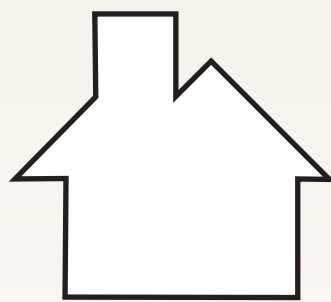
No Line of Symmetry



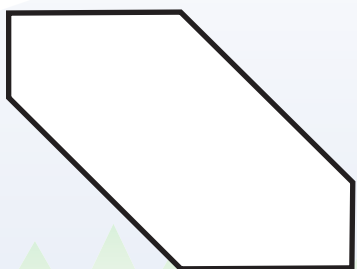
#7



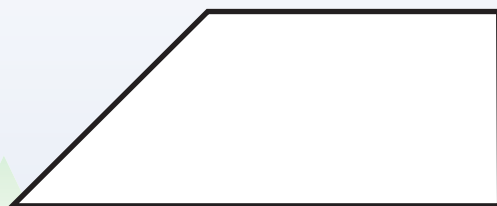
#9



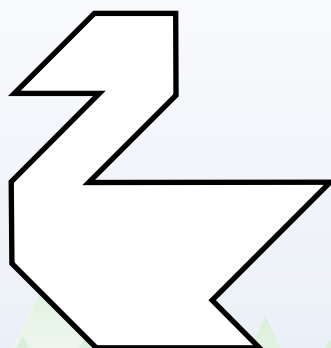
#14



#15



#16



#20



Making Symmetrical Shapes

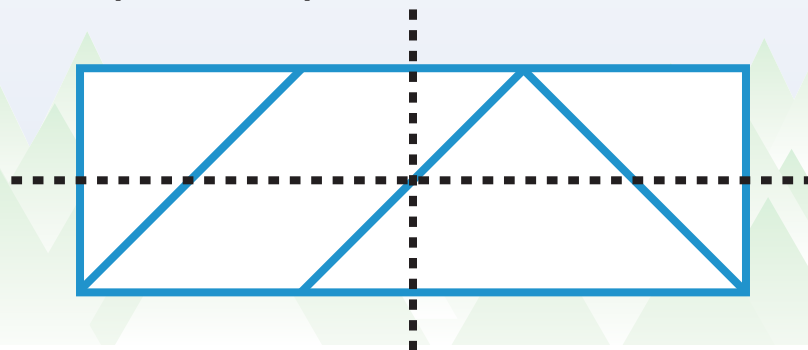
Build shapes using various combinations and numbers of tangram puzzle pieces. For each constructed shape, indicate the location of each line of symmetry.

Example 1

Using only (1) medium triangle, (2) small triangles, and (1) parallelogram, build a variety of shapes and indicate for each the line(s) of symmetry (if any).

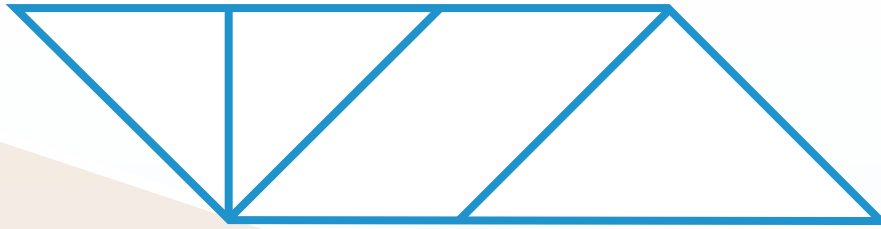
Rectangle

- Two lines of symmetry



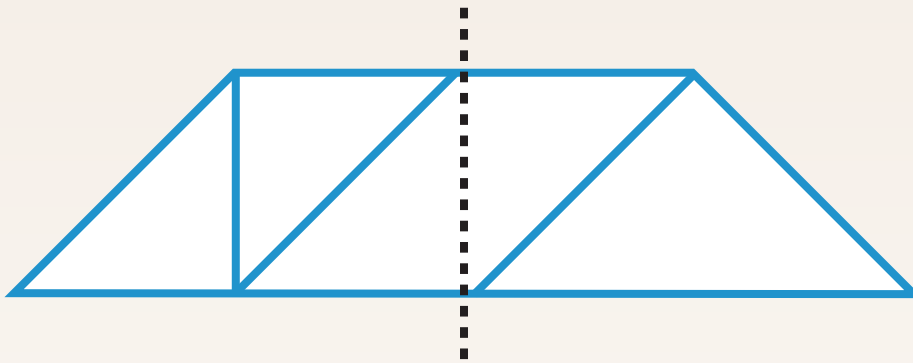
Parallelogram

- No line of symmetry



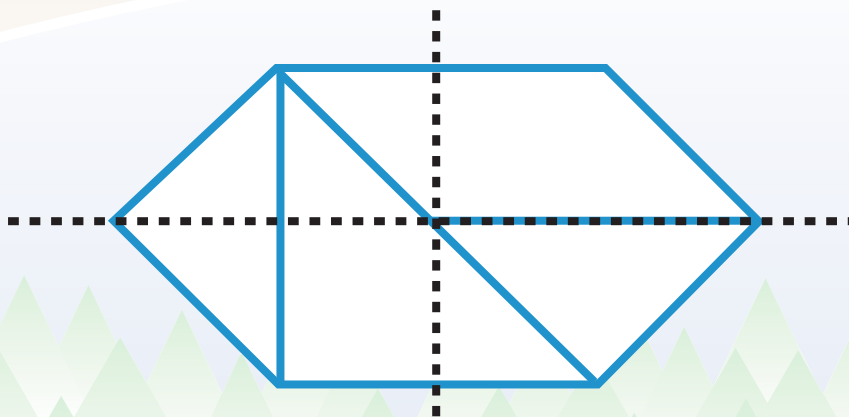
Trapezoid

- One line of symmetry



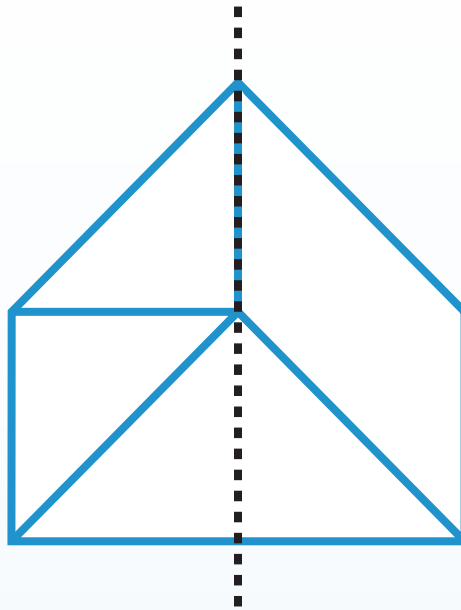
Hexagon

- Two lines of symmetry



Pentagon

- One line of symmetry

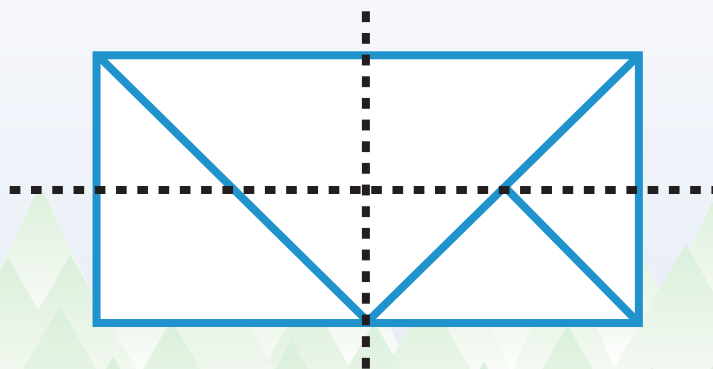


Example 2

Using only (1) medium triangle, (2) small triangles, and (1) large triangle, build a variety of shapes and indicate for each the line(s) of symmetry.

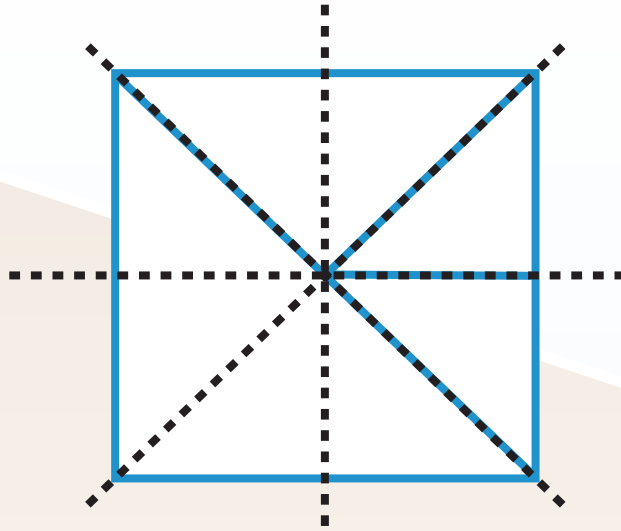
Rectangle

- Two lines of symmetry



Square

- Four lines of symmetry



Discussion

- Do all squares have four lines of symmetry?
- Do all rectangles have two lines of symmetry?
- Do all hexagons have two lines of symmetry?
- Are all pentagons symmetrical?
- Are all trapezoids symmetrical?



Area and Perimeter

Find the area and perimeter of each puzzle piece and combinations of puzzle pieces included in **Tactile Tangrams**.

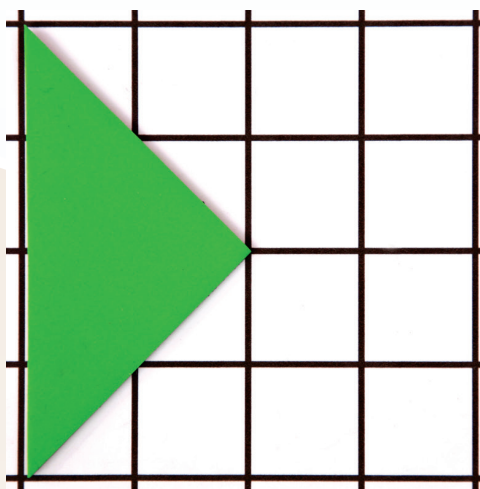
Area

The size of the region enclosed by the figure, usually expressed in terms of some square unit.

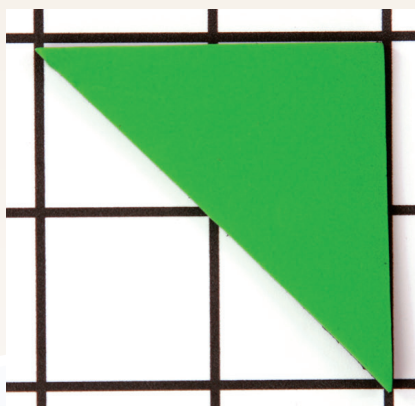
Using a sheet of the provided tactile/print graph paper, determine the exact area of each individual puzzle piece by 1) counting the number of whole and half squares of each piece positioned on the grid, and 2) using logical reasoning based on the relationships between the tangram pieces. For example, if the large triangle has an area of four square inches and the medium triangle is half its size, then the area of the medium triangle is two square inches. If the small triangle is half the size of the medium triangle, then the area of the small

triangle is one square inch. Since both the square and the parallelogram can be constructed using two small triangles, the area of each is two square inches.

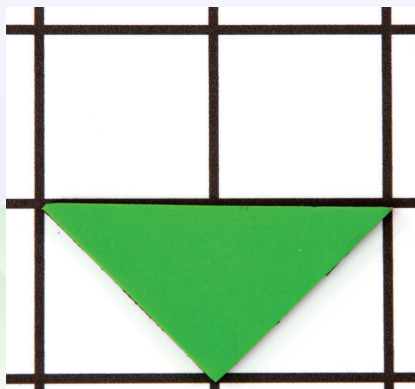
Large triangle =
4 square inches



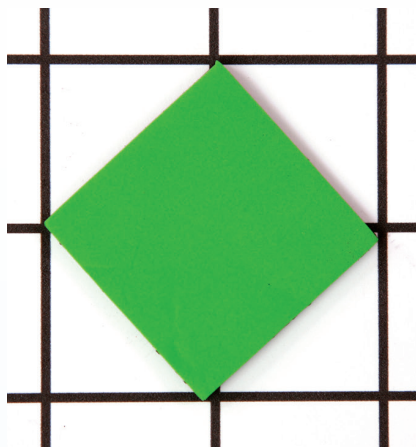
Medium triangle = 2 square inches



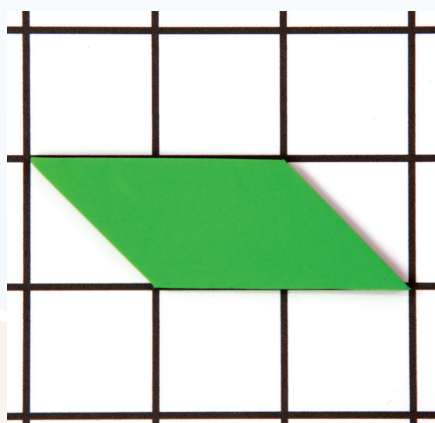
Small triangle = 1 square inch



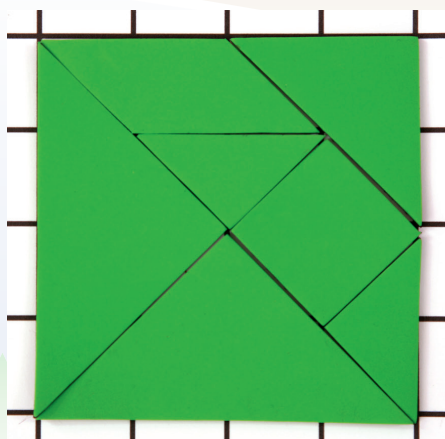
Square = 2 square inches



Parallelogram = 2 square inches



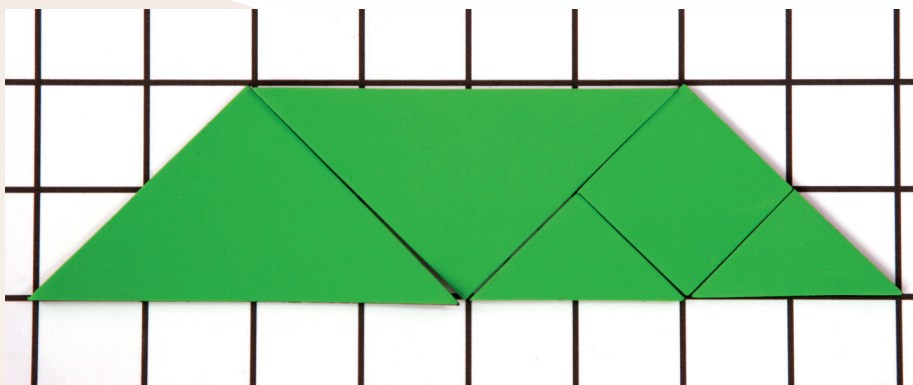
The area of the **whole tangram** = 16 square inches



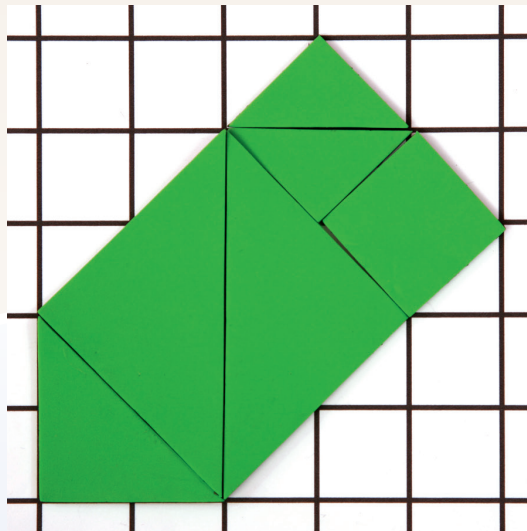
EXTENDED ACTIVITY

Build polygons with specific areas.

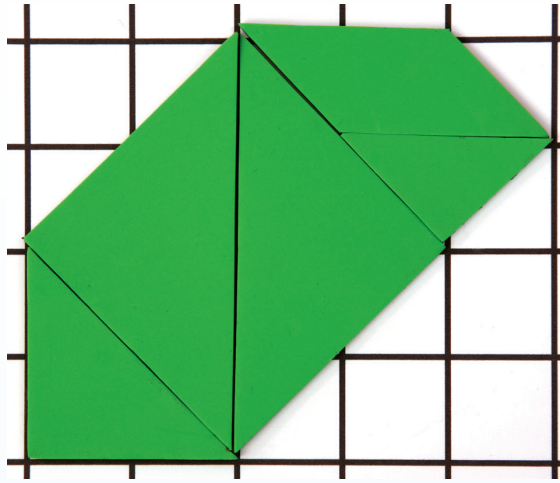
- Use only five tangram puzzle pieces to make a trapezoid with an area of 12 square inches.



- Use only six tangram puzzle pieces to make a pentagon with an area of 14 square inches.



- Use only five tangram puzzle pieces to make a convex polygon with an area of 13 square inches.



Perimeter

The perimeter of a polygon is the sum of the length of all of its sides.

Using an inch ruler, find the perimeter of each tangram puzzle piece to the nearest $\frac{1}{8}$ of an inch. An equation can be written for each:

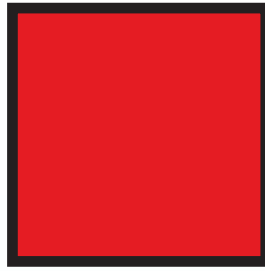
Large Triangle

$$P = 4 + 2\frac{7}{8} + 2\frac{7}{8} = 9\frac{3}{4}$$



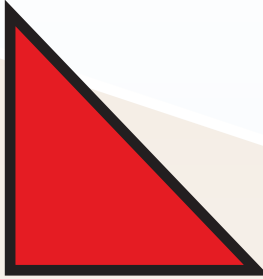
Square

$$P = 1\frac{3}{8} + 1\frac{3}{8} + 1\frac{3}{8} + 1\frac{3}{8} = 5\frac{1}{2}$$



Small Triangle

$$P = 1\frac{3}{8} + 1\frac{3}{8} + 2 = 4\frac{3}{4}$$



Medium Triangle

$$P = 2\frac{7}{8} + 2 + 2 = 6\frac{7}{8}$$



Parallelogram

$$P = 2 + 1\frac{3}{8} + 2 + 1\frac{3}{8} = 6\frac{3}{4}$$





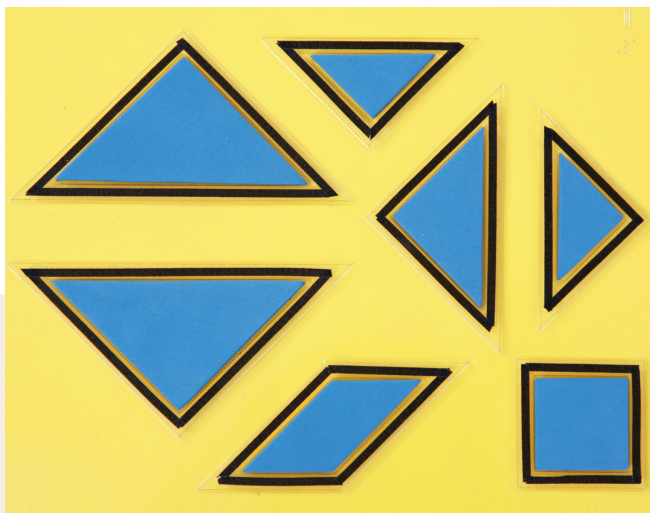
Solving Tangram Puzzles

Tactile Tangrams includes 26 unique puzzles. Each puzzle is presented as an outline raised frame or “silhouette” into which the tangram puzzle pieces can be arranged. The puzzle frames are labeled numerically in print and braille in the upper right corner of the frame and have corresponding three-hole punched Solution Pages located in the storage binder.

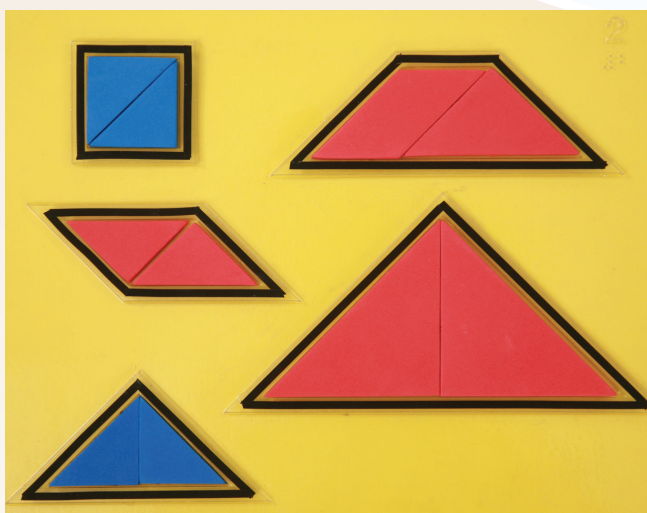
Puzzle Frames 1-4

Puzzle Frames 1-4 are intended to serve as easier puzzles for younger students to solve as they become acquainted with how the puzzle pieces fit within the puzzle frames. Each of these initial puzzle frames requires a different number of tangram puzzle pieces. For Puzzle Frames 2-4, multiple sets of tangram puzzle pieces are necessary to fill in all of the individual outline shapes.

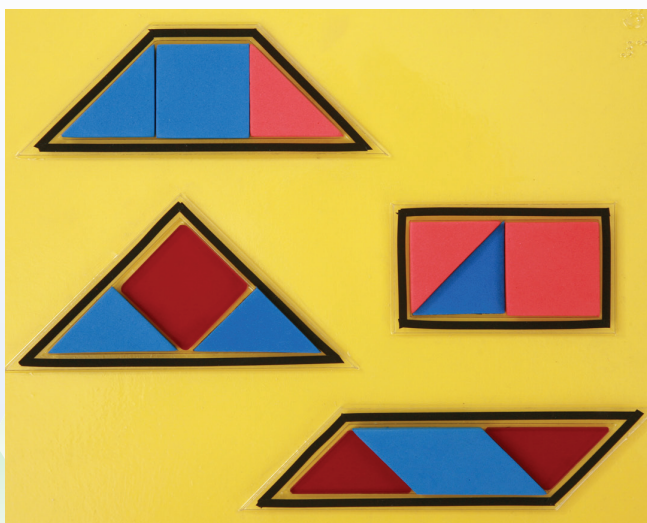
Puzzle Frame 1: One puzzle piece per outline shape.



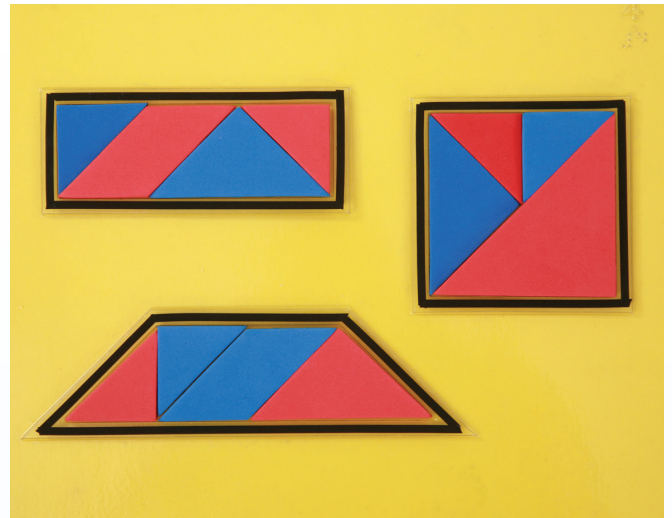
Puzzle Frame 2: Two puzzle pieces per outline shape.



Puzzle Frame 3: Three puzzle pieces per outline shape.



Puzzle Frame 4: Four puzzle pieces per outline shape.



Puzzles Frames 5-26

Puzzle Frames 5-26 are typical tangram puzzles that are solved using the following rules:

- All seven pieces must be used.
- All pieces must lie flat.
- All pieces must touch.
- No pieces may overlap.
- Pieces may be rotated and/or flipped to form the desired shape.

Types of Puzzle Pieces

Tangram puzzle pieces are made of three different kinds of material and can be selected based upon the intended mounting surface, student's preference, and/or color choice.

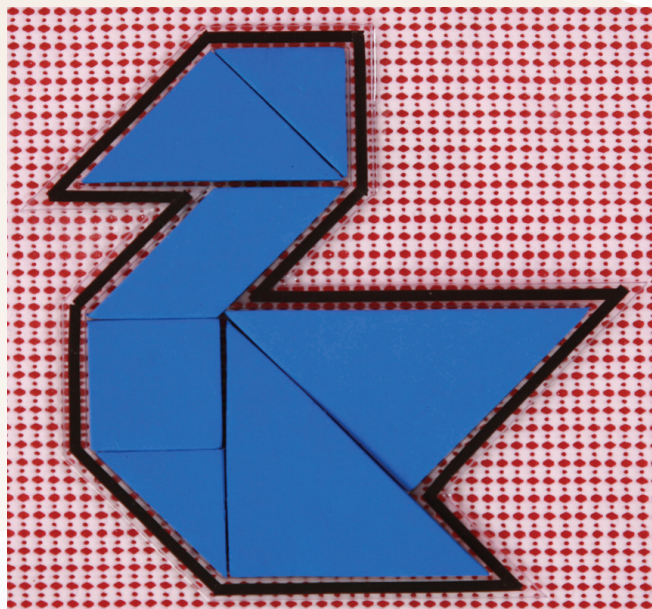
Translucent Pieces

Use these pieces in combination with the puzzle frames on a light box surface. If using an APH light box, simply slip the bottom edge of the puzzle frame behind the bottom ledge of the light box; this will hold the puzzle frame when the light box is tilted.



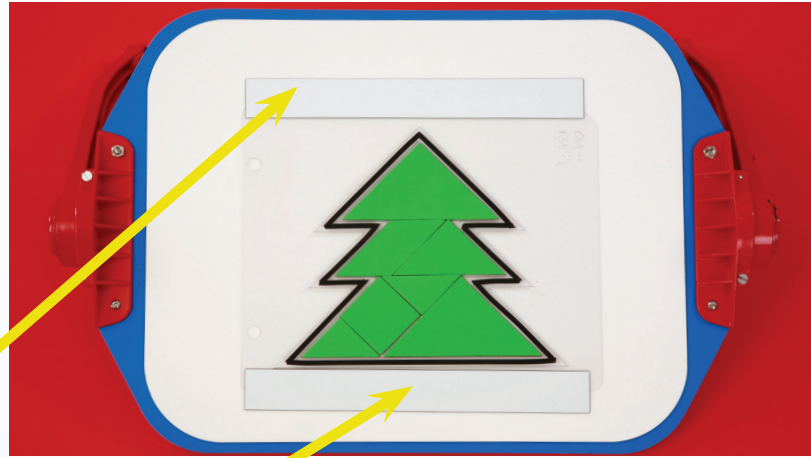
Thick Foam Pieces

Use the thick foam puzzle pieces in combination with the puzzle frames on a non-metal surface or apart from a light box. To provide a secure working area, place the puzzle frame on non-skid, shelf-liner material. The thick foam pieces may be easier for younger children, especially those with additional disabilities, to insert and remove from the puzzle frames.



Magnetic-backed Pieces

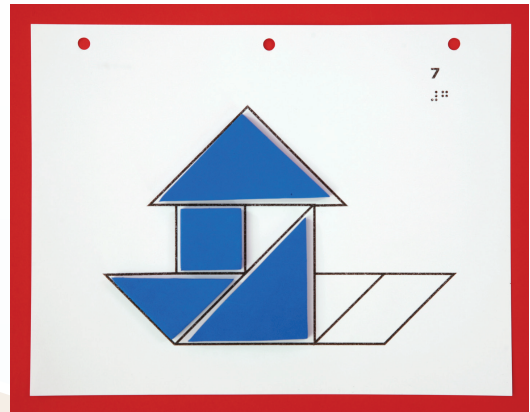
Use these puzzle pieces in combination with a metal surface (e.g., APH's ALL-IN-ONE Board or a cookie sheet). Secure the puzzle frame by placing the magnetic strips along its top and bottom edges.



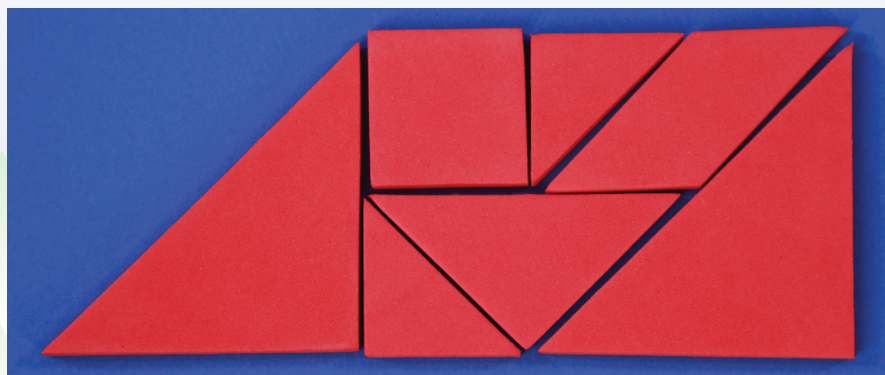
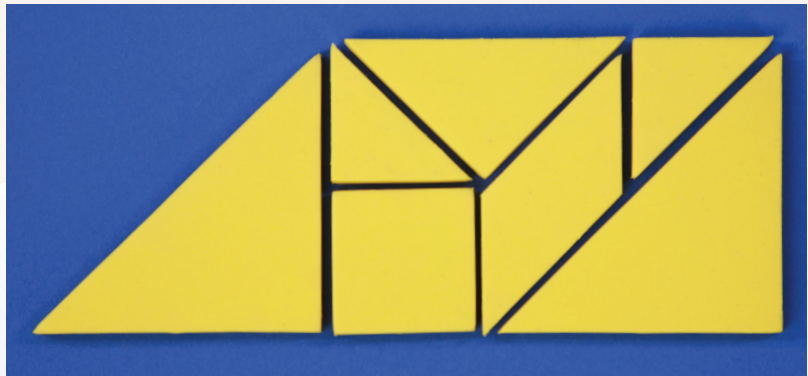
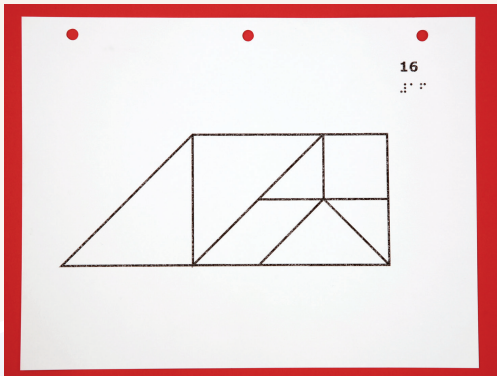
Use the magnetic strips to secure the puzzle frames to a metal surface.

SOLUTION PAGES

The Solution Pages present a dissected view of each whole image within the set of puzzle frames. The intended position of each of the puzzle pieces within the whole image or “silhouette” is illustrated. The dissected view is slightly oversized compared to the puzzle frame image to allow each puzzle piece to fit within its corresponding outline, leaving other division lines visually and tactually exposed.

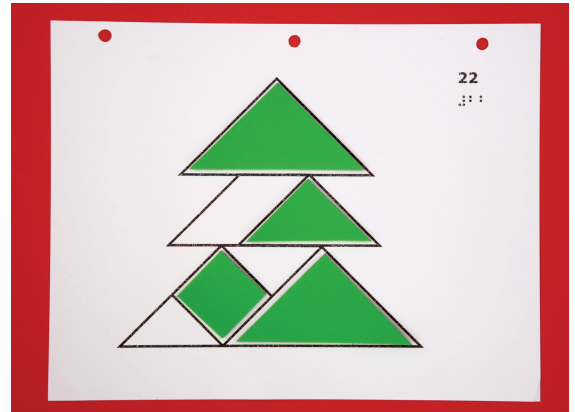


Note: Sometimes the student might discover solutions to a puzzle that are different from the one presented in the kit. For example, here are two other possible solutions for Puzzle #16.



VARIATIONS

- If working with students who may have trouble solving the puzzles using the frames, begin by presenting just the Solution Pages. Ask the student to arrange the puzzle pieces within the dissected view. This task will develop the basic skills of shape and size recognition and decrease the challenge of solving the puzzle. If working with magnetic puzzle pieces, the Solution Pages can be secured to a metal surface using the magnetic strips.
- If working with students or adults who might like an extra challenge, introduce a time element when solving the puzzles. How long does it take an individual student (or pair of students working together) to solve a puzzle? Can the student(s) complete each puzzle in less time after each trial? Multiple students can also challenge each other to solve different puzzles within a given time frame. Who can complete his puzzle the quickest?
- Ask the student to provide a name that describes each tangram puzzle frame. Some names might describe a geometric shape (e.g., square, triangle, trapezoid), an animal (e.g., swan, chicken), or even an inanimate object (e.g., table, spinning top, hourglass, house, etc.). Emphasize that these shapes, except geometric ones, are often abstract (visually *and*



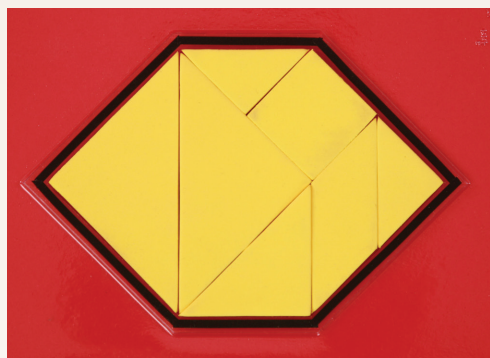
tactually) and likely lack any recognizable similarity to the real thing. Students might find themselves eventually referring to each puzzle by the name they assign to it.



HOUSE



CHICKEN



HEXAGON

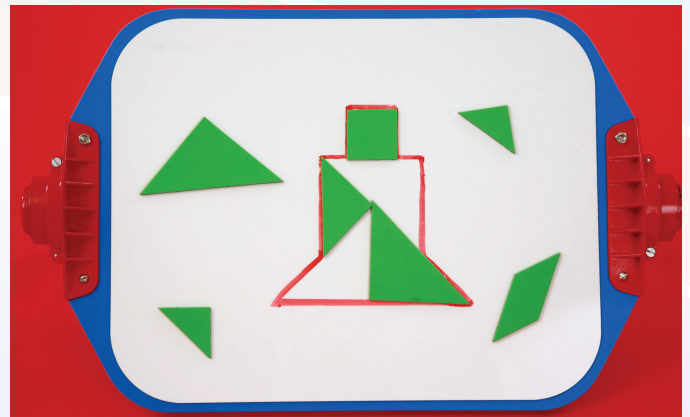
Activity 12

Creating Tangram Puzzles

Create new tangram puzzles and challenge friends and family members to solve them. Use the following methods to make additional tangram puzzles:

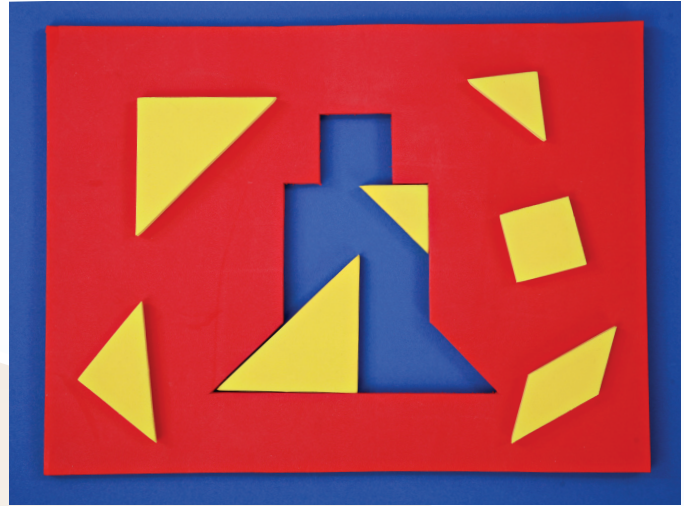
Option 1

Create a tangram puzzle by arranging the magnetic-backed puzzle pieces on APH's ALL-IN-ONE Board (or other metal/dry erase surface) to form a picture. Trace around the perimeter of the picture with a dry-erase marker. Remove the tangram pieces so that only a visual outline of the picture remains. Use the magnetic-backed puzzle pieces to re-create the new tangram puzzle.



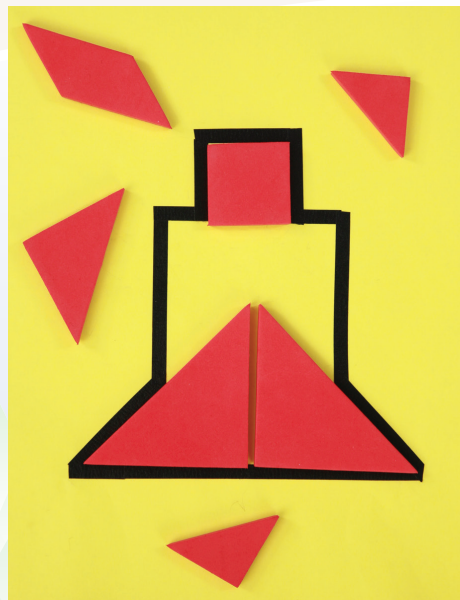
Option 2

Cut the outline of a tangram puzzle out of a solid sheet of corrugated cardboard or thick craft foam. Fit the puzzle pieces within the cutout area. For visual contrast, make sure the puzzle frame is placed on a surface of contrasting color (e.g., red frame on blue background).



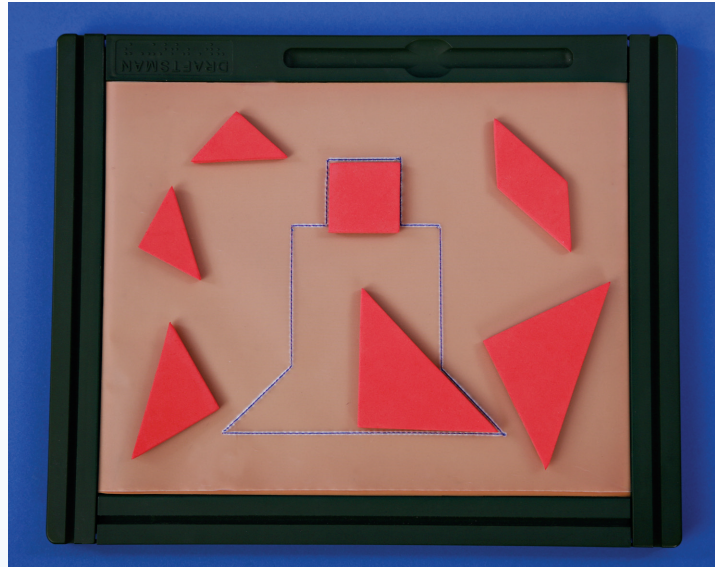
Option 3

Construct a tactile/visual outline of a tangram puzzle with strips of APH's Graphic Art Tape on a sheet of paper or cardboard of contrasting color (e.g., black tape on yellow background). Fit the puzzle pieces within the outlined area.



Option 4

Trace a raised outline of a tangram puzzle onto a sheet of drawing film included in APH's DRAFTSMAN: Tactile Drawing Board. Fit the puzzle pieces within the traced area.



Notes

Handwriting practice lines consisting of multiple horizontal blue lines across the page.