

Lesson 1: The tangram

Subject: Design and Math

Age(s): 11 and up

Duration: 45 minutes

Difficulty: low to medium

★ Objectives

By the end of class, students will be able to:

- Learn how to make simple drawings in XCS
- Draw a tangram based on its mathematic proportions
- Use the tangram to create elements to tell a story to the group

★ Overview

In this lesson, students will learn what a tangram is, where they come from, and how to draw one. Then, they will reproduce the design either on CAD software or directly in XCS and fabricate it with the help of the xTool P2. Once the group has created their tangrams, together they will tell a story using shapes and characters created with the pieces of the tangrams. In the end, the teacher and students will discuss the outcome and consider the possibilities to extend the lesson.

🔗 Key Focus

- Basic Geometric concepts and patterns
- Spatial visualization
- Reason mathematically and develop a story simultaneously

📄 Pre-lesson Checklist

For the teacher:

- One sample Tangram per group
- Computer with XCS (xTool Creative Space) installed
- 2D Vector Design/Illustration software (e.g., Inkscape) (optional)
- xTool P2 connected to the Smoke Purifier

- 3mm basswood sheet or equivalent material to create a tangram

For the students:

- Computer with XCS (xTool Creative Space) installed
- 2D Vector Design/Illustration software (e.g., Inkscape) (optional)
- 3mm basswood sheet or equivalent material to create their tangrams
- 7 different colors (optional)

Content Standards

Type	Indicator	Standard
ISTE	1.1d	Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
	1.2c	Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.
	1.3a	Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
	1.3c	Students curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
	1.3d	Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
	1.4a	Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
	1.4c	Students develop, test and refine prototypes as part of a cyclical design process.
	1.6b	Students create original works or responsibly repurpose or remix digital resources into new creations.
	1.6c	Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

Agenda (45 minutes)

Duration	Content
5 minutes	Section 1 - Engage (Introduction) <ul style="list-style-type: none">• Background and history of the tangram
5 minutes	Section 2 - Explore <ul style="list-style-type: none">• Explore the basic configuration of a tangram from a set of loose parts
10 minutes	Section 3 - Explain <ul style="list-style-type: none">• Step-by-step instructions to draw a tangram• Discuss the relations between its dimensions and proportions
20 minutes	Section 4 - Elaborate <ul style="list-style-type: none">• Groups of students work with CAD software to draw tangrams, or• The teacher can make use of the sample design included in the lesson• Students fabricate their tangrams using the xTool machine and XCS software• Collective storytelling exercise with the class• Ideas to extend the lesson
5 minutes	Section 5 – Evaluate and Exchange <ul style="list-style-type: none">• Review of the lesson objectives (summary)• Couple of questions• Key vocabulary used• Reflection• Invite students to present their outcomes and ask questions to each other

Section 1 – Engage (Introduction)

The tangram, or qiqiaoban (in Chinese), is an educational toy originated from the ancient China. However, historians still don't know exactly when they were invented. Some believe that they were invented in Ming or Qing Dynasty (Mid-14th century to early-20th century), while others argue the invention can be dated back to the Song Dynasty in China (about 1100 AD).

Qiqiaoban (referring to seven intriguing pieces in Chinese) consists of five isosceles right triangles (two small, one medium, and two large ones), one square, and one parallelogram. Amazingly, these seven pieces can make at least 1600 designs, including numbers, English letters, human figures, animals, plants, buildings, etc.



Section 2 - Explore

Give each group of students one tangram as a set of loose geometric shapes and ask them to put it back into a shape that is easily cuttable. Ideally, this shape should tessellate over a plane for cutting it from the prepared 3mm wood or cardboard with minimum waste. Depending on the age of the students, the waste of material can be calculated or just visually compared among different suggestions.

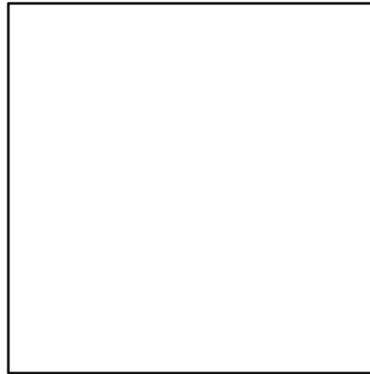
In the next steps, a sample construction of a tangram is explained to allow students to process (and optionally color) their own tangram for further use in lessons. They can focus on math topics or be interdisciplinary, e.g., by inventing a story based on animal creatures constructed from tangrams. Here mathematical reasoning meets storytelling :-).

Section 3 - Explain

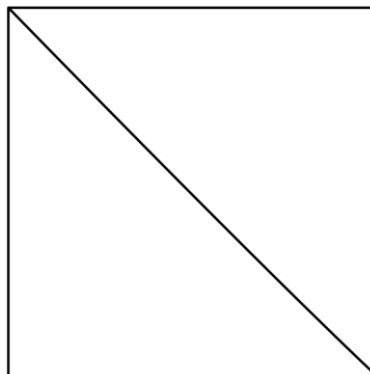
How to draw a tangram?

Whether it is drawn on paper using rulers or digitally using CAD software, the process to create a tangram consists of the same steps:

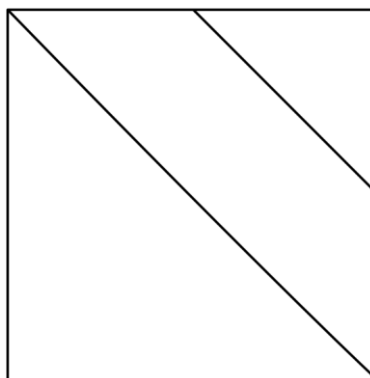
1. To begin, draw a square that measures 70x70mm.



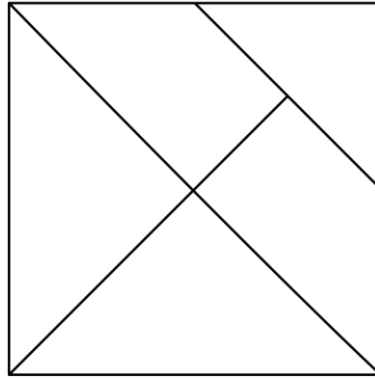
2. Draw a diagonal line from the top left corner to the bottom right corner, splitting the square into two equal triangles.



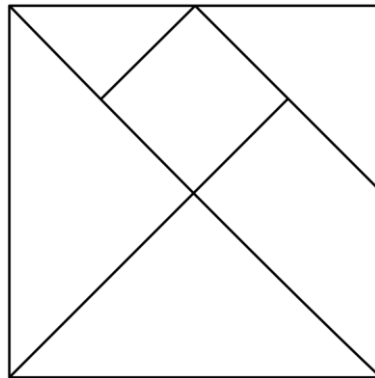
3. Draw a diagonal line from the midpoint of the top side to the midpoint of the right side.



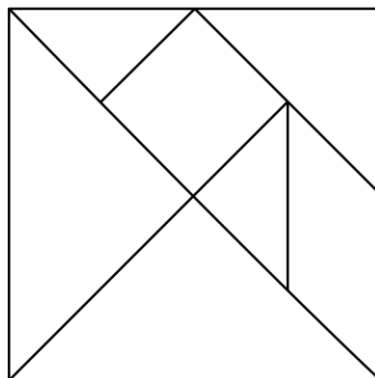
4. Draw a diagonal line from the bottom left corner of the square to the middle of the smaller diagonal that was drawn on step 3.



5. Draw a parallel line to the one you draw on step 4, starting from the midpoint of the top side of the square until it meets the diagonal from step 2 (the one that splits the square into 2 equal triangles).

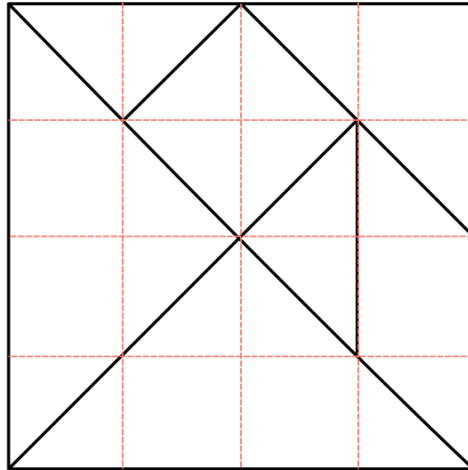


6. To end, draw a vertical line down from the end point of the diagonal you drew on step 4 (the point where the second line and third line meet) until it meets the diagonal from step 2.

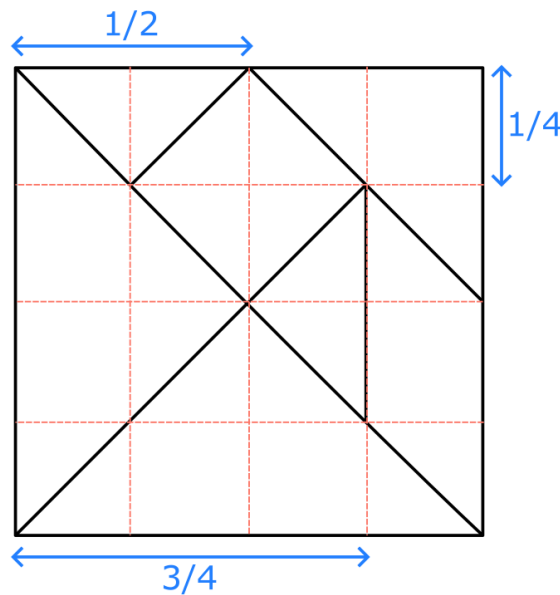


Are there other ways to draw a tangram?

A tangram consists of basic geometric figures, and if you divide the main square of a tangram into a 4x4 grid, you will notice that the intersection of each line meets one of the crossings of the grid.



Knowing this, you can draw a tangram of any size and calculate the dimensions of the lines based on their proportions with respect to the main square.



Section 4 - Elaborate

It is now time for students to make their own tangrams. Have students work in pairs and draw a tangram following the steps above.

In order to cut the tangrams with the P2 laser machine, you need to have the digital drawing in the XCS software. Students can either draw it on a third-party CAD software and import it or directly draw it on the XCS interface.

Unlike other CAD software, it is not possible in XCS to snap the points of lines to other lines or other points, so you need to make use of the X and Y coordinates and calculate the dimensions and position of the lines in order to draw a tangram.

Alternatively, if the class doesn't have the possibility to do the digital drawing of the tangram, the teacher can use the sample file provided with this lesson to produce the tangrams.

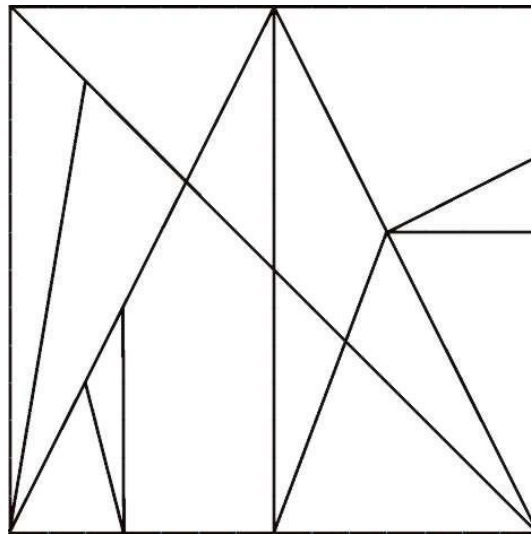
Once the class has fabricated their tangrams, it is time for a brief storytelling game. It's a fun task: make a group story based on tangram shapes. The teacher can set some easy rules:

- The seven pieces of a tangram must all be used when making a design.
- Each piece must have contact with at least one of the others.
- There can be no overlap between the pieces.

Students take turns to tell the next part of the story, and they can be encouraged to make tangram designs based on the story as it unfolds.

Extending the lesson

Archimedes' Stomachion is a Greek mathematical puzzle similar to the tangram. You can cut a square following the pattern below to make a Stomachion.



Strikingly, mathematicians who study combinations found that there are 17,152 solutions to the Stomachion. Similar to the tangram, the Stomachion pieces can be used to make various shapes. You can encourage students to make a Stomachion, solve the puzzle, and make designs with its pieces; students can even create their own tangram design and cut them with the xTool P2.

Section 5 – Evaluate & Exchange

It is now time for a brief reflection. The students should think on their own and discuss with the group the following questions:

- What do you think turned out well?
- What could be better?
- Which parts of the lesson did you find easy, and which did you find more difficult?
- What would you like more explanation about?
- Who could help you with that?
- Could you think of improvements regarding the design process of the tangram?