Trebuchet Tests

Learning about Potential and Kinetic Energy

HCID 521 - PROTOTYPING STUDIO

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Activity Overview

In this project, groups of 3 students are asked to assemble a trebuchet from cardstock and simple classroom supplies. Through this activity, students will learn basic circuitry, the history behind trebuchets, and the transformation of stored to kinetic energy. In addition, students will applies engineering principles such as the importance of iteration in refining designs.

Alignment with NGSS

4-PS3-4.
Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

ETS1-3.
Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved
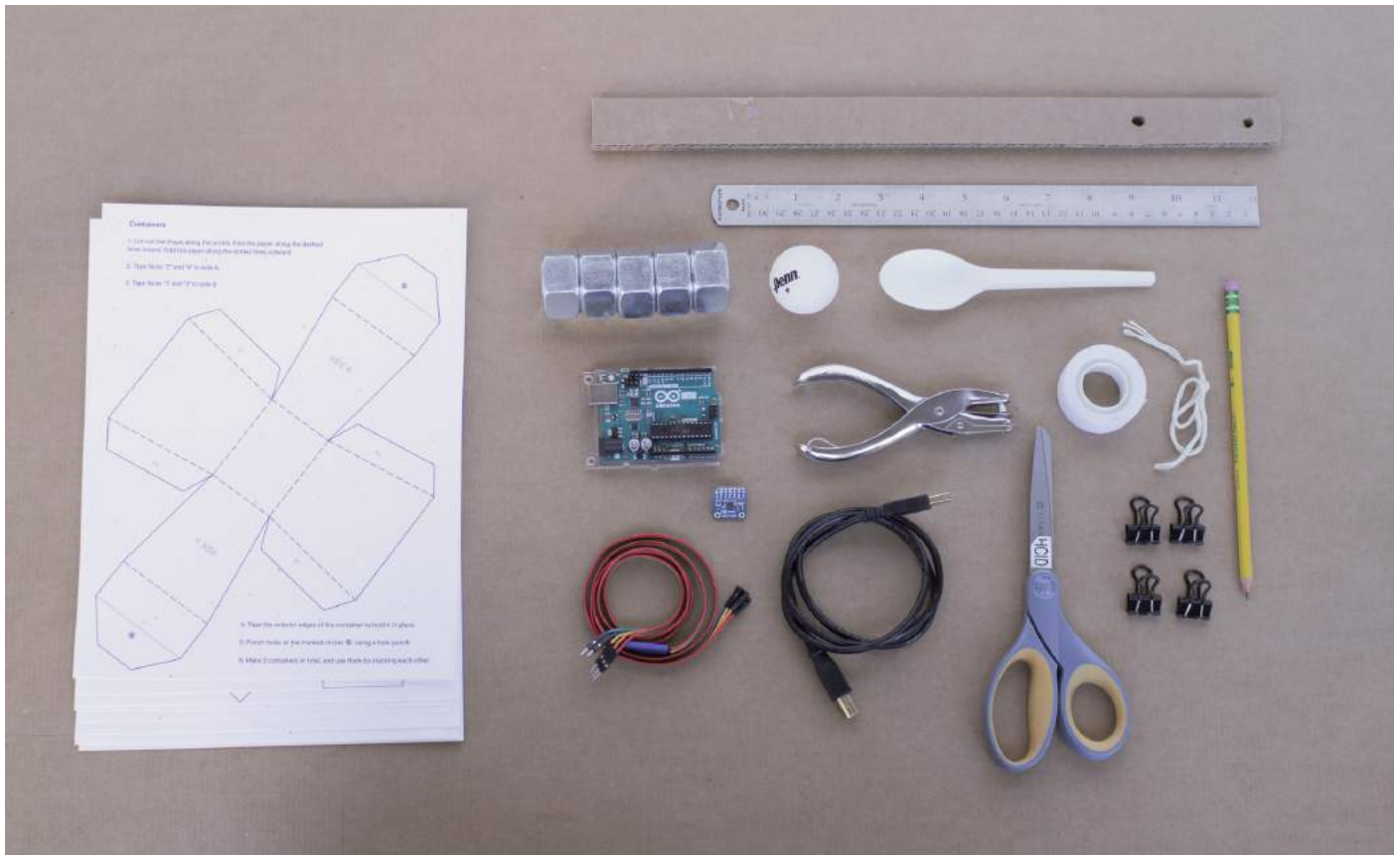
Historical context

The later counterweight trebuchet, also known as the counterpoise trebuchet, uses a counterweight to swing the arm. Through the transformation of energy, students will learn how siege engineers were able to launch 90kg projectiles over 300m in medieval times by using basic physical principles.

Contents

What you'll need for this

Materials

2 plastic spoons
3 pieces of c-flute cardboard, 16" x 1"
1 4" long string
10 sheets of 8.5" x 11" cardstock
5 25" male-to-female jumper cables
5 hex nuts (3/4" in diameter)
4 small binder clips

Toolkit
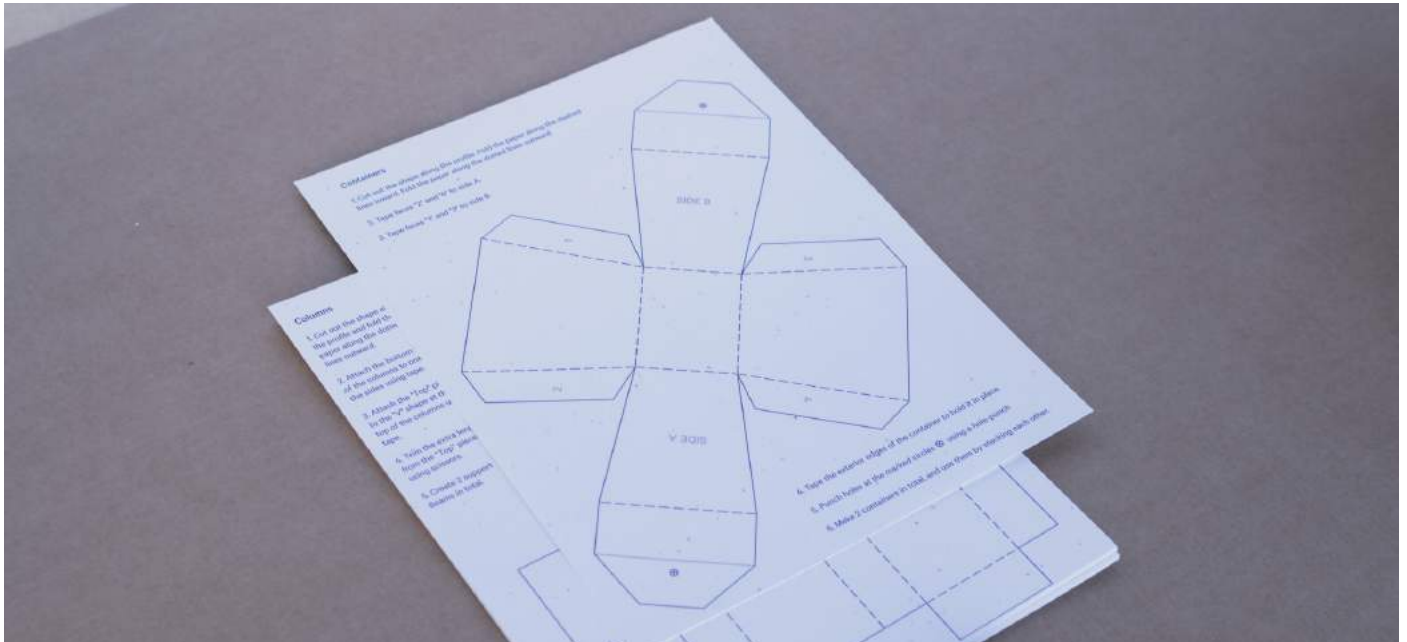
scissors
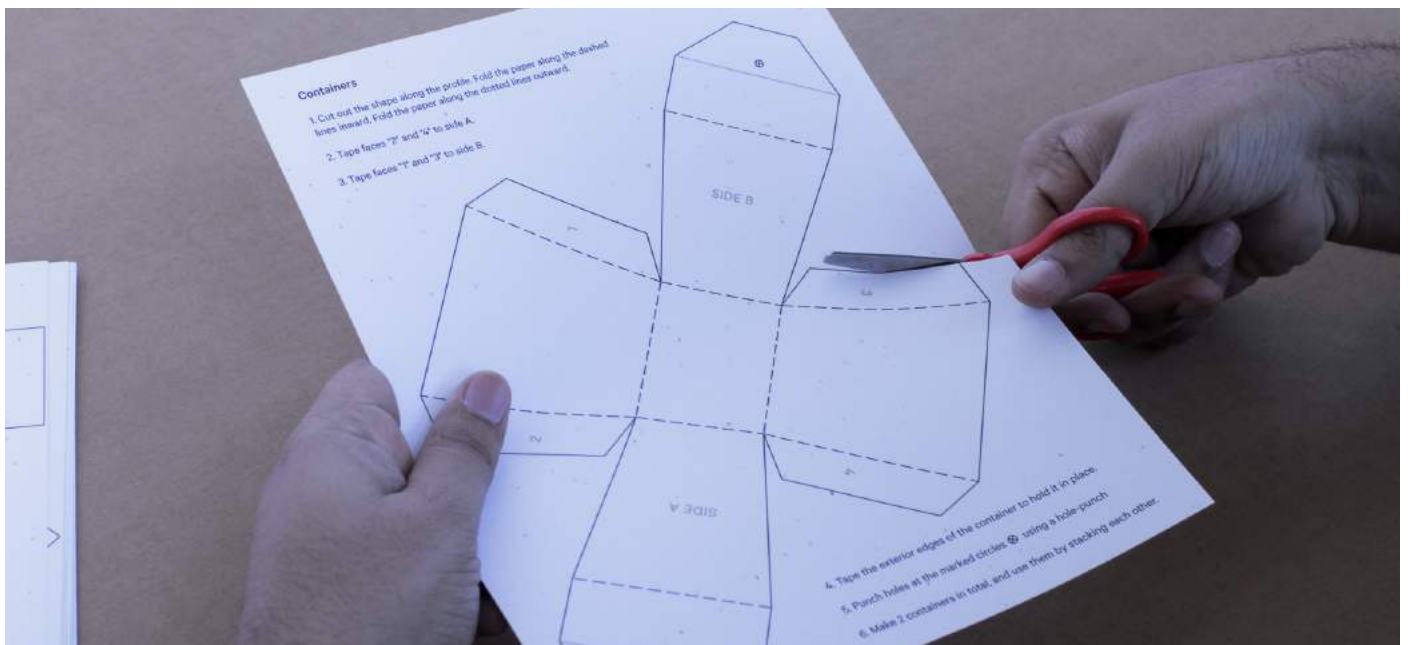single hole-puncher
pencil
ruler
adhesive tape
ping pong ball

Reusables

1 Arduino
1 USB cable A-to-B for Arduino
1 3-axis accelerometer

Assembling the pieces

1. Print out the pieces from page 10 to 19 on cardstock.

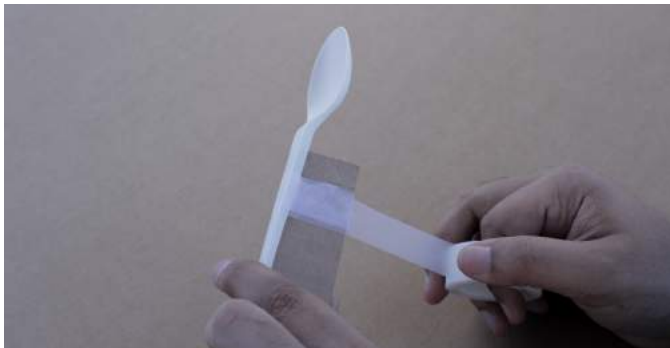**2.** Assemble the individual pieces by following the instructions on the sheets.

Building the Swing Arm

1. Take the 16" x 1" pieces of cardboard. Make 2 holes along the center of the 3 sheets using a hole-punch. The first hole should be 1" from the tip, the second hole should be 4" from the tip.
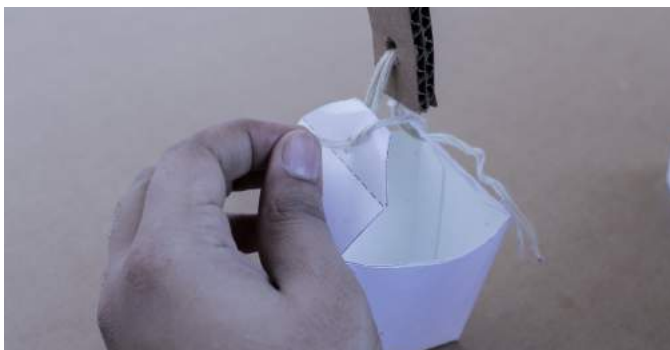

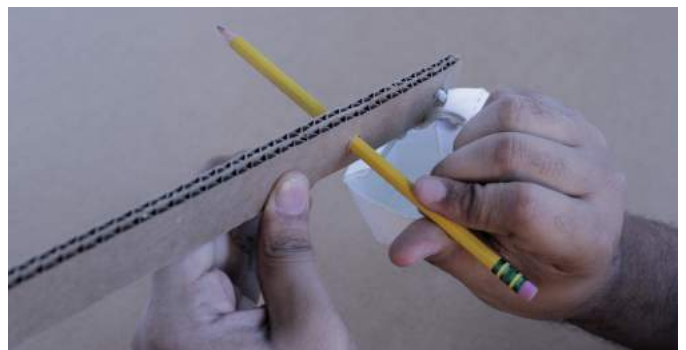2. Using adhesive tape, bound the 3 pieces pieces together.

3. Take a plastic spoon and tape it to the end of the arm.

4. Cut the handle of the second spoon in half. Tape the second spoon underneath the first spoon with the handle facing outwards.
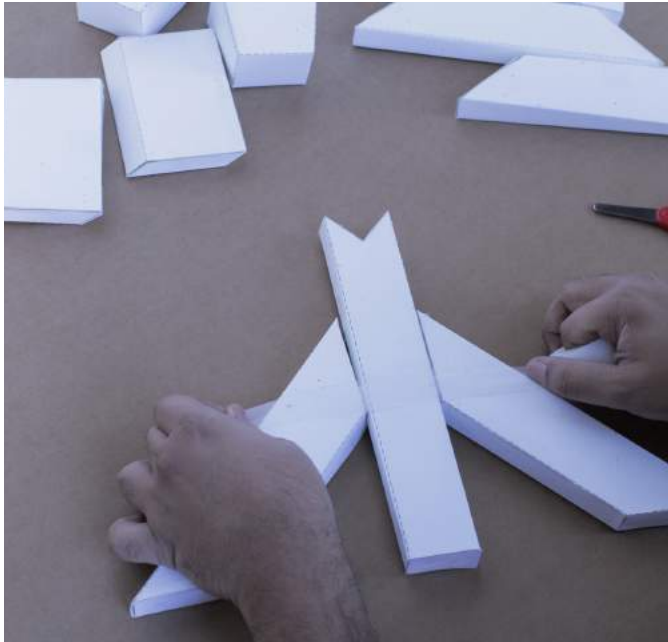

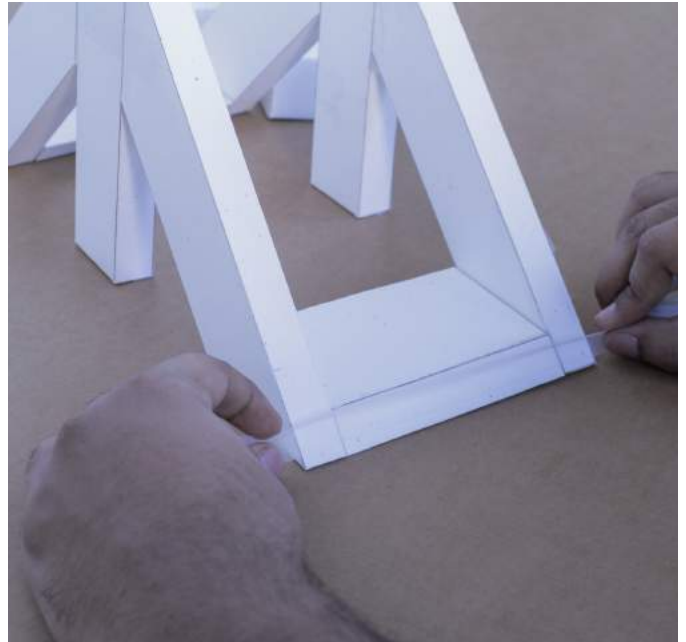5. Attach the weight container to the swing arm by folding and threading the string through the first hole.

6. Drive a pencil through the second hole on the swing arm to complete the setup.

Putting it all together

1. Using glue and tape, fasten the Rafters to the marked faces on the sides of the tower. Repeat the step for the second Tower and the remaining Rafters.

2. Using glue and tape, fasten the Joists to the marked faces on the sides of the Rafters. Repeat this step for the opposite side.
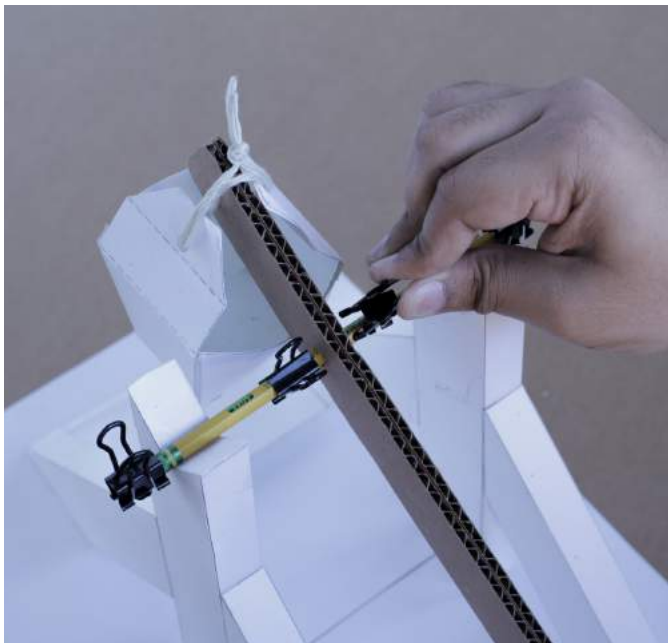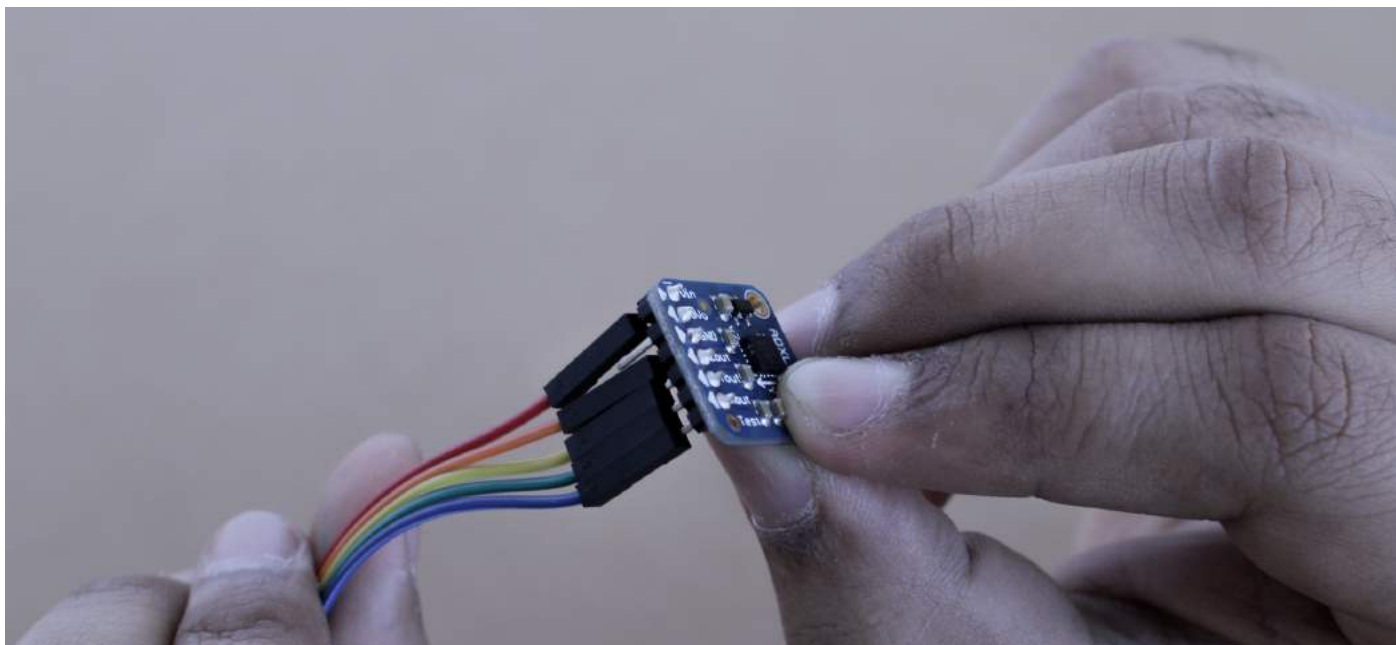

3. Mount the assembled swing arm to the base. Add binder clips to secure the swing arm in place.
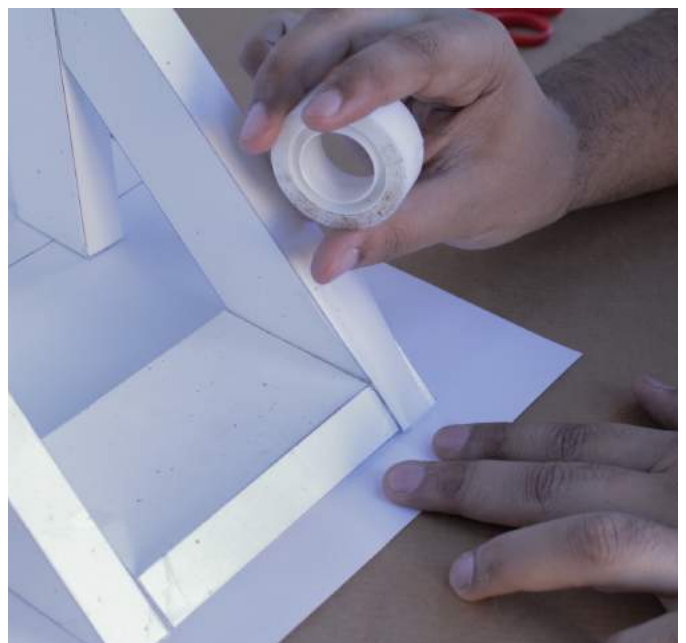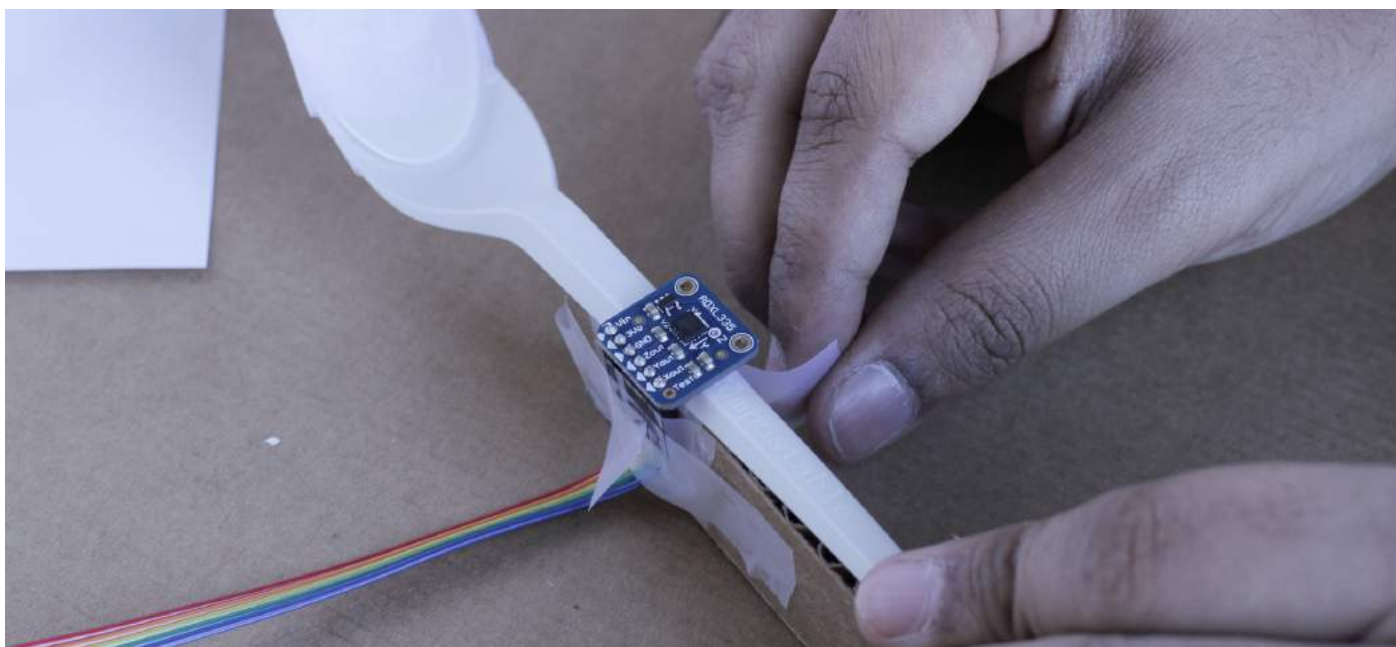

4. We recommend taping the base setup to a sheet of paper or a solid surface to prevent the trebuchet from swaying back and forth when launching.
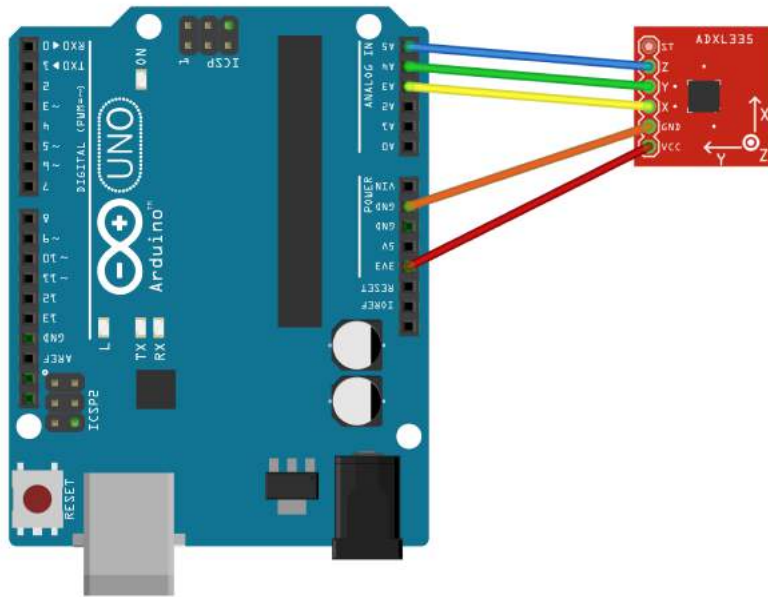
Attaching the Accelerometer

1. Attach the female side of the jumper cable to all the pins on the accelerometer except 3 Vo.
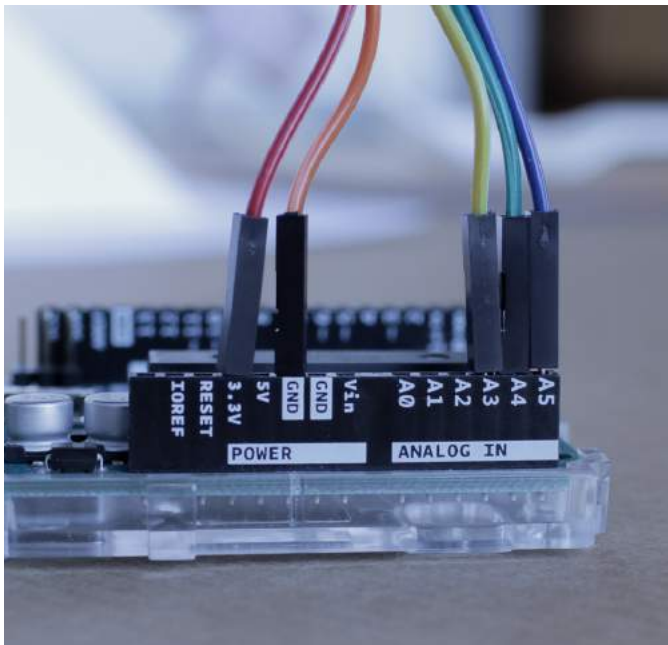

2. Using adhesive tape, bind the cable to the side face of the swing arm, near the spoon. Make sure the accelerometer is facing forwards.
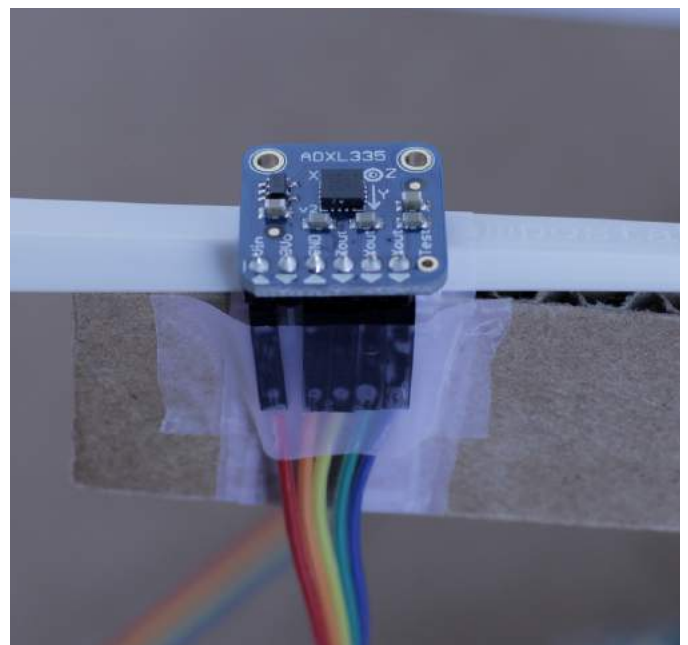
Connecting the Arduino

1. Connect the male end of the jumper cables linked to the Xout, Yout, and Zout on the accelerometer to the A5, A4, and A3 Arduino ports respectively.

2. Connect the male end of the cable connected to the GND port on the accelerometer to the GND port on the Arduino.

3. Connect the male end of the cable connected to the Vin port on the accelerometer to the 3.3V port on the Arduino.
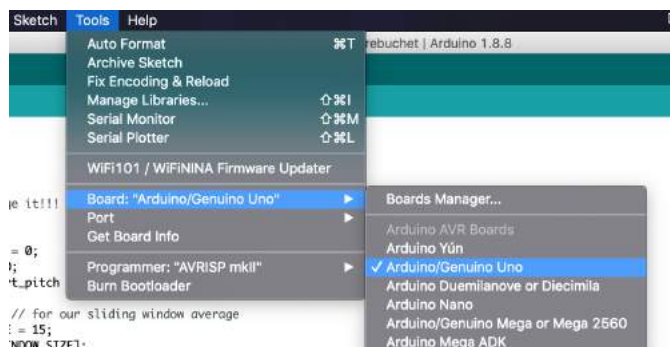
Upload the Arduino Code
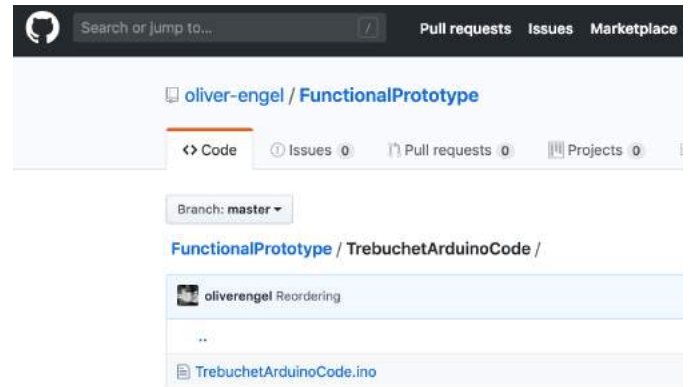

Download the Arduino IDE

1. Install the Arduino IDE from arduino.cc/en/Main/Software. Follow prompts to complete the installation.

2. Go to goo.gl/p1gJqa and download the Arduino code.
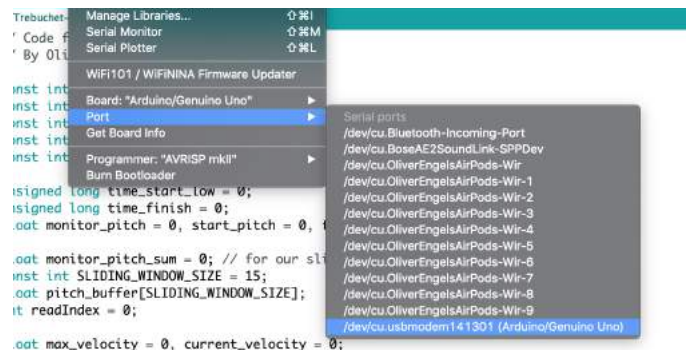
3. Open the downloaded file to launch the Arduino app.

4. In the Arduino app, select: Tools > Port > usbmodem141301 (Arduino/Genuino Uno). Your port may be different than usbmodem141301.

5. Select Tools > Board: Arduino/Genuino Uno
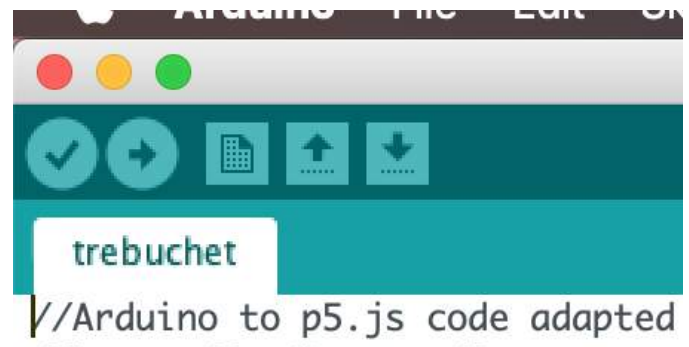
6. Click on the circular right arrow button to upload the code.

Setting up p5.js Connection

1. Download and open the p5.serialControl app from github.com/vanevery/p5.serialcontrol/archive/0.0.5.zip.
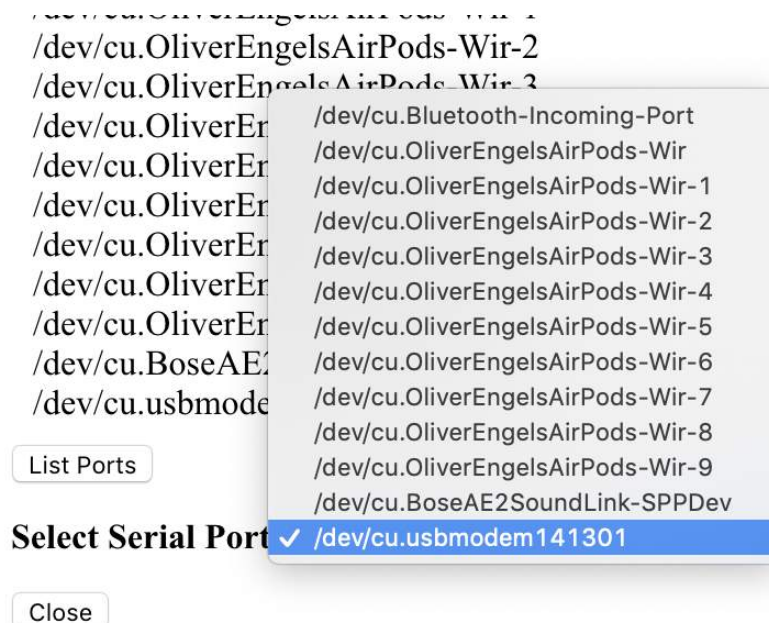
2. Select the serial port that corresponds to the Arduino from the dropdown.

Visualizing Data
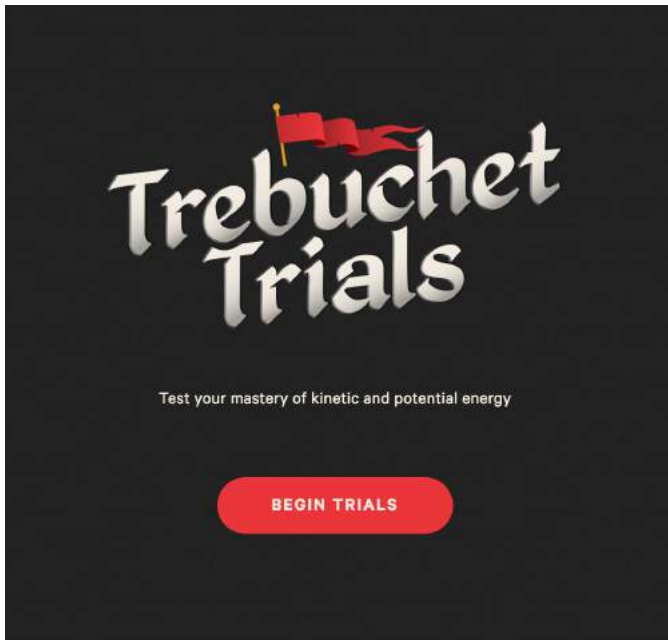
1. Go to trebuchet.netlify.com, and press begin trials to start the activity.
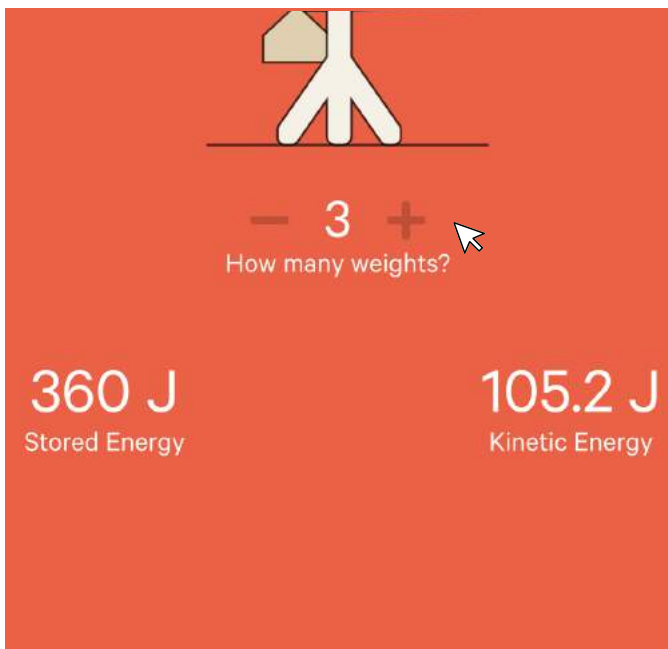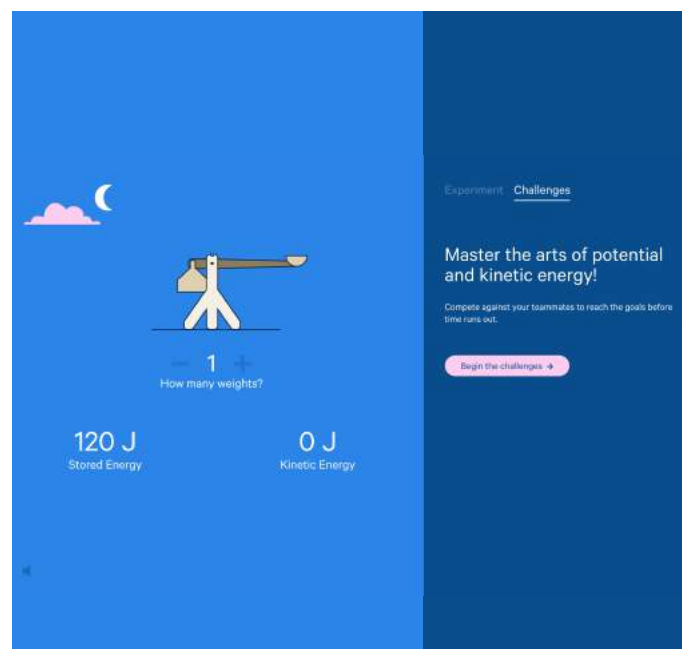

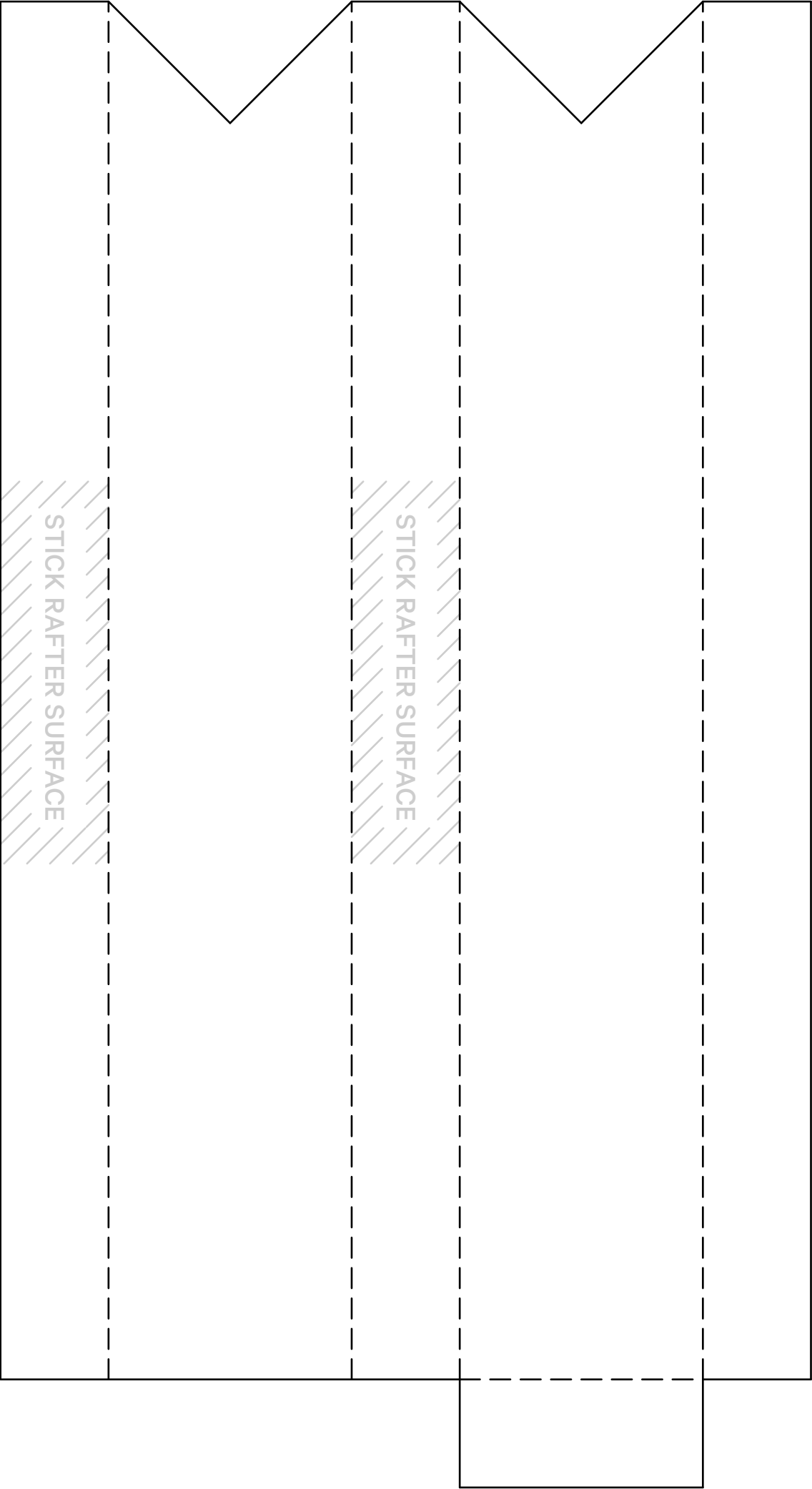2. Lower the launch arm to begin recording trials. Once the projectile appears in the launch cup, it's ready to go.

3. Increase/decrease the number of weights by using the - / + buttons.

4. Toggle to challenges to attempt different goals.

Columns

1. Cut out the shape along the profile and fold the paper along the dotted lines outward.

2. Attach the bottom face of the columns to one of the sides using tape.

3. Attach the "Top" piece to the "V" shape at the top of the columns using tape.

4. Trim the extra lengths from the "Top" piece using scissors.

5. Create 2 support Columns in total.

TOP

STICK RAFTER SURFACE

STICK RAFTER SURFACE

Rafters

1. Cut out the shape along the profile and fold the paper along the dotted lines inward.

2. Attach the top and bottom faces of the rafter to one of the sides using tape.

3. Create 2 rafters in total

STICK TO TOWER

Containers

1. Cut out the shape along the profile. Fold the paper along the dashed lines inward. Fold the paper along the dotted lines outward.

2. Tape faces "2" and "4" to side A.

3. Tape faces "1" and "3" to side B.

1

SIDE B

⊗

2

3

SIDE A

4

⊗

4. Tape the exterior edges of the container to hold it in place.

5. Punch holes at the marked circles ⊗ using a hole-punch

6. Make 2 containers in total, and use them by stacking each other.

Joists

1. Cut out the shape along the profile and fold the paper along the dashed lines inward.

2. Attach the top and bottom faces of the joists to one of the sides using tape.

3. Create 2 joists in total.
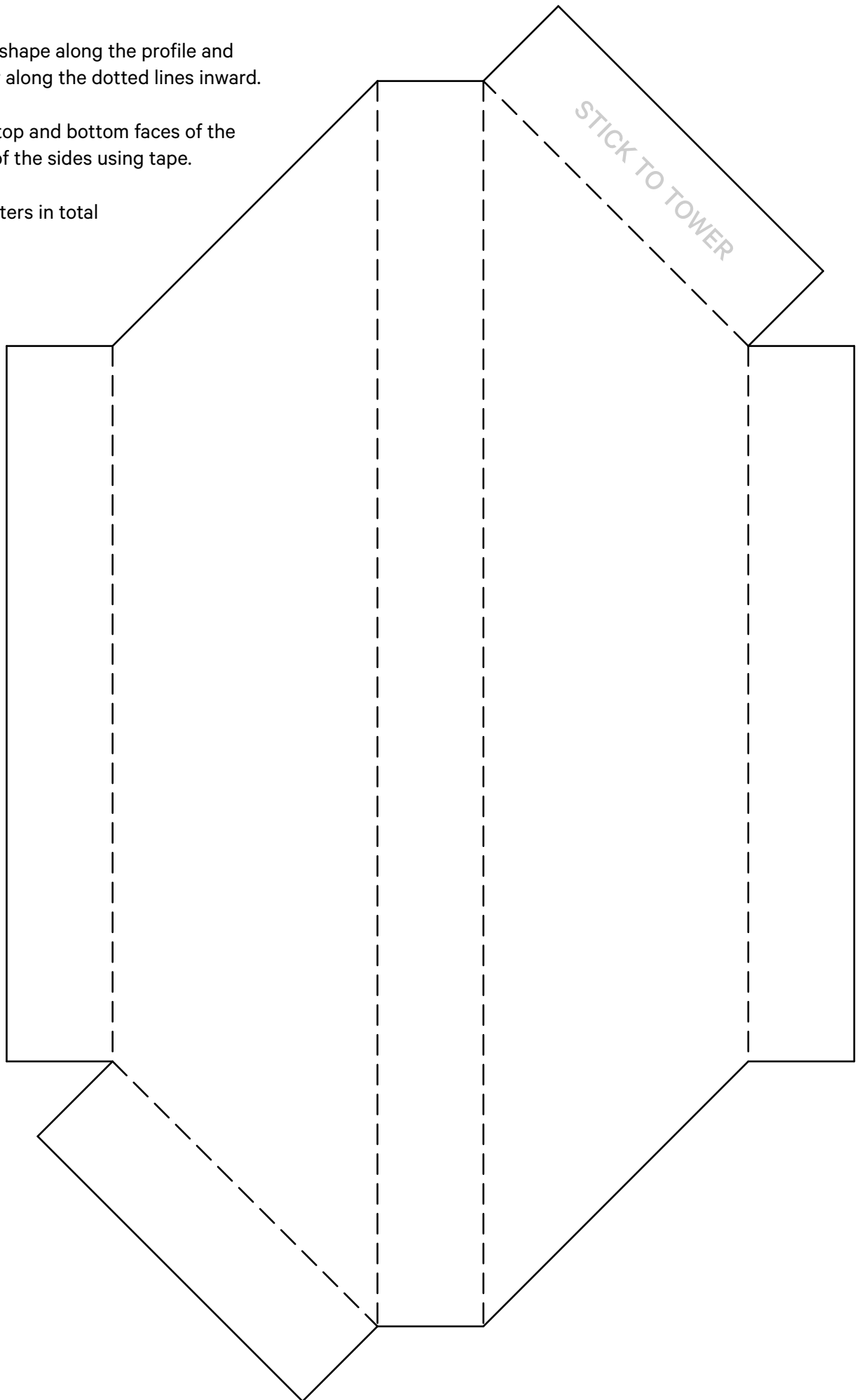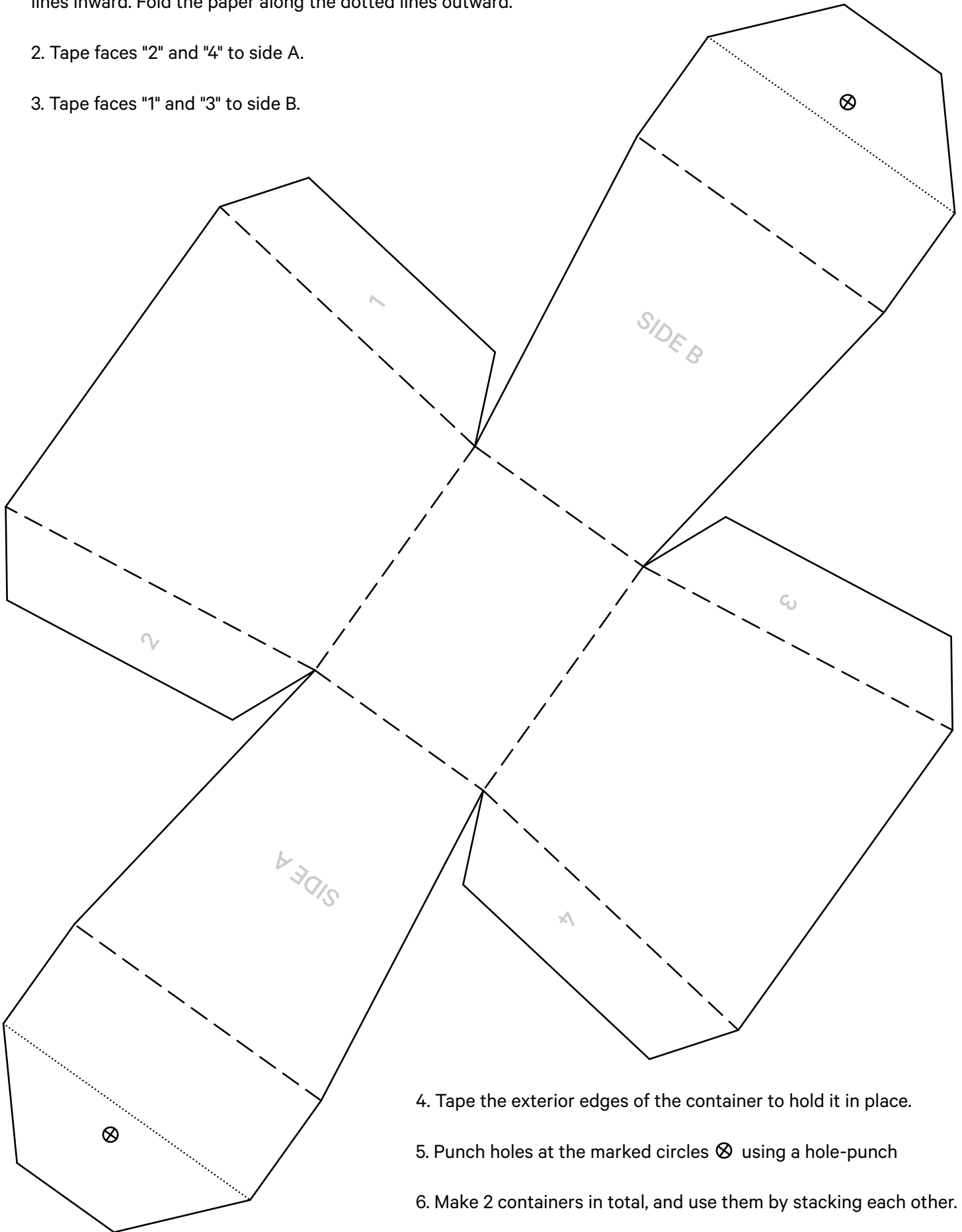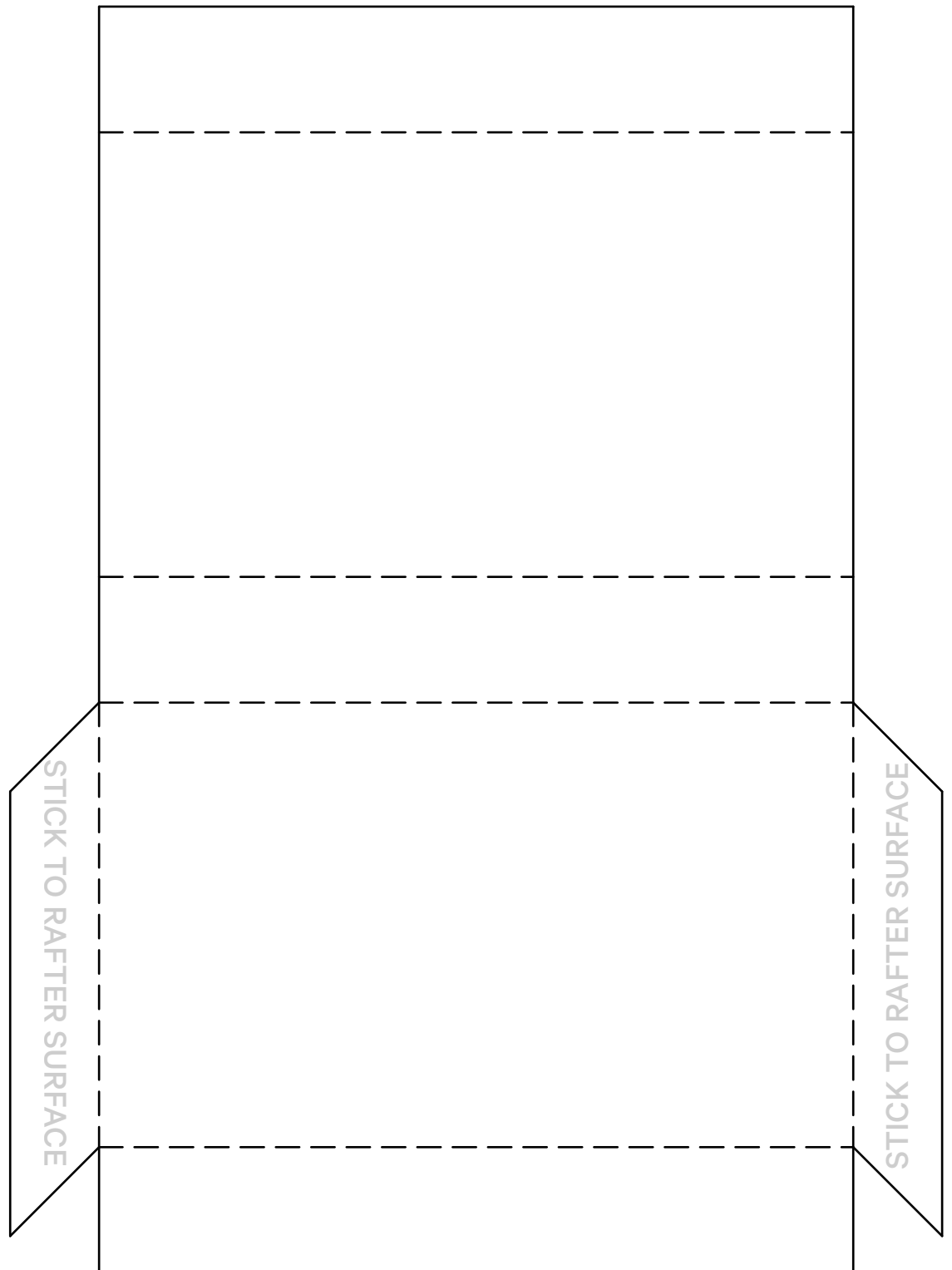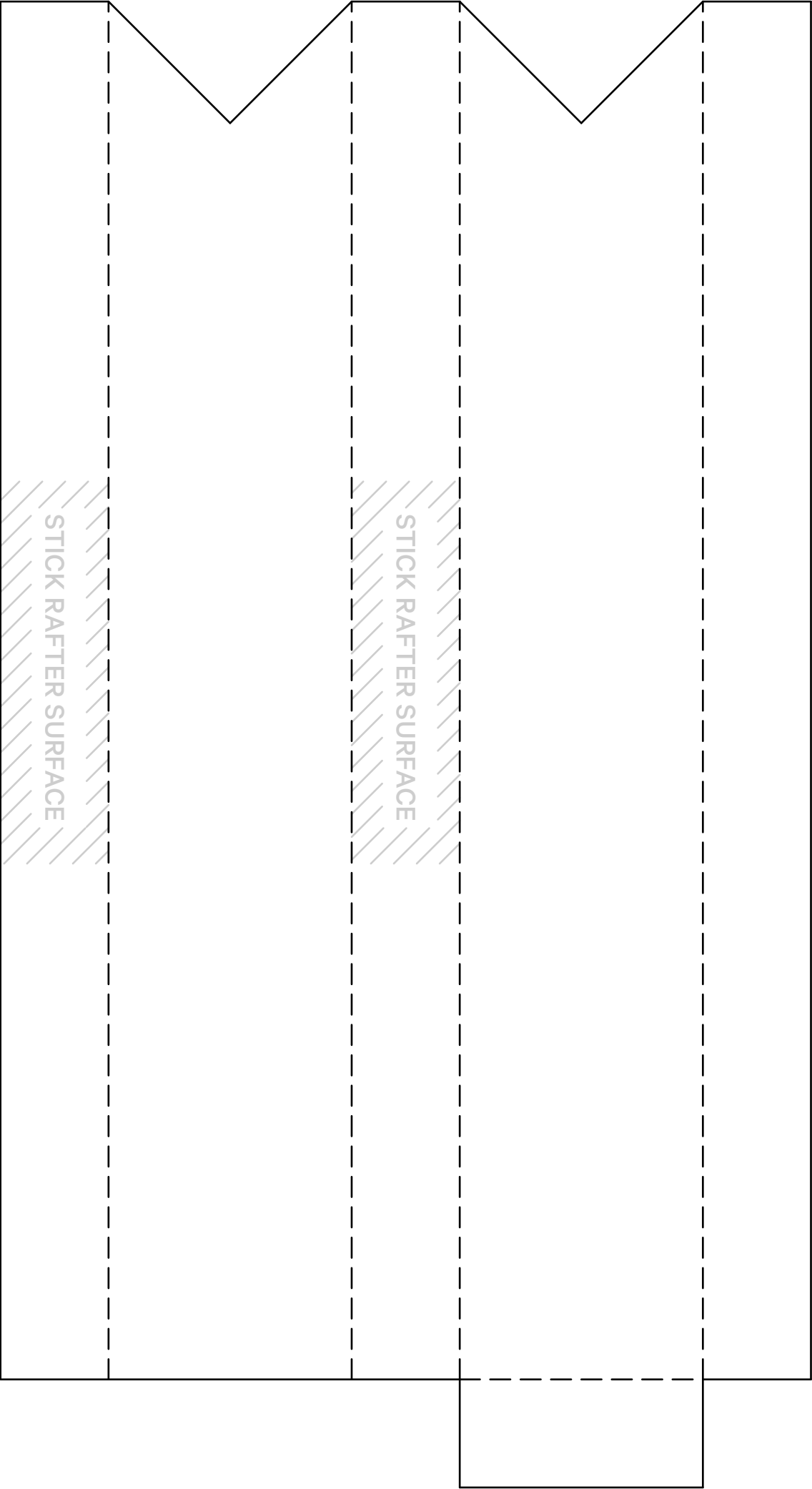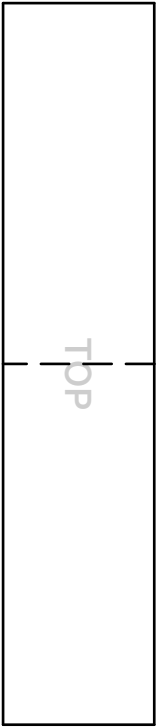
STICK TO RAFTER SURFACE

STICK TO RAFTER SURFACE

Columns

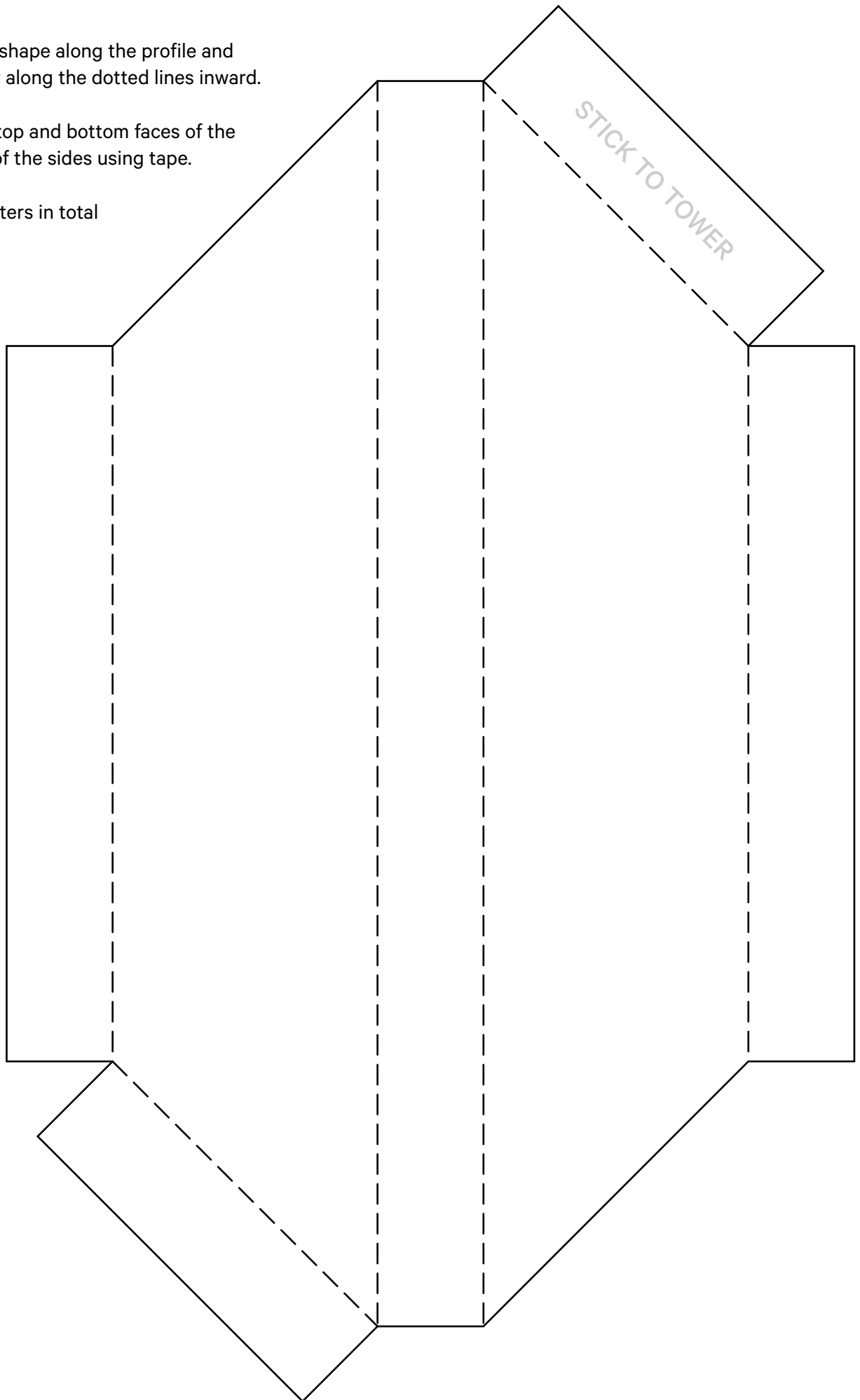1. Cut out the shape along the profile and fold the paper along the dotted lines outward.

2. Attach the bottom face of the columns to one of the sides using tape.

3. Attach the "Top" piece to the "V" shape at the top of the columns using tape.

4. Trim the extra lengths from the "Top" piece using scissors.

5. Create 2 support Columns in total.

TOP

STICK RAFTER SURFACE

STICK RAFTER SURFACE

Rafters

1. Cut out the shape along the profile and fold the paper along the dotted lines inward.

2. Attach the top and bottom faces of the rafter to one of the sides using tape.

3. Create 2 rafters in total

STICK TO TOWER

Rafters

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2. Attach the top and bottom faces of the rafter to one of the sides using tape.
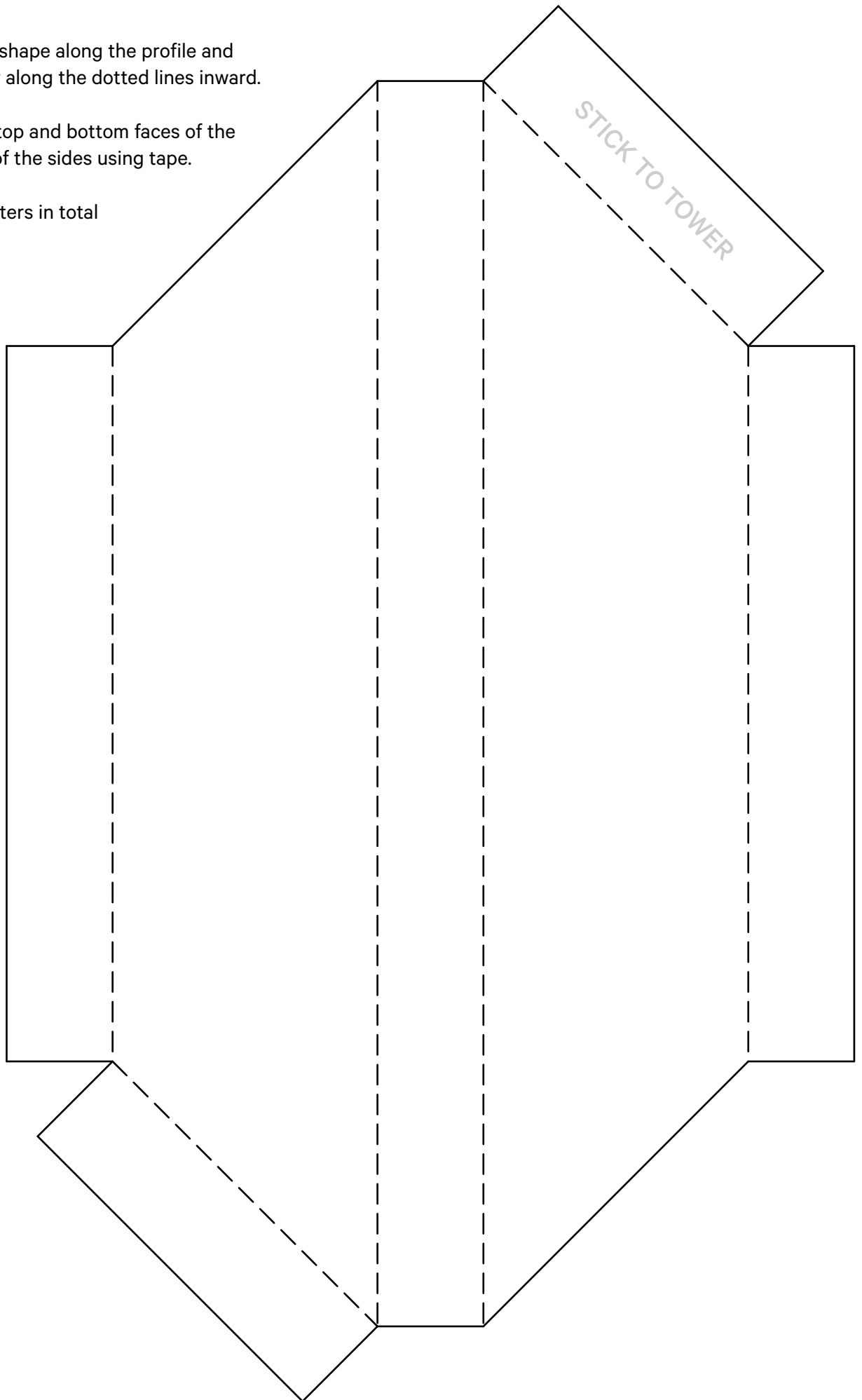
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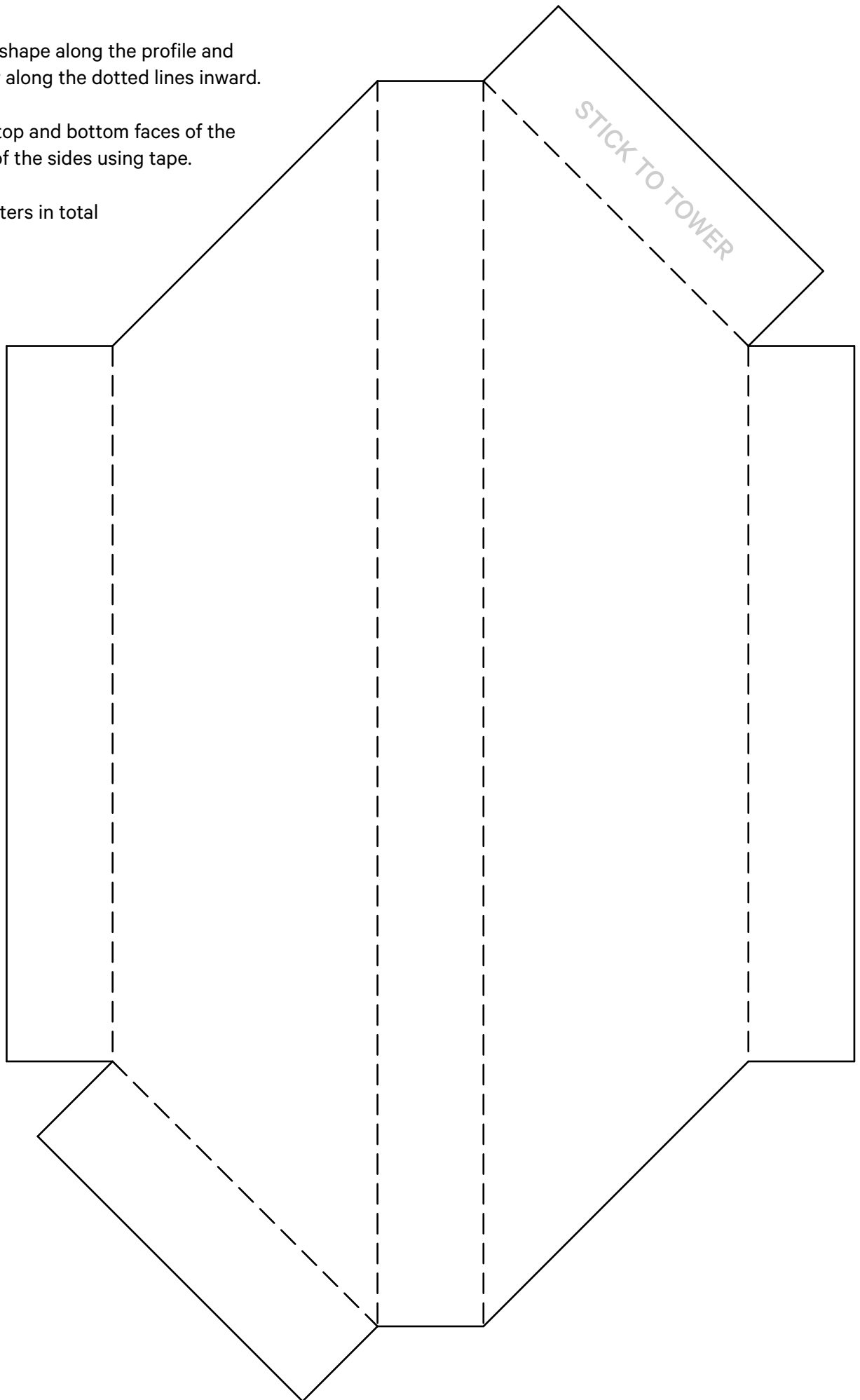
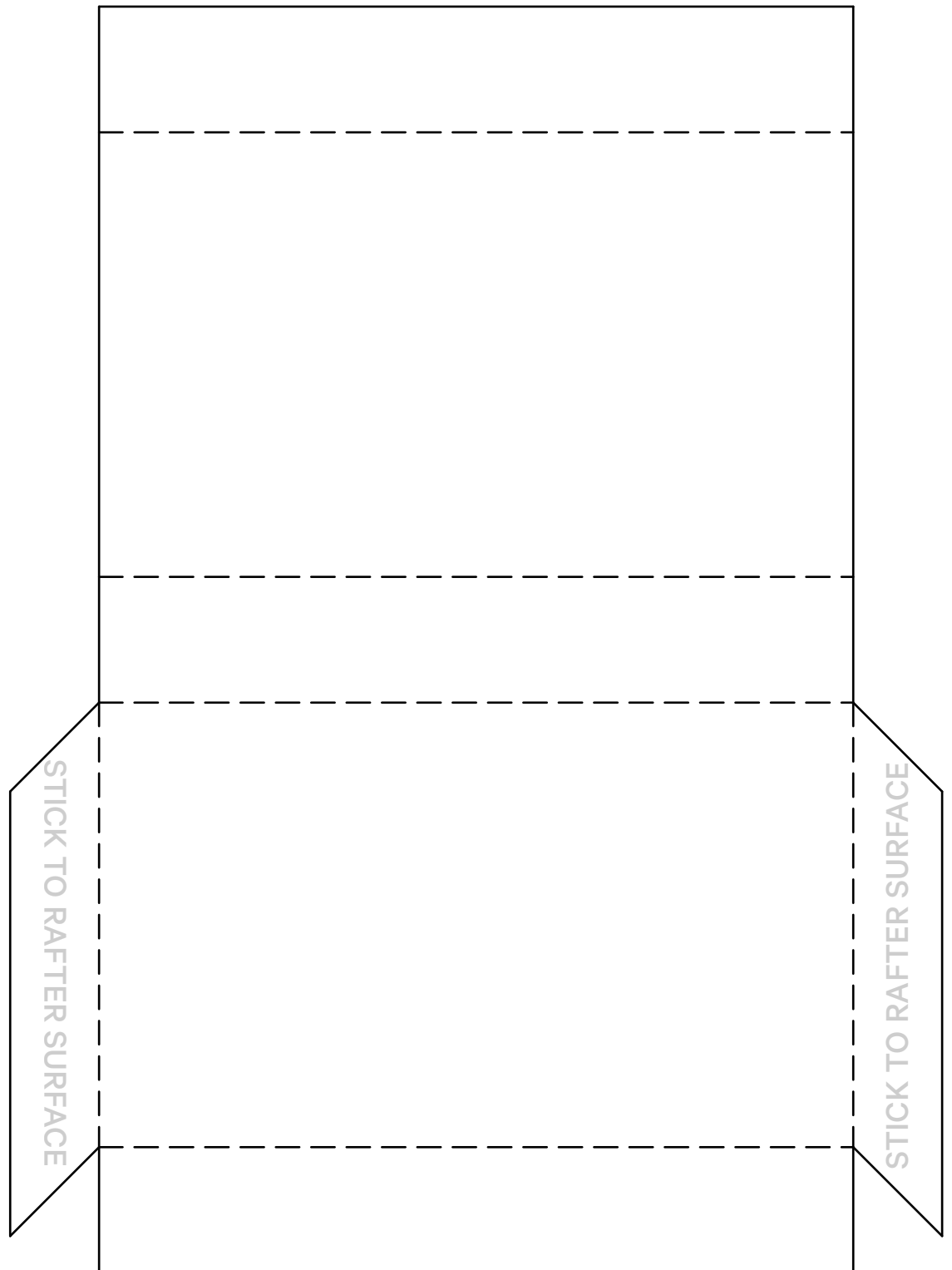3. Create 2 rafters in total

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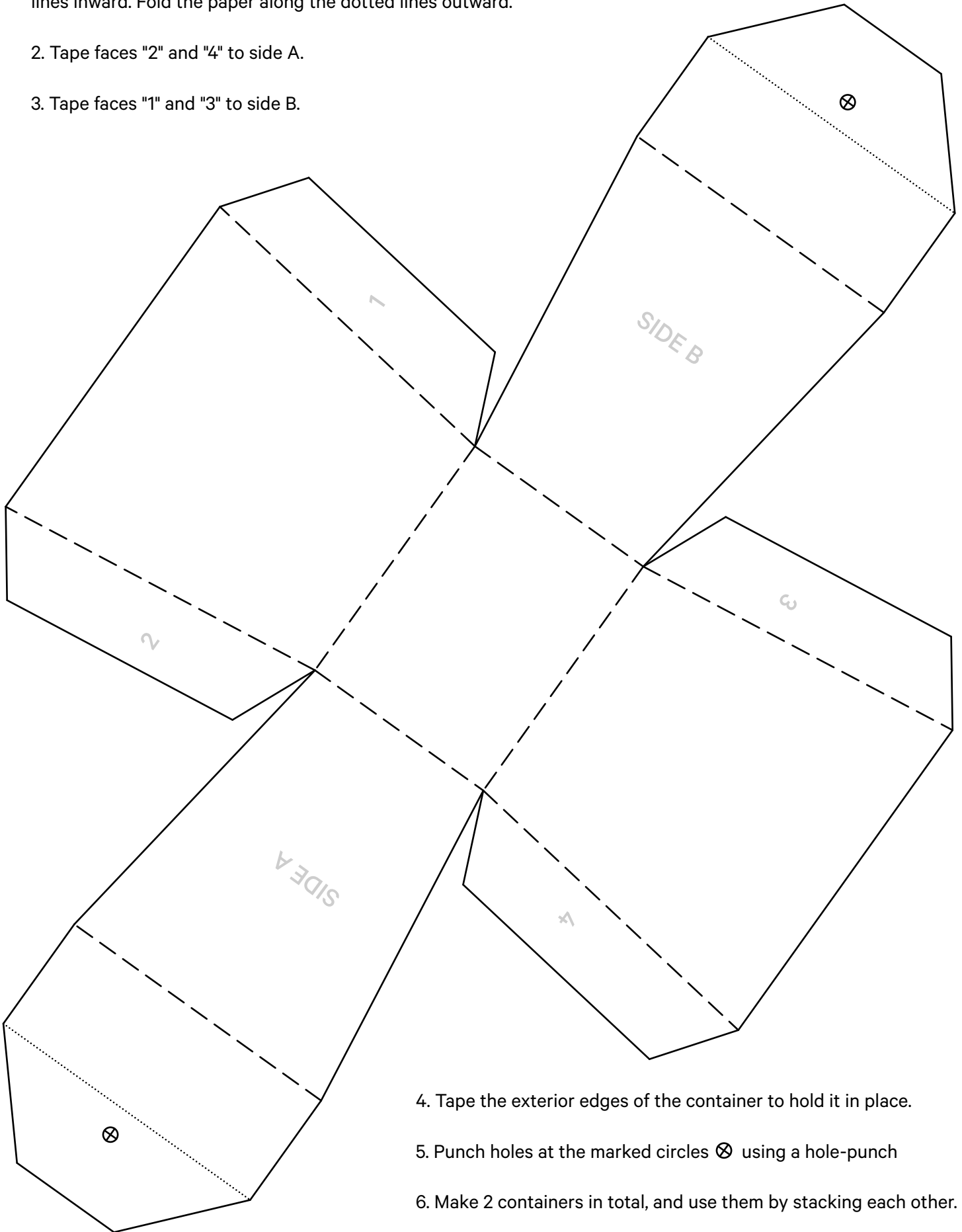
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SIDE A

4

4. Tape the exterior edges of the container to hold it in place.

5. Punch holes at the marked circles ⊗ using a hole-punch

6. Make 2 containers in total, and use them by stacking each other.