Grade: 6, Unit: Polyhedrons and Surface Area

Essential Question: Is determining the surface area of polyhedrons related to determining the area of polygons?

In this series of lessons, students will examine polyhedrons and sort them based on their attributes, use collected data to create working definitions, classify polyhedrons based on the definitions, construct paper models of polyhedrons and identify their bases, sides, faces, vertices and edges, identify polyhedrons represented on nets, and use the nets to determine the surface area of polyhedrons.

Summary

Lesson I:	Lesson II:
Students will use Venn diagrams and their knowledge of two- and three-dimensional objects to create definitions of *polyhedron*, *prism* and *pyramid*. They will use their definitions and create T-charts to classify three dimensional figures and be able to justify their answers. Once they are proficient using the definitions to classify 3-D models, they will apply those skills to classifying two-dimensional representations of three-dimensional figures (nets). Students will need the following background knowledge before engaging in this lesson: • Polygons are two-dimensional figures • Circles are not polygons Objectives: • Determine if a three dimensional figure is a polyhedron • Classify polyhedrons • Identify a polyhedron from its net	Students will predict which three-dimensional figures are represented in nets, and then cut them out and assemble the figures to determine whether their predictions are correct. They will collect data about the number of faces, edges and vertices each figure has. After identifying the figures, they will determine the surface area of each by measuring and using the appropriate area formulas. Students will discern that they can find the total surface area of the figures displayed on nets by finding the area of each polygon and then adding them together. Students will need the following background knowledge before engaging in this lesson: • How to determine the area of rectangles and triangles Objectives: • Identify and count faces, edges and vertices of polyhedrons • Use nets to find the surface area of rectangular prisms, rectangular pyramids, triangular prisms and triangular pyramids

Standards:

- 6.NS.3 Fluently add, subtract, multiply and divide multi-digit decimals using the standard algorithm.
- 6.G.1 Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context solving real-world and mathematical problems
- 6.G.4 Represent three-dimensional figures using nets made up of rectangles and triangles, and use nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.

Lesson I:

Required Materials:

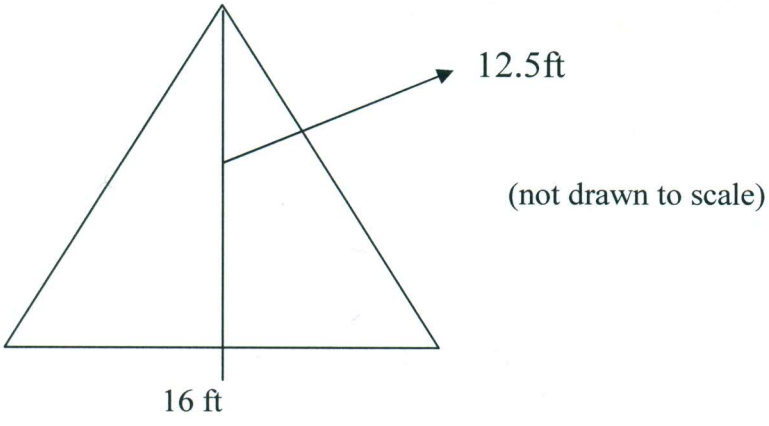
- Notebooks
- Pencils
- Three-Circle Venn diagrams (one for each student)

Procedures

1. Lead- In: Three area problems displayed on Smart Board. Students should begin working independently and silently. (These problems all review the prerequisite skill of determining the area of polygons that is necessary for success with today's lesson. The decimal multiplication necessary for solving these problems addresses fluency in multi-digit multiplication.) As students complete the problems they should be directed to think about the Motivational Question (also displayed on the board.)

    1. Mrs. Dieck wants to determine the area of a rug on the floor in her living room. If the rug has a length of 132 inches, and it is 96 inches, what is the area of the rug in square inches

    2. Mr. Bullis' office is in the shape of a triangle. A diagram of the office is below.



(not drawn to scale)

What is the area, in square feet, of Mr. Bullis' office?

3. Kathy wants to determine the area of the square playground in her neighborhood. One side of the playground measures 45.25 meters. What is the area, in square meters, of the playground?

Motivational Question: A storage company receives its boxes in flat sheets. The boxes and lids need to be assembled by the customers when they buy them. What are some reasons the storage company would sell their boxes in flat sheets?

2: Step by Step:

a) Quickly review the Warm-up activity.
b) Present the Motivation question to the students. Ask them to write a prediction of what the answer will be. Do not allow discussion of the question at this time, but assure the students that they will discuss it at the end of the lesson.
c) Ask, "How are a square and a cube similar? How are they different?" (This set of questions taps into background knowledge. No need to take notes here.) Establish with the students that a square is two-dimensional and a cube is three-dimensional. Explain that today's lesson will focus on different types of three-dimensional figures.
d) Distribute a three-circle Venn diagram to the students. Have them label the circles "soda can", "number cube" and "Egyptian pyramid". Ask students to take a minute to think about the shape of each object, and then fill in the corresponding parts of the diagram.
e) Display a blank Venn diagram on the board or Smartboard. Using information elicited from the students, fill in the characteristics of the figures. Be sure that the characteristics shared by the cube and the pyramid include information about the faces, edges and vertices (the students may, at this point, still be calling them sides, lines and corners.) The mathematically correct names of the objects should be included in each oval (soda can=cylinder, number cube=prism, Egyptian pyramid=pyramid.) This information may or may not have to be supplied to the students. For the remainder of the lesson only the mathematically correct vocabulary should be used.
f) Ask, "How is the cylinder (soda can) different from the other two shapes?" "What do the prism and the pyramid have in common" Discuss. Explain to the students that three-dimensional figures with straight edges are called polyhedrons. Pause to allow students to write that definition on their papers.
g) Explain that all polyhedrons fit into one of two categories. Ask, "Based on the information on your Venn diagram, and what we've discussed so far, what do you think the two categories are?" (prisms and pyramids)
h) Instruct students to fold a sheet of notebook paper in half, vertically, to form a "T" chart. Write "Prism" at the top of one column, and "Pyramid" at the top of the other. Break students into triads. Supply each group with a set of polyhedrons to examine. The students should discuss and list the attributes of each type of figure.

i) Circulate to offer guidance and assistance as necessary. As each group completes their list of attributes, ask them to come up with a working definition of prism and pyramid.
j) Have groups share their working definitions, and guide the class in using them to create one class definition (that includes all necessary components: pyramid- one base, triangular sides / prism-two congruent bases, rectangular sides). These definitions will be very important for students to rely on when they are identifying three dimensional figures displayed in their nets.
k) Display a cube represented on a net using the board or Smart board. Model for the students how to use the information in the T-charts to classify the figure. (Be sure to ask students how they know the figure is NOT a pyramid.)
l) Guided practice: *(OPTIONAL: If time permits) Distribute a sheet with three dimensional figures displayed in nets. Have students work independently, or with a partner as necessary, to identify each shape and explain why they are correct. Circulate to offer assistance and check work as needed.

3. Closure: Review the answers to the guided practice problems. Revisit the Motivational question from the beginning of the lesson. Ask students to take a minute to reread their original prediction, decide if it was correct and add to it, if necessary. Discuss and chart student responses.

Differentiation
This lesson lends itself to flexible heterogeneous grouping. The triads should ideally contain both advanced and struggling learners. Since this information is generally new for all students, there is often less of a gap in abilities. A lot of discourse is required for students to discover and list attributes of prisms and pyramids, as well as create working definitions for same. Working in their groups, students will have the opportunity to assist and learn from one another. This should help assure that the needs of different level learners are met.

Homework/Assessment

Differentiation
All students will receive the same homework sheet. Instructions for each student may vary by ability at the discretion of the teacher. There is an area on the bottom of the homework sheet for students to write down which problem numbers they have been assigned to do.

*Assessment of student understanding is an ongoing process throughout the lesson. The teacher should use tools such as observation, awareness of student participation levels, and circulating to see student work in order to have a constant gauge of student understanding. The homework assignment will be collected and used as an additional, more formal assessment piece.

Classifying Polyhedrons
Homework Assignment

1. Solve.
   a) 27.34 x 6.7
   b) 752 x 56.3
   c) 0.09 x 0.09

2. Create a T-chart out of loose leaf paper. Label the tops of the columns "prisms" and "pyramids". Look around your home. List as many objects as you can find that are either prisms or pyramids.

3. Answer the following questions based on your T-chart from number two.
   a) Did you find more of one type of polyhedron that the other?
   b) Why do you think that happened?
   c) Where do you think you could find more objects to put on your chart?
   d) Why do you think that is so?

4. Write a "What figure am I?" riddle for each of the figures listed below. (For example: "I am a three-dimensional figure with six congruent faces. All of my faces are squares. I have eight vertices and twelve edges. What figure am I?" *cube*)
   a) Triangular pyramid
   b) Rectangular prism
   c) Hexagonal prism
   d) Octagonal pyramid
   e) Cylinder

**Problem numbers to be completed for homework:*_____, _____, _____, _____

Lesson II:

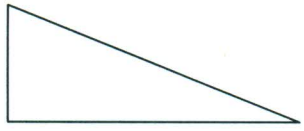
Required Materials:

- Three dimensional figures represented on nets
- Data recording chart (to record prediction, names of figure, number of faces, edges and vertices for each figure)
- Scissors
- Scotch tape or glue sticks
- Centimeter rulers

Procedures

1. Lead- In: Three Warm-Up problems displayed on Smart Board. Students should begin working independently and silently. (These problems review prerequisite skills necessary for success with today's lesson. The problems contain operations with multi-digit decimals which will provide practice necessary to build fluency in these areas.)

1. A garden has the shape of a right triangle. The sides of the triangle are 43 feet, 34 feet and 26 feet. What is the area of the garden?



2. A net for a solid figure consists of 2 triangles and 3 rectangles. Which polyhedron is displayed in the net? Explain how you know you are correct.

3. Joe says that two triangles of different types (for example: one isosceles triangle and one scalene triangle) can have the same area measurement. Is he correct? Draw an example to prove your answer.

Motivational Question: A tent rental company makes camping tents and party tents out of canvas. They are looking for ways to lower the cost of making the tents. One employee suggested fitting more tents on each sheet of canvas before they cut them out. How can they know, without wasting real sheets of canvas, if this plan will work?

2: Step by Step:

a) Quickly review the Warm-up activity.
b) Present the motivation question to the students. Ask them to think of, and jot down, one possible reason. Do not entertain any discussion of the question at this time, but assure students that they will discuss it at the end of the lesson.
c) Tell students that today they will continue working with three-dimensional figures.

d) Break students into pairs. Distribute one data chart to each student, and one packet of figures to each pair of students.
e) Instruct the students to look carefully at the polygons that make up each polyhedron, and predict which figure they will be creating when they cut it out and assemble it. They should write these predictions in their data chart.
f) After predicting which figure it will be, they work with their partner to cut out and assemble the figure. Using the definitions created yesterday, they should classify the figure and write the actual name in the data chart. If there is a discrepancy between the prediction and the actual name, students should try to figure out what it was that caused them to predict incorrectly.
g) Once each pair has assembled and identified the figures, they should work together to count the faces, edges and vertices of each one.
h) When all groups have completed their data charts, display a blank one on the Smart Board and fill it in with information from the groups. Discuss any data that does not match the correct answers, so that students may see where they made errors.

*The first part of this lesson will take a full class period. It can be immediately followed by the next part if there is a double period math block, or the lesson may be completed the next day.

i) Distribute rulers and a new set of nets to each pair of students. Read the following situations aloud:

    1. Sue wanted to be sure there was enough wrapping paper on the roll, so she calculated the surface area of the gift box.
    2. Mr. Petersen wanted buy enough waterproofing for the outside of his camping tent, so he calculated the surface area of the tent.
    3. A baker needs to know how much fondant is needed to completely cover a cake. He calculated the surface area of the cake.

j) Ask, "What is similar about each situation?" (They all involve surface area.) Through discussion, elicit from students that surface area is the measure of the total outside area of a three-dimensional object. It is measured in square units.
k) Ask, "What are some ways we can find the surface area of a rectangular prism?" Allow some time for students to think about this before asking them to share their ideas. Create a chart in the front of the room with all ideas that will work. Display a diagram of a rectangular prism with measurements on it. Model for the students how to determine its surface area.
l) Instruct students to work with their partners to measure the figures in the packet that was distributed to them. They should measure to the nearest half-centimeter. They should then use the measurements to calculate the surface area of each figure. Each student should do the calculations independently, and then compare answers with their partners. (When the answers don't match, they should ask for a calculator to determine the correct answer.) The teacher should circulate during this activity to observe and offer assistance as necessary.
m) When the students have completed the activity, display each of the figures on the Smart Board one at a time. Invite one pair at a time to come to the Board and demonstrate how they found their answer. (Allow time for other groups who may have solved the problem in a different way to explain their method as well.)

3. Closure: Revisit the Motivational Question from the beginning of the lesson. Ask students to take a minute to reread their original prediction and see if they can add to it. Discuss and chart student responses.

Differentiation

This lesson is structured around partner-work. The pairs can be put together at the teacher's discretion, but it is important that none of the pairs consist of two severely-struggling students. Since this lesson incorporates many prerequisite skills, such as measuring, it offers many opportunities for more struggling learners to contribute to the learning process. Throughout the lesson, students will assist and learn from one another.

Homework/Assessment

Differentiation

All students will receive the same homework sheet. Instructions for each student may vary by ability at the discretion of the teacher. There is an area on the bottom of the homework sheet for students to write down which problem numbers they have been assigned to do.

*Assessment of student understanding is an ongoing process throughout the lesson. The teacher should use tools such as observation, awareness of student participation levels, and circulating to see student work in order to have a constant gauge of student understanding. The homework assignment will be collected and used as an additional, more formal assessment piece.

Surface Area of Polyhedrons
Homework Assignment

1. Solve.
   a) $2(a \times b) + 2(c \times d)$ *for $a=14$, $b=10$, $c=5$, $d=15$*
   b) $6(n \times m)$ *for $n=7.25$, $m=25.5$*

2. The problems in question #1 could be surface area calculations. Tell which polyhedron each problem could be describing. Explain how you know you are correct.

3. List four real-life situations when it would be necessary to calculate the surface area of a three-dimensional figure. For each situation, use sequence words to explain how you would do it.

4. Write four word problems involving surface area. You may write the problems or type them. Include a diagram for each one. You may draw the diagram yourself (with a ruler!) or print them from the computer. Put each word problem on the front of an index card. Put the solution on the back. You may use whole or decimal numbers in your problems. Check your solutions with a calculator before you hand in your question cards.

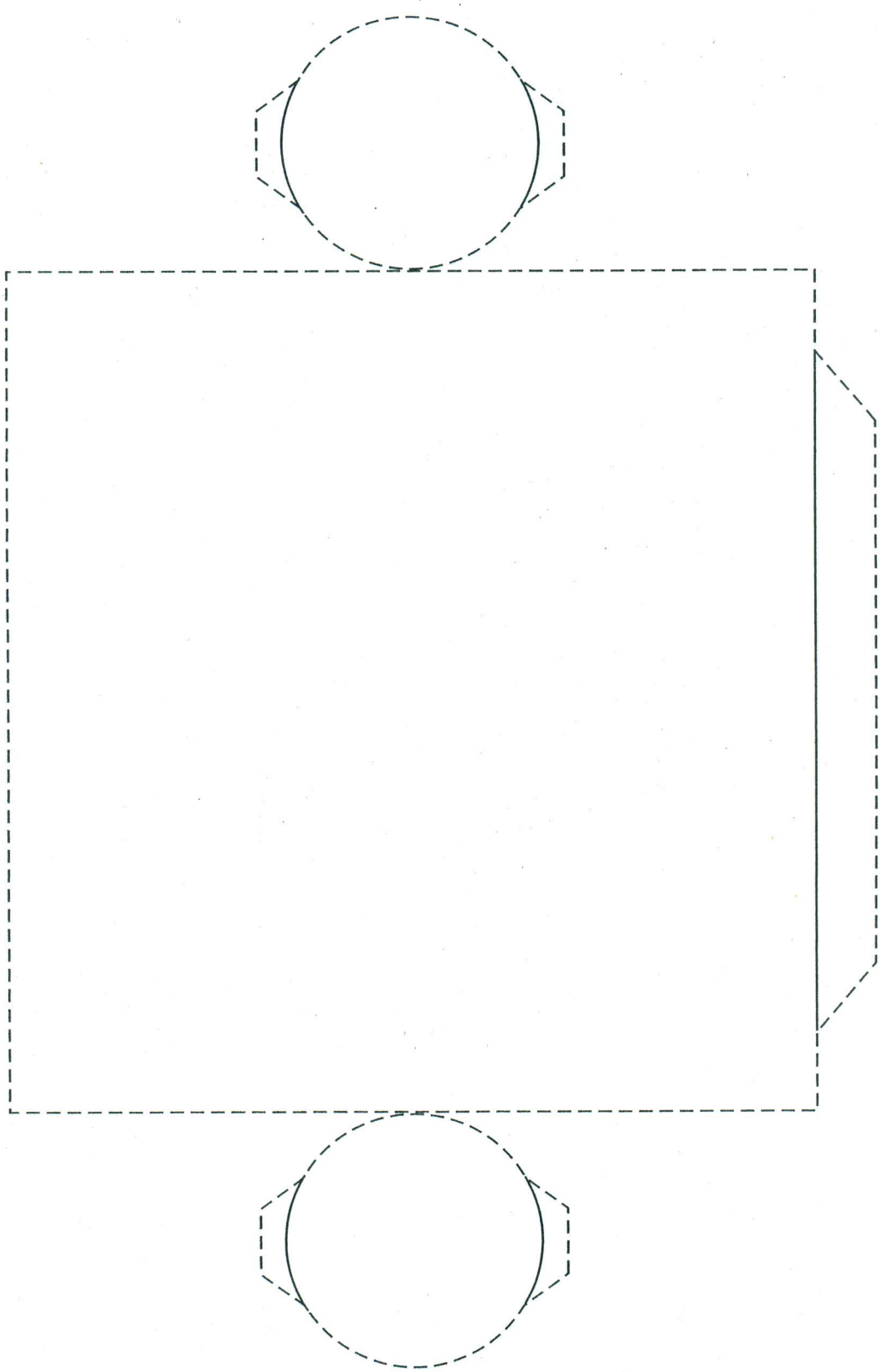
**Problem numbers to be completed for homework:*_____, _____, _____, _____

Name_____

	Prediction	Actual Figure Name	Number of Vertices	Number of Faces	Number of Edges
Figure #1					
Figure #2					
Figure #3					
Figure #4					
Figure #5					
Figure #6					
Figure #7					

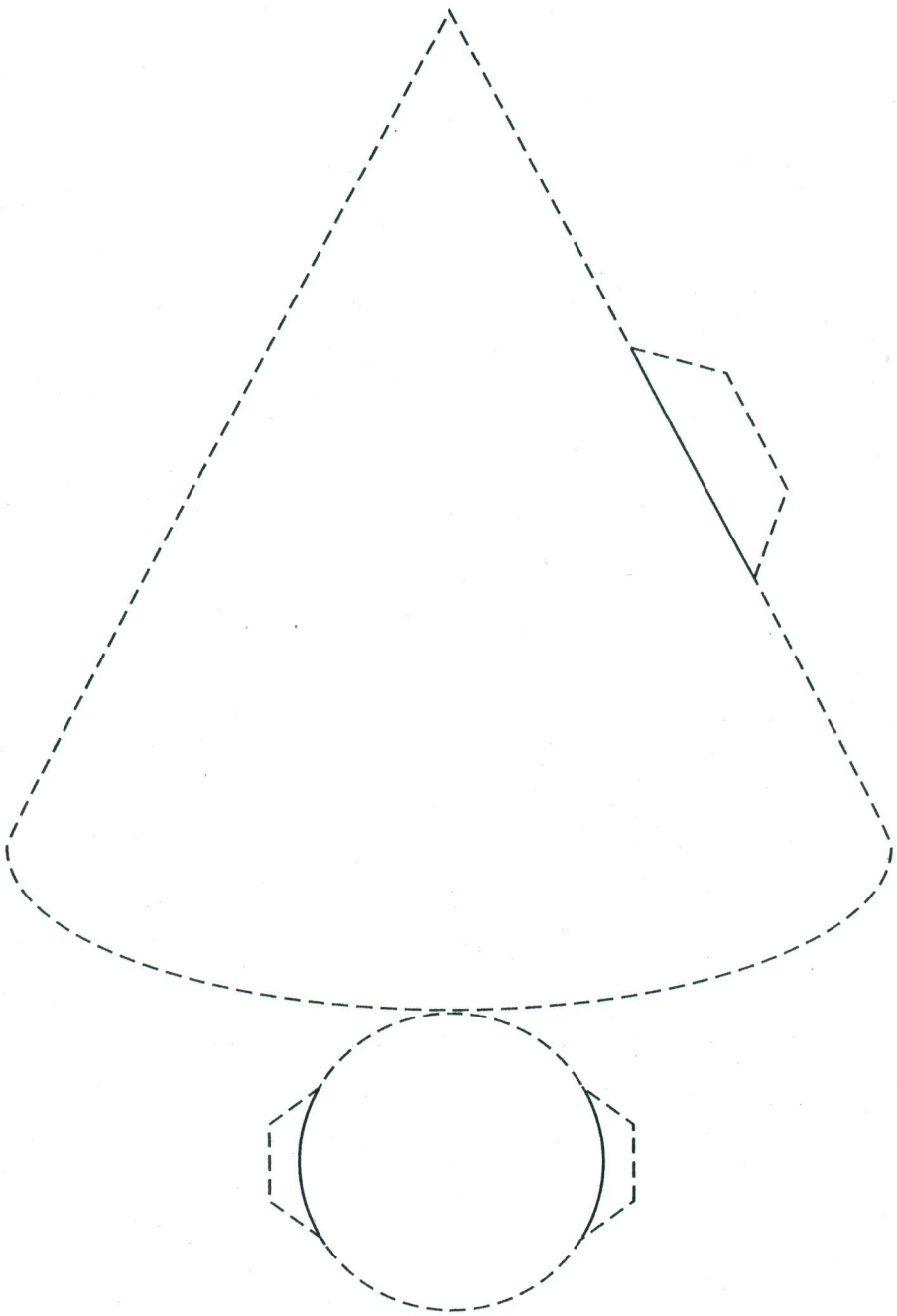
Name _____

Figure #1



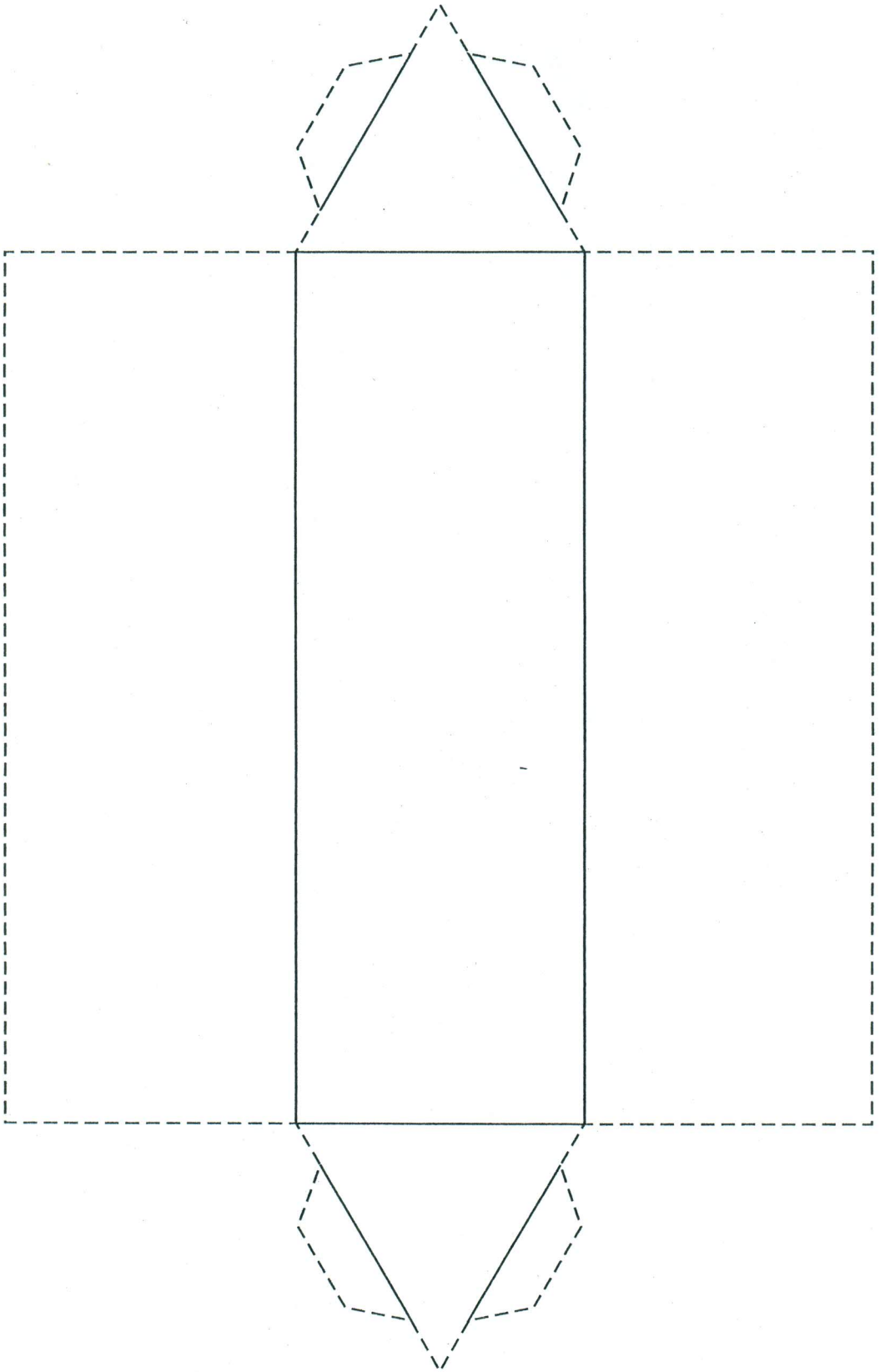
Name _____

Figure #2



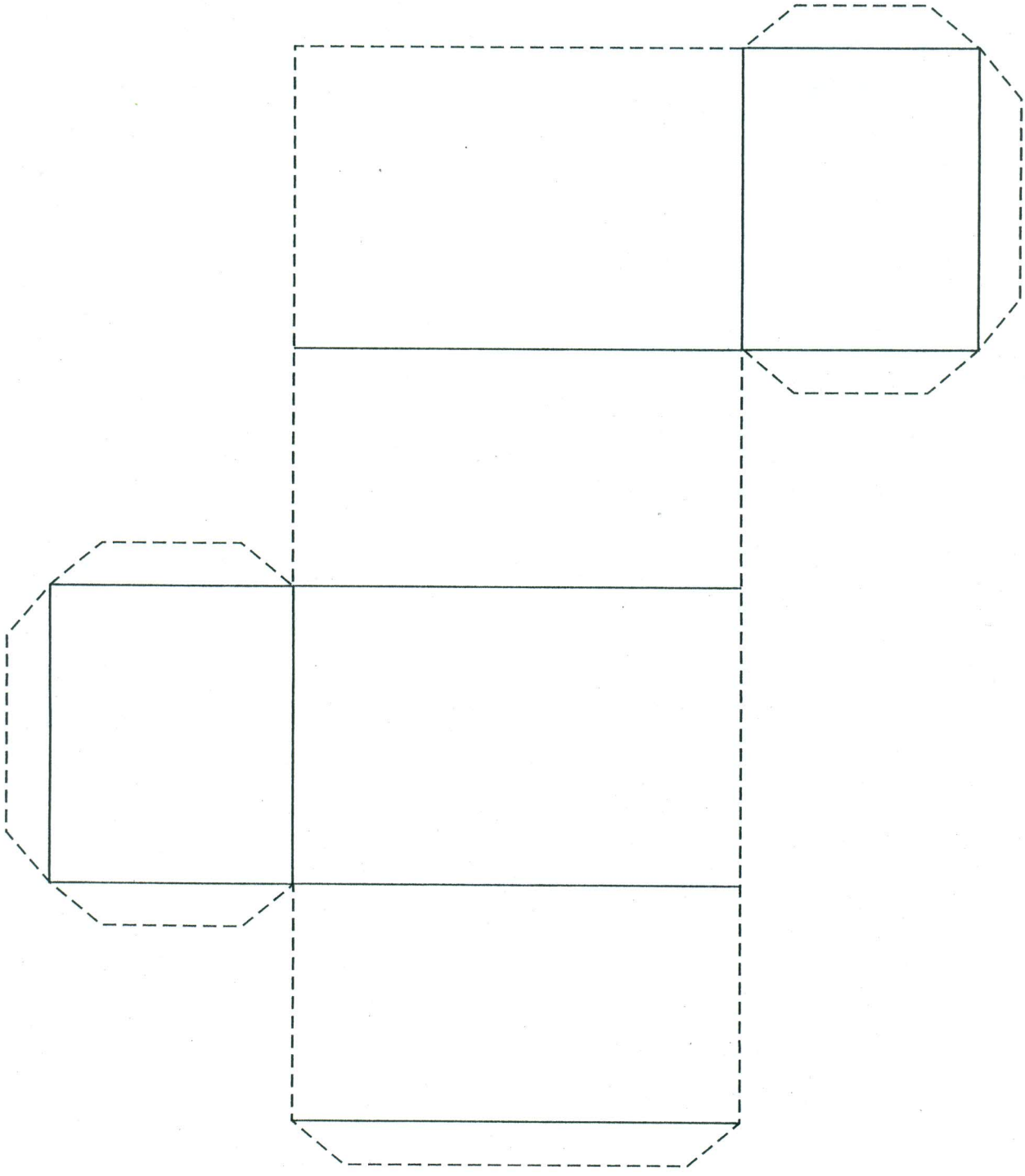
Name _____

Figure #3



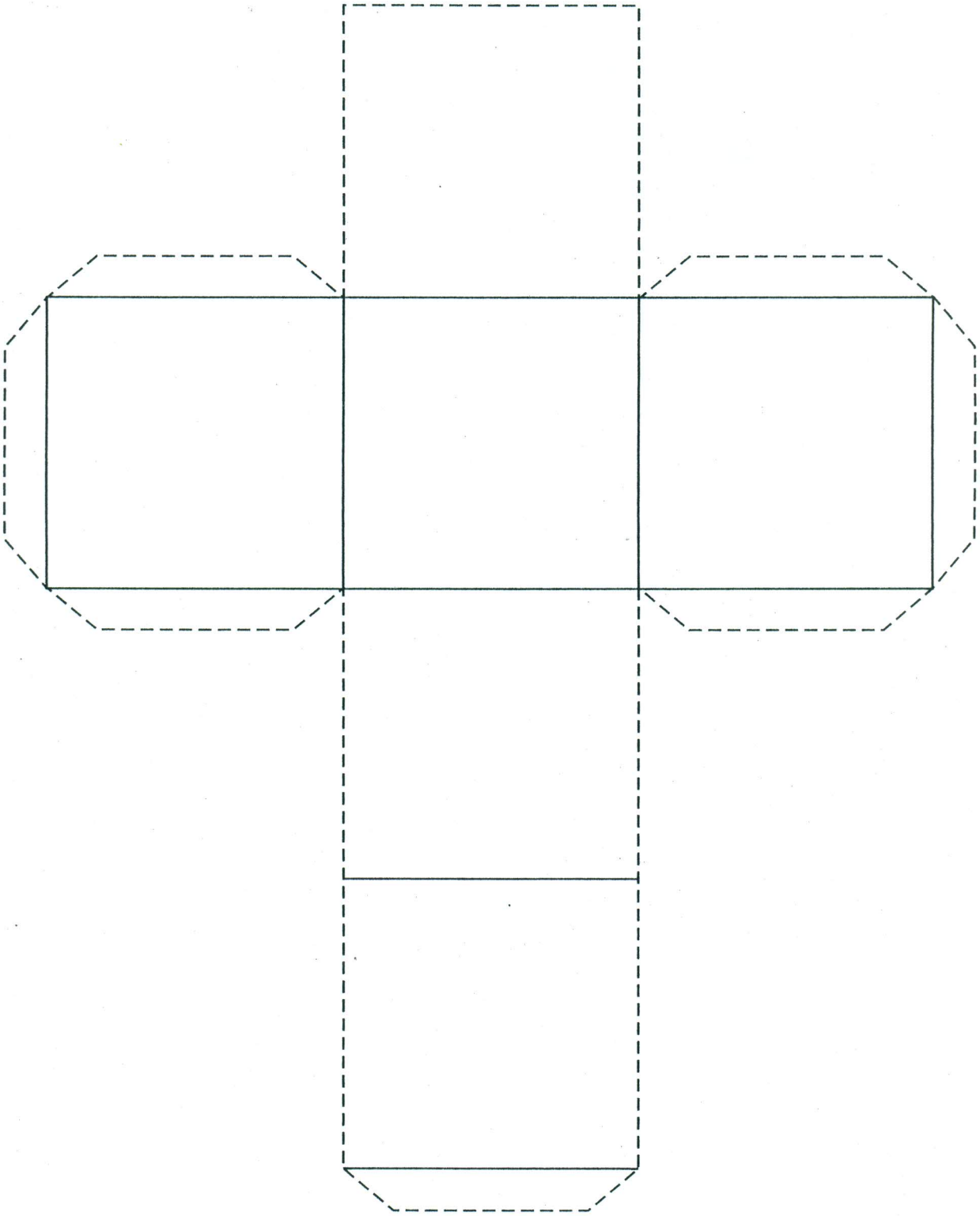
Name _____

Figure #4

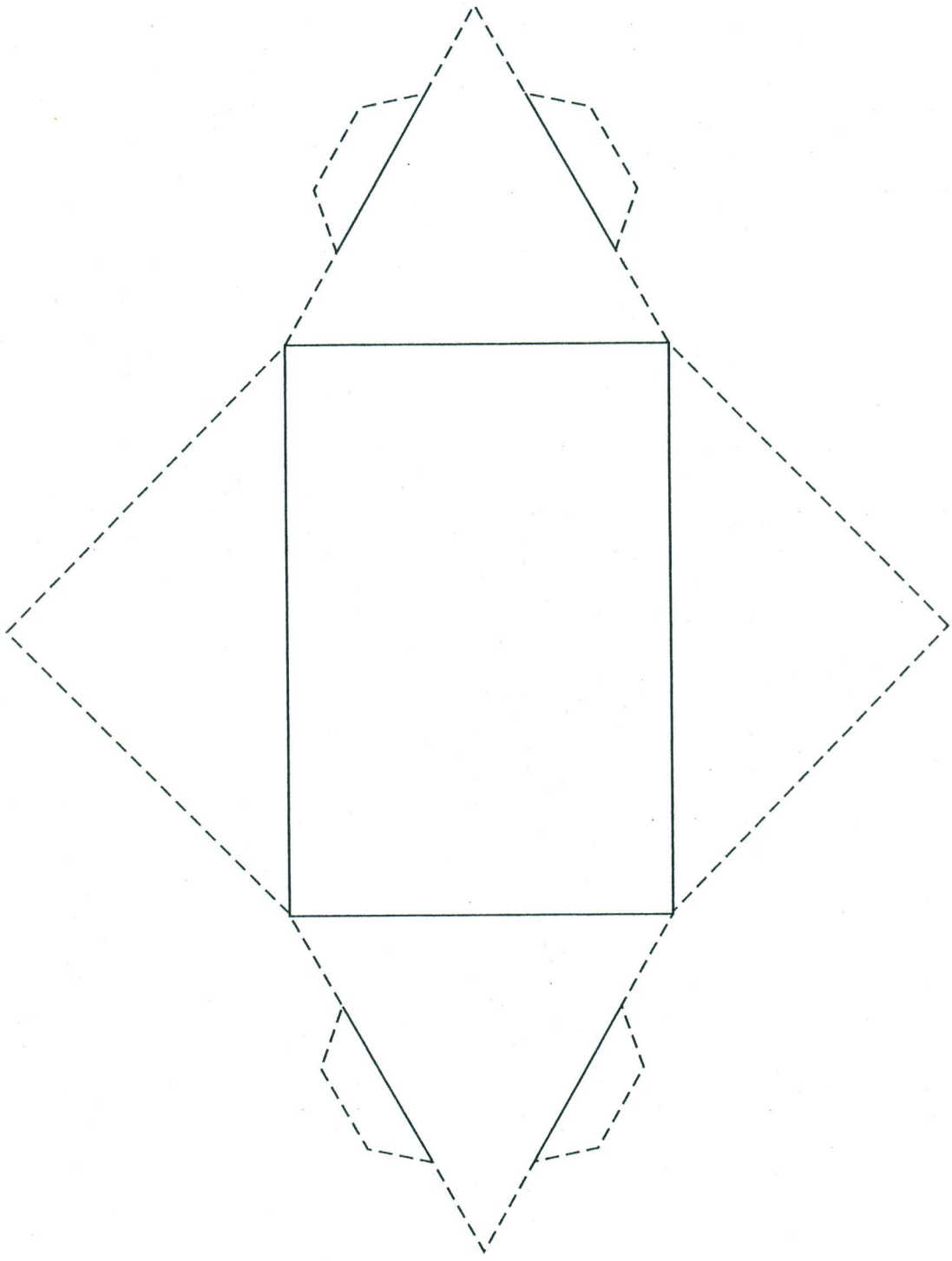


Name _____

Figure #5



Name _____ Figure #6



Name _____

Figure #7