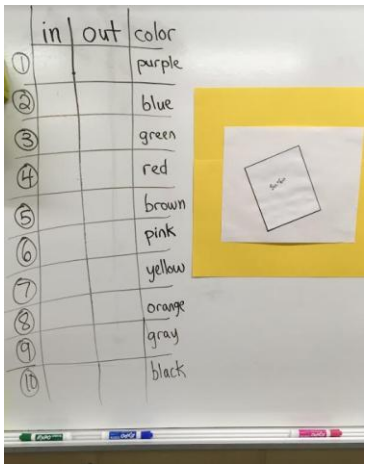
Preview to the Project: Active Learning in the Classroom

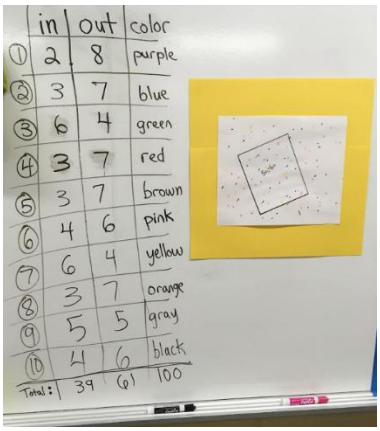
Materials:

- 10 inches by 12 inches of a sheet of paper
- 5 inches by 6 inches of a sheet of paper
- 10 markers, all different colors

Directions:

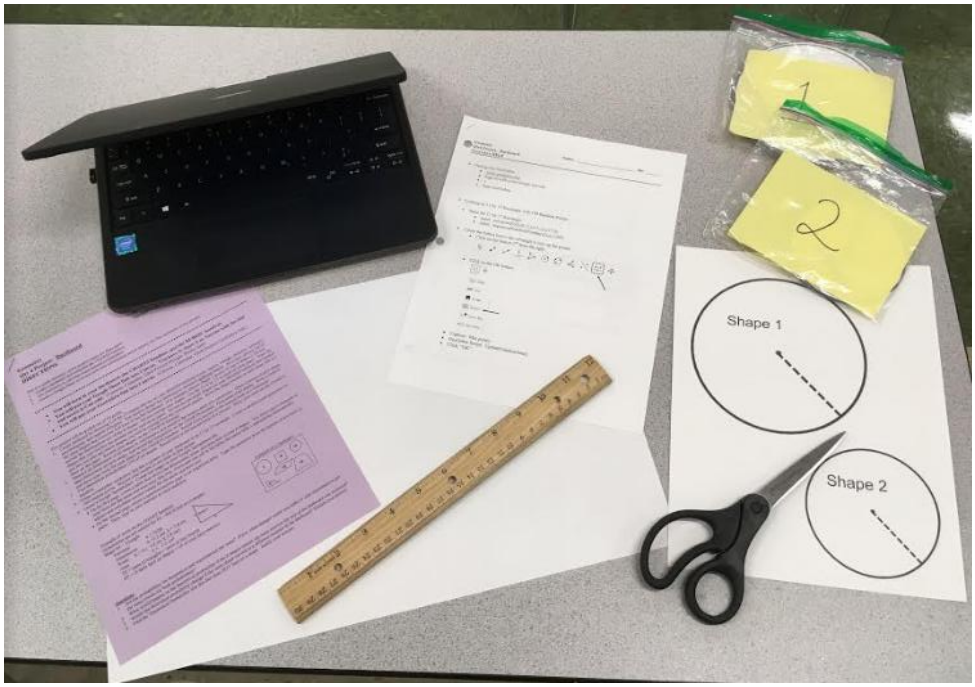
- The teacher or the students can do the following:
  - Create the dartboard: Cut one rectangular piece of paper that is 10 inches by 12 inches (easiest to do this from using an 11 inch by 17 inch sheet of paper).
  - Create the target: Cut one rectangular piece of paper that is 5 inches by 6 inches.
  - Tape or glue the target to the dartboard. Frame the dartboard with paper around it so that random marker hits will mark up the frame and not the wall. Then, place the framed dartboard on a wall or on a vertical whiteboard.
- Split the class into 10 groups. Each group is assigned one of the marker colors.
- Each of the 10 groups will discuss their answers to the following questions:
  - Out of 100 random marker hits, how many should land in the target? Why? Justify your answer mathematically.
  - What is the area of the target?
  - What is the area of the dartboard?
  - What is the ratio of the area of the target to the area of the dartboard?
  - Would you get different results for any of these questions if you moved the target?
- While the groups are answering the questions, have each group walk up to the dartboard at different times. They must use their marker color and randomly place "darts" on the dartboard with their marker.
  - Students should face away from the dartboard, turn around, and randomly mark the dartboard with the marker.
  - Each group should do this 10 times, so each marker has 10 hits (10 darts per marker color).
  - Students should record their "hits" and their "misses" (you can call these "in" and "out" of the target). A chart can be written on the whiteboard or on a sheet of paper next to the dartboard.
  - Turning around can be fun, but also can create dizzy students, so the teacher will need to monitor this active learning activity so that students don't hurt themselves. Perhaps, limit one turn at a time so that students are not constantly turning around to make marks.
- Once all groups have placed their marker "darts" on the dartboard, total up the table values.
  - Discuss the answers to the four questions.
  - Discuss how accurate your class was.
  - Discuss how your class could be more accurate with their "darts".
  - Discuss how your class could conduct this experimental trials to get very accurate results.





Materials

- The teacher will make copies of the project, one for each student.
  - Project Packet (print on colored purple paper – students will turn in this packet)
    - Dartboard DIRECTIONS
    - Dartboard CHARTS
    - Dartboard RUBRIC
  - Helps Packet (print on white paper – students keep this packet as a reference packet)
    - GeoGeobra HELPS sheet
    - Google Sheets HELPS sheet
- 11 inches by 17 inches white paper (This will be the dartboard. Students will trace 6 of the big shapes on this dartboard. Students will work with pairs, so have enough paper for each group)
- Rulers (in centimeters)
- Scissors (unless the teacher wants to cut the shapes out of the cardstock paper before the students do the activity)
- Computer or Chromebook
- The teacher will make about 10 sets of the big shapes with White Cardstock Paper.
- OPTIONAL: It is helpful to have the cut-out shapes organized in plastic bags and place them around the room so that students have room to select their shapes.



Geometry **Name:_____ Hr:_____**

Project: Dartboard **Partner's Name:_____**

DIRECTIONS

This is a quick summary of the project; there are three parts:

1. Create a dartboard and complete the CHARTS handout.
2. Use GeoGebra to calculate experimental probabilities.
3. Create a Google Sheet to record your area calculations and to answer the four questions of this project.

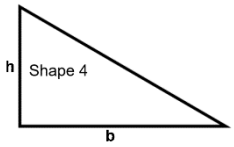
- **You will turn in your dartboard and the purple packet.**
- **Google Sheets: Get shareable link, you have to share it as *Anyone with the link* and access is *Anyone Can edit*. Copy this link and put it in Canvas.**
- **GeoGebra: Save as "Shared". Copy this link and put it in Canvas.**

These are the steps for the Dartboard Project:

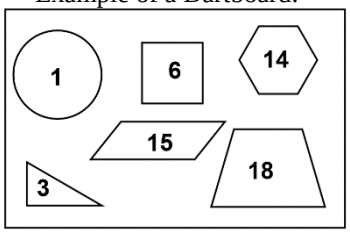
1. Create dartboard by choosing 6 of the 22 shapes that are on your SHAPES handout (circle, square, triangle, rhombus, rectangle, parallelogram, and regular polygon). You need to design the dartboard to include 6 different shapes (i.e., you must not have two triangles or two or more of any one shape). One of the 6 shapes must be a pentagon or a hexagon, and Shape 1 must be one of your 6 shapes. Do not include the dartboard as one of the 6 shapes. Do not overlap your shapes. Use the 11 in by 17 in sheet of white paper as your dartboard. Trace using a pencil the shapes that your teacher has printed out on card stock paper. Do not use the small shapes on your SHAPES handout; that handout just lets you plan out which shapes you will be tracing from the card stock papers. Write the shape number in each shape that you draw on the paper. Use a marker to trace your penciled shaped on your dartboard. Record your shapes on the CHARTS handout.
2. Measure all dimensions of all shapes in centimeters, and round to the nearest tenth of a centimeter. Draw a picture of each shape, label dimensions on each shape, and record the dimensions on the CHARTS handout. Find areas of all shapes. Write a formula and show your work for each shape on the CHARTS handout. Round every answer to the nearest tenth of a centimeter.
3. Find theoretical probabilities (TP) of all shapes. To find the TP, find the area of each shape as a percentage of the total area of the dartboard. Round each to the nearest tenth of a percent. Show your work on the CHARTS handout.
4. Create a GeoGebra worksheet that has a picture of your dartboard in an 11 by 17 rectangle. Create a Random Point Generator for 100 random points. Record your results on the Experimental Trials Chart in the CHARTS handout. You will record five trials. (Since any one trial can have unusual results, it is necessary to perform more than one trial.)
5. Create a Google Spreadsheet. Create two pages in your Google Spreadsheet file.
   - On the first page, create a table that shows the dimensions, areas, and area sum of your 6 shapes. You must type in formulas in your sheet for the areas and area sum; this way, if you edit one cell in the table, the entire table's calculations automatically adjusts and calculates correct values for the areas and area sum.
   - On the second page, create a question/answer page in an organized table. Type the questions that are listed on the last side of this packet. Then, type in your answers to each question. Your work for the 4th question should be done in pencil in the space provided on the last side of this packet.

Example of work on the CHART handout:
(The dimensions are not correct for #4; this is just an example.)
Shape #4 – Triangle

Formula: $A = \frac{1}{2} bh$
Dimensions: b =1.2 cm; h = 3.8 cm
Work: $A = \frac{1}{2}$ (1.2 cm)(3.8 cm)
Area: A = 2.3 cm²
TP = (area of triangle**)** ÷ (area of dart board)
EP = (# darts land on shape) ÷ (# of total darts thrown)



Example of a Dartboard:



Geometry
Project: Dartboard
CHARTS

Area of the Dartboard

Work to find the area of the dartboard:

**Measure to the insides of the sides of each shape.*
**Measure to the center of a point.*

Measurements/Work Chart

Shape A #_____ Shape Name:_____	**Shape B #_____ Shape Name:_____**
Dimensions (labeled picture and measurements)	**Dimensions (labeled picture and measurements)**
Area (formula and work)	**Area (formula and work)**
TP =	**TP =**
EP =	**EP =**

Shape C #_____ Shape Name:_____

Dimensions (labeled picture and measurements)

Area (formula and work)

TP =

EP =

Shape D #_____ Shape Name:_____

Dimensions (labeled picture and measurements)

Area (formula and work)

TP =

EP =

Shape E #_____ Shape Name:_____

Dimensions (labeled picture and measurements)

Area (formula and work)

TP =

EP =

Shape F #_____ Shape Name:_____

Dimensions (labeled picture and measurements)

Area (formula and work)

TP =

EP =

Experimental Trials Chart

	Shape A #	Shape B #	Shape C #	Shape D #	Shape E #	Shape F #	Misses	TOTAL
Trial 1								= 100
Trial 2								= 100
Trial 3								= 100
Trial 4								= 100
Trial 5								= 100
Average								**= 100**

Questions

You must type these questions out and answer them in your second page of your Google Sheets.

1. Are the probabilities for theoretical and experimental the same? If not, what changes could you make to your experiment to get the same results for both probabilities?
2. What would happen to the theoretical probability if the 6 shapes remain the same size but the size of the dartboard was increased?
3. Would the theoretical probability change if the same shape moved to a different location of the dartboard? Explain your answer.
4. Find the Theoretical Probability that the dart does NOT land on a shape. Justify your answer.
   (Show your work for question #4 right here in the empty space below.)

Geometry Honors and GeoAcc **Name:**_____

/55 pts **Partner's Name:**_____ **Hour:**____

Project: Dartboard
RUBRIC

Turn in: (1) dartboard, (2) purple packet, (3) GeoGebra link, and (4) Google Sheets link

Due Date:_____ (5 points reduced each block it is turned in late)
**No help from your teacher the last two days!*

	5 - Excellent	3 - Fair	1 - Poor
Dartboard Design	Dartboard displays all 4 of the following: 1. 6 distinct shapes, not overlapping 2. Shapes with correct numbers 3. A pentagon or a hexagon is one of the 6 distinct shapes 4. Professional display	Dartboard displays all 3 of the following: 1. 6 distinct shapes, not overlapping 2. Shapes with correct numbers 3. A pentagon or a hexagon is one of the 6 distinct shapes 4. Professional display	Dartboard displays all 1-2 of the following: 1. 6 distinct shapes, not overlapping 2. Shapes with correct numbers 3. A pentagon or a hexagon is one of the 6 distinct shapes 4. Professional display
Dimensions of Shapes	Shapes are correctly identified, sides are accurately measured, correct units are used (centimeters), and measured to the nearest tenth of a centimeter on the paper.	There are minimal errors: Shapes are correctly identified, sides are accurately measured, correct units are used (centimeters), and measured to the nearest tenth of a centimeter on the paper.	There are many errors: Shapes are correctly identified, sides are accurately measured, correct units are used (centimeters), and measured to the nearest tenth of a centimeter on the paper.
Area Calculations	Correct formulas are used for every shape, work is shown, and all calculations and units are correct on the paper.	There are minimal errors: Correct formulas are used for every shape, work is shown, and all calculations and units are correct on the paper.	There are many errors: Correct formulas are used for every shape, work is shown, and all calculations and units are correct on the paper.
Theoretical Probability (TP) Calculated	The theoretical probabilities calculated are correct for each shape. Work is shown for all calculation on the paper.	There are minimal errors: The theoretical probabilities calculated are correct for each shape. Work is shown for all calculation on the paper.	There are many errors: The theoretical probabilities calculated are correct for each shape. Work is shown for all calculation on the paper.
Experimental Probability (EP) Calculated	The experimental probabilities calculated are correct for each shape. Work is shown for all calculations. Experimental Trials Chart is completed on the paper.	There are minimal errors: The experimental probabilities calculated are correct for each shape. Work is shown for all calculations. Experimental Trials Chart is completed on the paper.	There are many errors: The experimental probabilities calculated are correct for each shape. Work is shown for all calculations. Experimental Trials Chart is completed on the paper.
GeoGebra link	The GeoGebra link is in Canvas and works.		
GeoGebra worksheet	All of the following are met: 1. Dartboard picture is in GeoGebra 2. Dartboard is inscribed in the rectangle 3. Random Point generator works	Most of the following are met: 1. Dartboard picture is in GeoGebra 2. Dartboard is inscribed in the rectangle 3. Random Point generator works	One/some of the following are met: 1. Dartboard picture is in GeoGebra 2. Dartboard is inscribed in the rectangle 3. Random Point generator works
Answers to Questions	All of the following are met: 1. All four questions are answered correctly and completely. 2. Answers use complete sentences.	Most of the following are met: 1. All four questions are answered correctly and completely. 2. Answers use complete sentences.	One/some of the following are met: 1. All four questions are answered correctly and completely. 2. Answers use complete sentences.
Google Sheets (followed directions)	All of the following are met: 1. One Google Sheet file, each labeled 2. 1st sheet is for the calculations 3. 2nd sheet is for the answers to the ?s 4. The file is submitted into Canvas.	Most of the following are met: 1. One Google Sheet file, each labeled 2. 1st sheet is for the calculations 3. 2nd sheet is for the answers to the ?s 4. The file is submitted into Canvas.	One/some of the following are met: 1. One Google Sheet file, each labeled 2. 1st sheet is for the calculations 3. 2nd sheet is for the answers to the ?s 4. The file is submitted into Canvas.
Google Sheets (organization)	All of the following are met: 1. A grid is shown in both sheets. 2. Data is centered in each cell. 3. All information can be read without scrolling to the right. 4. Colors are used in both sheets.	Most of the following are met: 1. A grid is shown in both sheets. 2. Data is centered in each cell. 3. All information can be read without scrolling to the right. 4. Colors are used in both sheets.	One/some of the following are met: 1. A grid is shown in both sheets. 2. Data is centered in each cell. 3. All information can be read without scrolling to the right. 4. Colors are used in both sheets.
Google Sheets (accurate math)	The formulas are correct for area and for total sum. Work is shown on packet (lower 3rd side)	The formulas are not all correct for area and for total sum and work is shown in packet.	The formulas are not all correct for area and for total sum and work is shown in packet.

/45 pts **Partner's Name:_____ Hour:____**

Project: Dartboard
RUBRIC

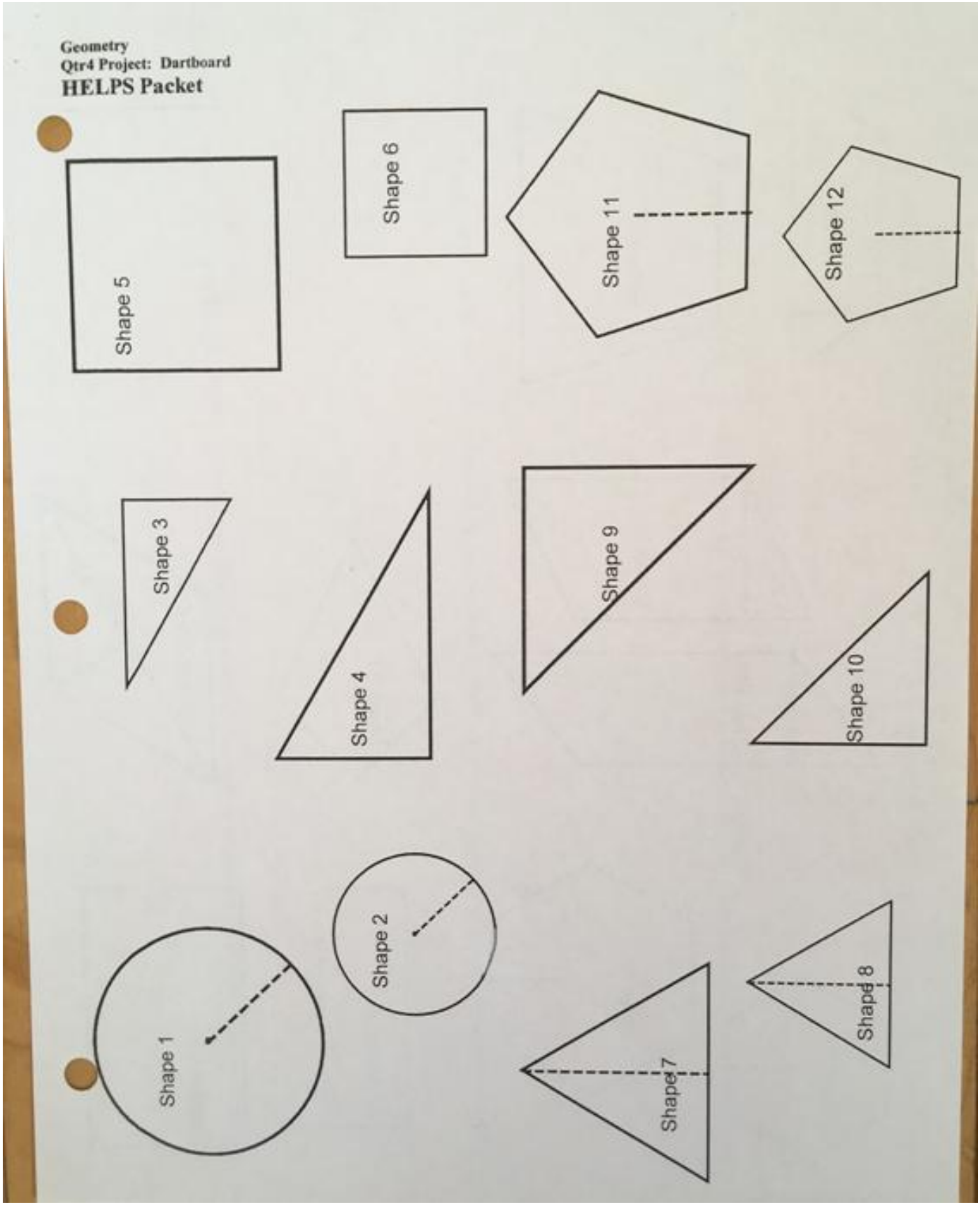
Due Date:_____ (5 points reduced each block it is turned in late)

Turn in: (1) dartboard, (2) purple packet, and (3) Google Sheets link

	5 - Excellent	3 - Fair	1 - Poor
Dartboard Design	Dartboard displays all 4 of the following: 5. 6 distinct shapes, not overlapping 6. Shapes with correct numbers 7. A pentagon or a hexagon is one of the 6 distinct shapes 8. Professional display	Dartboard displays all 3 of the following: 5. 6 distinct shapes, not overlapping 6. Shapes with correct numbers 7. A pentagon or a hexagon is one of the 6 distinct shapes 8. Professional display	Dartboard displays all 1-2 of the following: 5. 6 distinct shapes, not overlapping 6. Shapes with correct numbers 7. A pentagon or a hexagon is one of the 6 distinct shapes 8. Professional display
Dimensions of Shapes	Shapes are correctly identified, sides are accurately measured, correct units are used (centimeters), and measured to the nearest tenth of a centimeter on the paper.	There are minimal errors: Shapes are correctly identified, sides are accurately measured, correct units are used (centimeters), and measured to the nearest tenth of a centimeter on the paper.	There are many errors: Shapes are correctly identified, sides are accurately measured, correct units are used (centimeters), and measured to the nearest tenth of a centimeter on the paper.
Area Calculations	Correct formulas are used for every shape, work is shown, and all calculations and units are correct on the paper.	There are minimal errors: Correct formulas are used for every shape, work is shown, and all calculations and units are correct on the paper.	There are many errors: Correct formulas are used for every shape, work is shown, and all calculations and units are correct on the paper.
Theoretical Probability (TP) Calculated	The theoretical probabilities calculated are correct for each shape. Work is shown for all calculation on the paper.	There are minimal errors: The theoretical probabilities calculated are correct for each shape. Work is shown for all calculation on the paper.	There are many errors: The theoretical probabilities calculated are correct for each shape. Work is shown for all calculation on the paper.
Experimental Probability (EP) Calculated	The experimental probabilities calculated are correct for each shape. Work is shown for all calculations. Experimental Trials Chart is completed on the paper.	There are minimal errors: The experimental probabilities calculated are correct for each shape. Work is shown for all calculations. Experimental Trials Chart is completed on the paper.	There are many errors: The experimental probabilities calculated are correct for each shape. Work is shown for all calculations. Experimental Trials Chart is completed on the paper.
Answers to Questions	All of the following are met: 3. All four questions are answered correctly and completely. 4. Answers use complete sentences.	Most of the following are met: 3. All four questions are answered correctly and completely. 4. Answers use complete sentences.	One/some of the following are met: 3. All four questions are answered correctly and completely. 4. Answers use complete sentences.
Google Sheets (followed directions)	All of the following are met: 5. One Google Sheet file, each labeled 6. 1st sheet is for the calculations 7. 2nd sheet is for the answers to the ?s 8. The file is submitted into Canvas.	Most of the following are met: 5. One Google Sheet file, each labeled 6. 1st sheet is for the calculations 7. 2nd sheet is for the answers to the ?s 8. The file is submitted into Canvas.	One/some of the following are met: 5. One Google Sheet file, each labeled 6. 1st sheet is for the calculations 7. 2nd sheet is for the answers to the ?s 8. The file is submitted into Canvas.

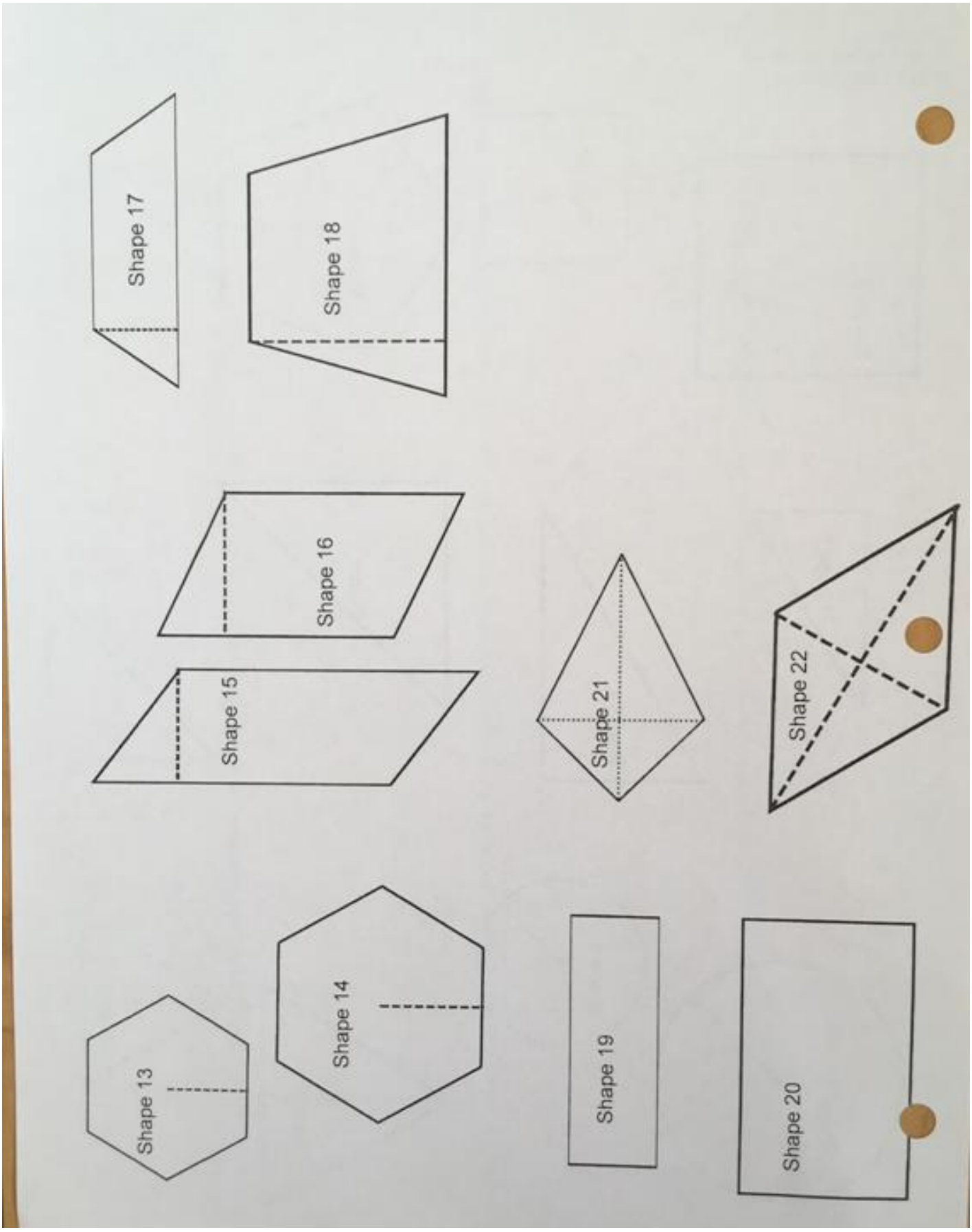
Shapes Sheet (first side)

Do NOT use these to cut and trace. Use this to determine which 6 shapes you will choose for your DARTBOARD. Then, use the big shapes for your 11 inch by 17 inch DARTBOARD.



<u>Shapes Sheet</u> (second side)

Do NOT use these to cut and trace. Use this to determine which 6 shapes you will choose for your DARTBOARD. Then, use the big shapes for your 11 inch by 17 inch DARTBOARD.



Geometry **Name: _____ Hr: _____**
Project: Dartboard
GeoGebra HELPS

➢ Getting into GeoGebra

- www.geogebra.org
- Sign In with your Google account
- Click on the 3 by 3 grid in the upper right hand corner
- Click on Graphing Calculator in the upper right hand corner

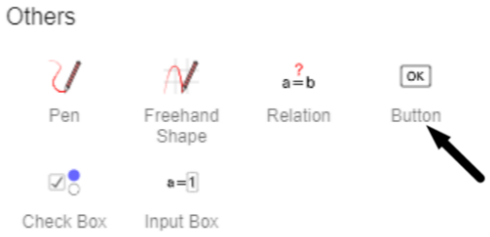
➢ Creating an 11 by 17 Rectangle with 100 Random Points

- Make the 11 by 17 rectangle.
  - On the left side, after the +, click on "Input" and type:
    - ➢ polygon((0,0),(0,11),(17,11),(17,0)

- Make the 100 random points.
  - On the left side, after the +, click on "Input" and type:
    - ➢ sequence(RandomPointIn(q1),a,1,100)

- Create the button below the rectangle to mix up the points.
  - On the left side, change from the Graphing Calculator mode to the Geometry mode.

  - In the Geometry menu, find the OK button (it may be at the bottom of the menu) and then click on the OK button.



  - Click in an area just below the x-axis, underneath the rectangle on the graph.
  - Click on the line segment just beneath the "Caption" and type:
    - ➢ Random Point Generator
  - Click in the rectangle just beneath "GeoGebra Script" and type:
    - ➢ UpdateConstruction()
  - Click, "OK"

➢ Placing Your Dartboard Picture in the GeoGebra 11 by 17 Rectangle

- In the Geometry menu, find "Image" and click on "Image".

- Choose your file that has the picture of your Dartboard.

➢ Saving Your GeoGebra File

- Title: Qtr4 Dartboard Project First and Last Name
- Shared

➢ Sharing your GeoGebra File Link with your teacher

- Share
- Canvas
- Calendar (go to the day that this project is due)
- Qtr4 Project GeoGebra link

Geometry **Name:**_____ **Hr:**_____
Project: Dartboard
Google Sheets HELPS

Google Sheets Guidelines

- You must have a formula for each of your 6 shapes.
  - Example: In cell K2, I typed **=pi()*C2*C2** into the cell.
- You must have a formula for the total sum.
  - Example: In cell K9, I typed **=sum(K2:K7)** into the cell.
- You must have two sheets.
  - Sheet 1 should have your measurements, formulas, and total area sum.
  - Sheet 2 should have the questions written out with your written answers.
- You will be also graded on how organized and professional your spreadsheets appear.

On this front side of this sheet of paper, I've attached a picture of what the first sheet of the Google Spreadsheet could look like. On the back side of this sheet of paper, I've attached a picture of what the second sheet of the Google Spreadsheet could look like.

SAMPLE: Project DARTBOARD

File Edit View Insert Format Data Tools Add-ons Help All changes saved in Drive

	A	B	C	D	E	F	G	H	I	J	K
1	Shape Number	Shape Name	r	b	h	n	b1	b2	d1	d2	Area
2	1	Circle	7								153.93804
3	7	Triangle		13.5	11.3						76.275
4	11	Pentagon		8.6	6.4	5					137.6
5	16	Parallelogram		13.8	8.5						117.3
6	17	Trapezoid			4.9		10	16.7			65.415
7	21	Kite							14.4	9.7	69.84
8											
9										TOTAL SUM:	620.36804
10											
11		3.141592654									
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Calculations | Answers to Questions

SAMPLE: Project DARTBOARD

File Edit View Insert Format Data Tools Add-ons Help All changes s

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	A
1	**Answers to Questions:**
2	**(1) Are the probabilities for theoretical and experimental the same? If not, what changes could yo make to your experiment to get the same results for both probabilities?**
3	This would be my answer to question #1. Remember to use complete sentences.
4	
5	**(2) What would happen to the theoretical probability if the 6 shapes remain the same size but the size of the dartboard was increased?**
6	This would be my answer to question #2. Remember that before turning in your project, you should talk with other people to make sure that your answers are correct. Talk with your teacher also about your project before turning it in.
7	
8	**(3) Would the theoretical probability change if the same shape was moved to a different location of the dartboard? Explain your answer.**
9	This would be my answer to question #3. Remember that the goal for this project is to: learn, have fun, understand, and get a great score!
10	
11	**(4) Find the Theoretical Probability that the dart does NOT land on a shape. Justify your answer.**
12	This would be my answer to question #4. Remember to ask other people for help if you need help, but don't ask your teacher (your boss) until you have asked other students (your colleagues) first. You don't want to annoy your boss!
13	
14	***TIP: Enter newlines in cells by using Ctrl+Enter while editing the cell.**
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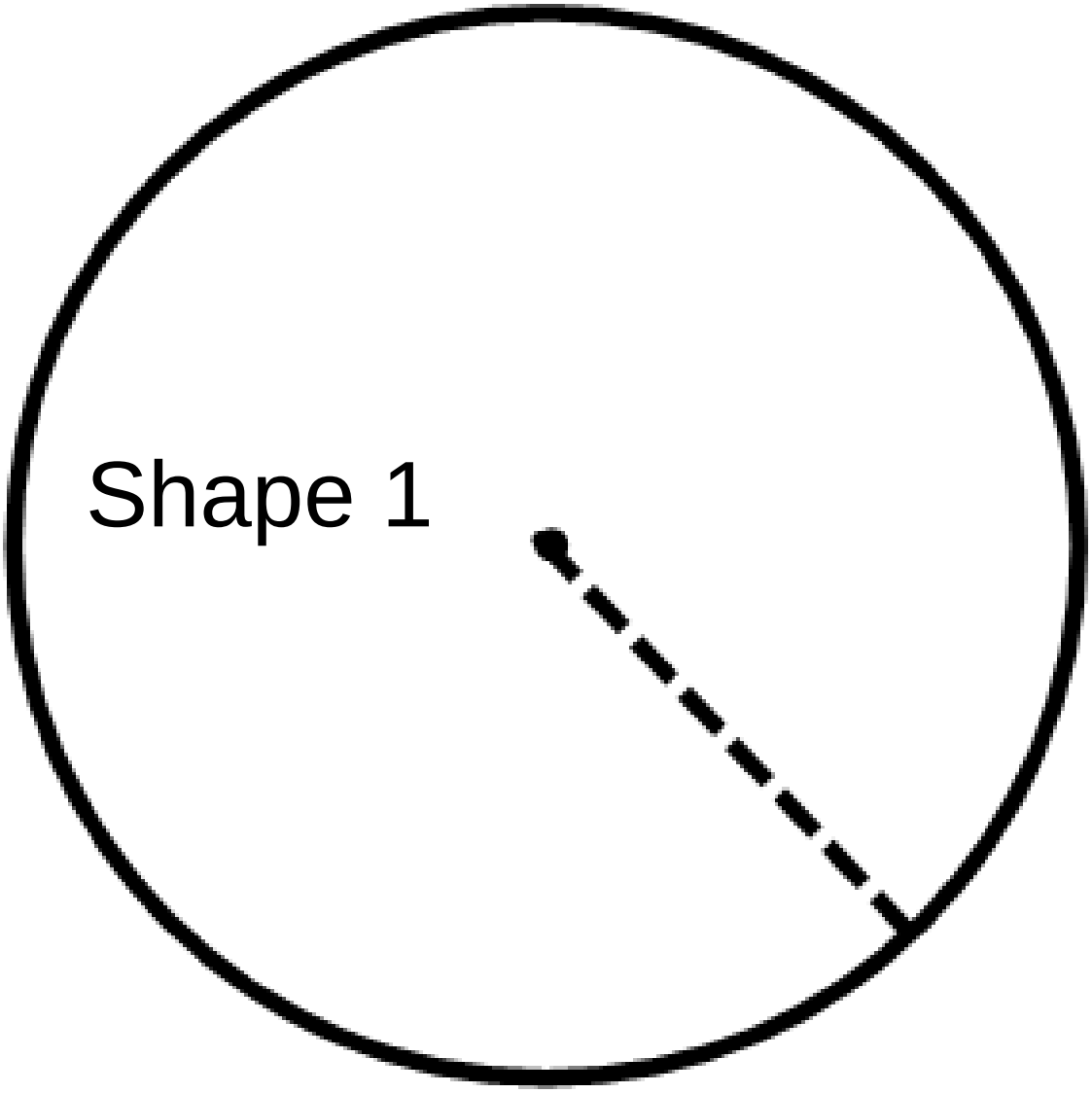
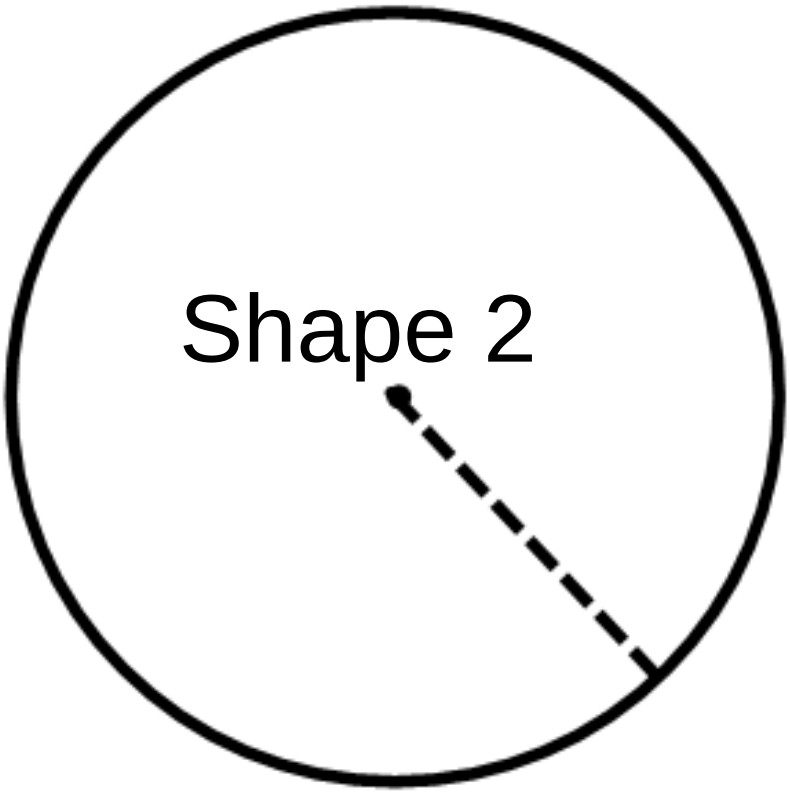
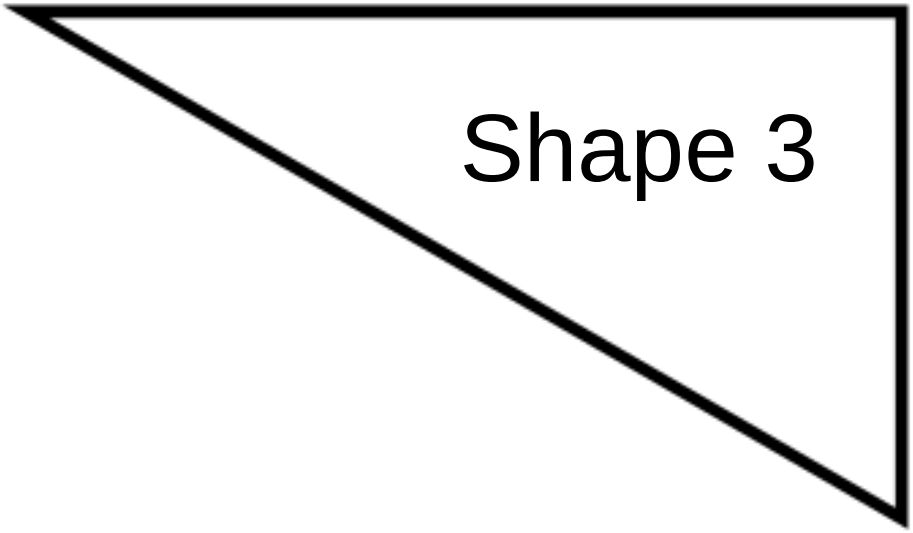
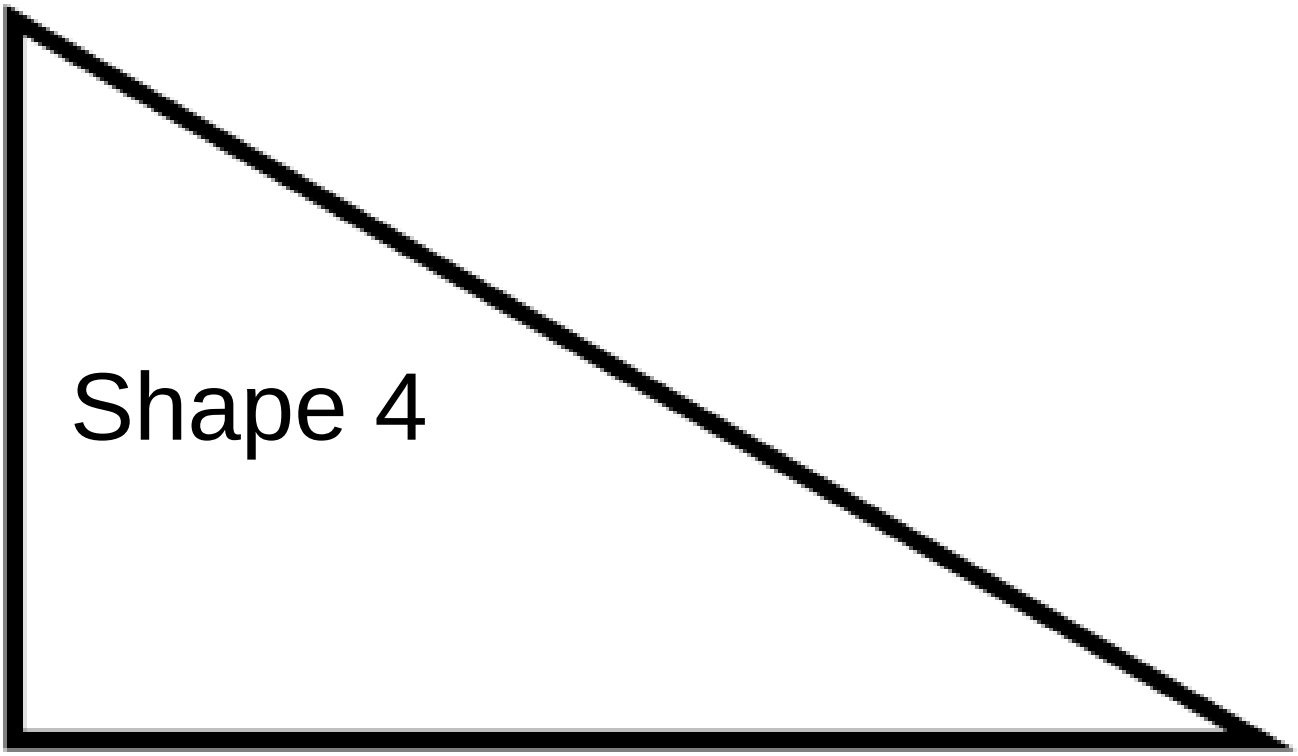
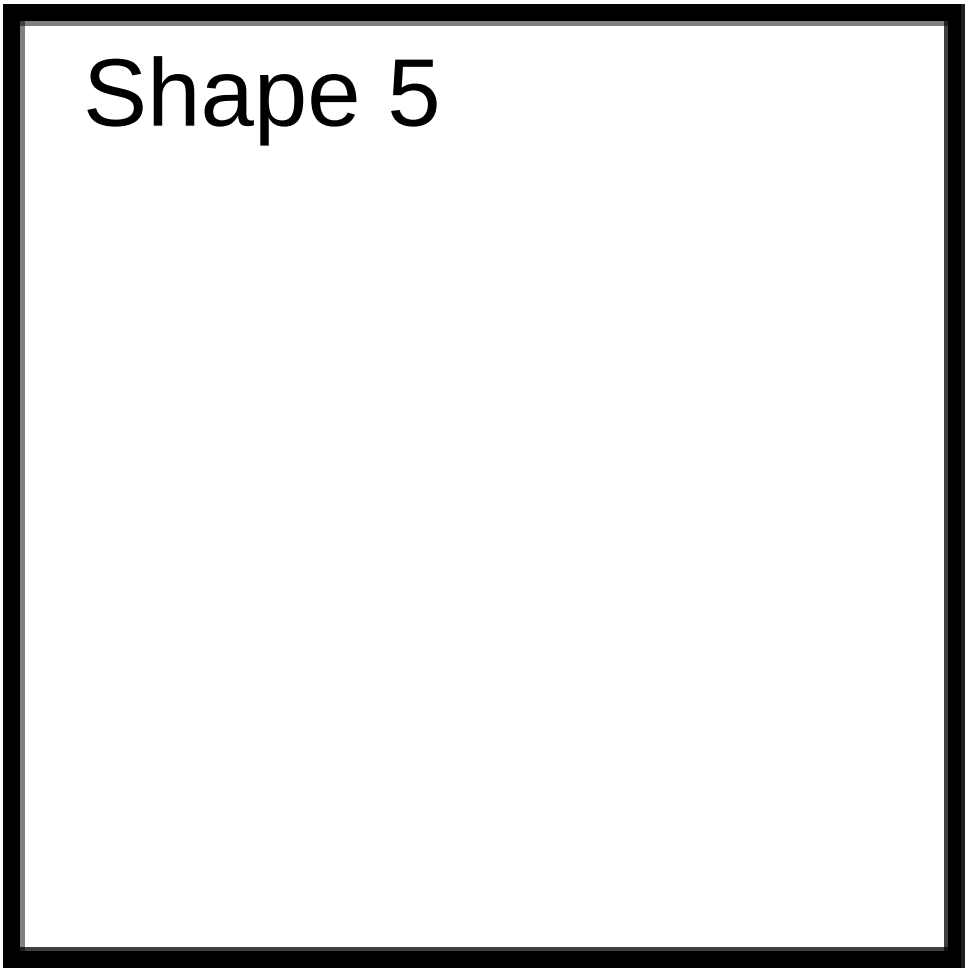
+ Calculations Answers to Questions

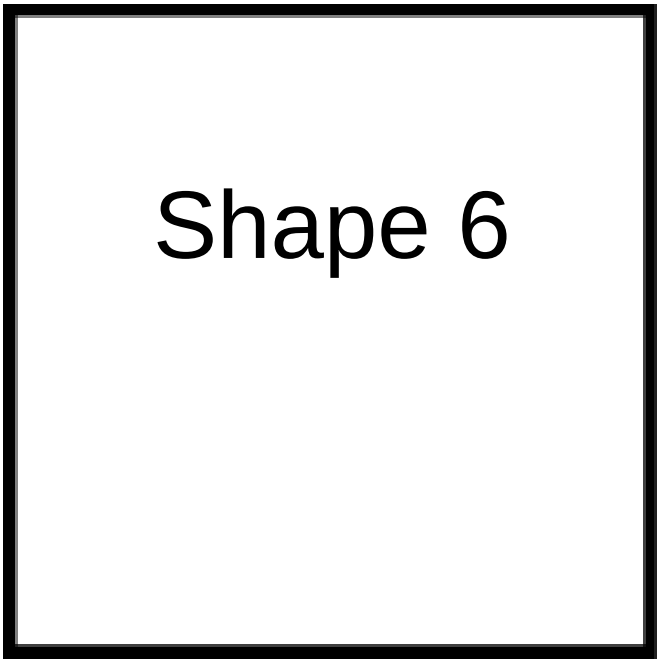

Shape 1

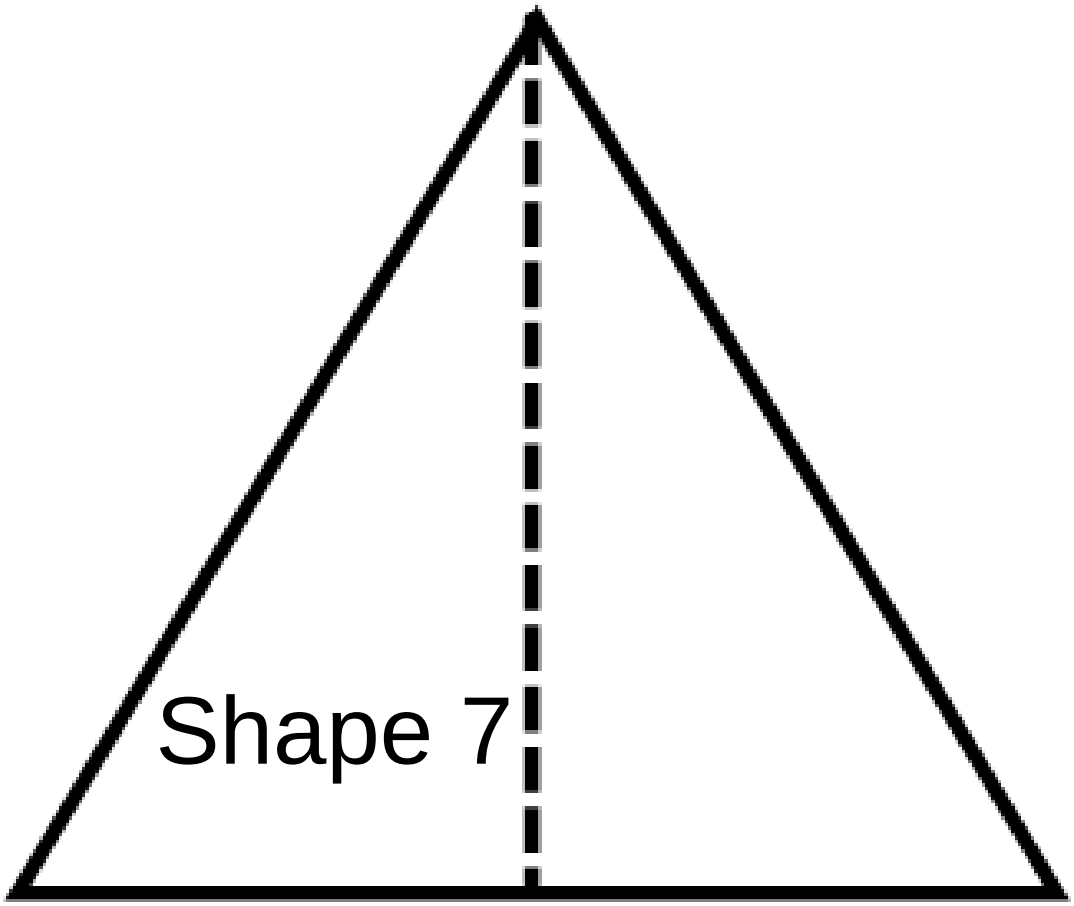

Shape 2

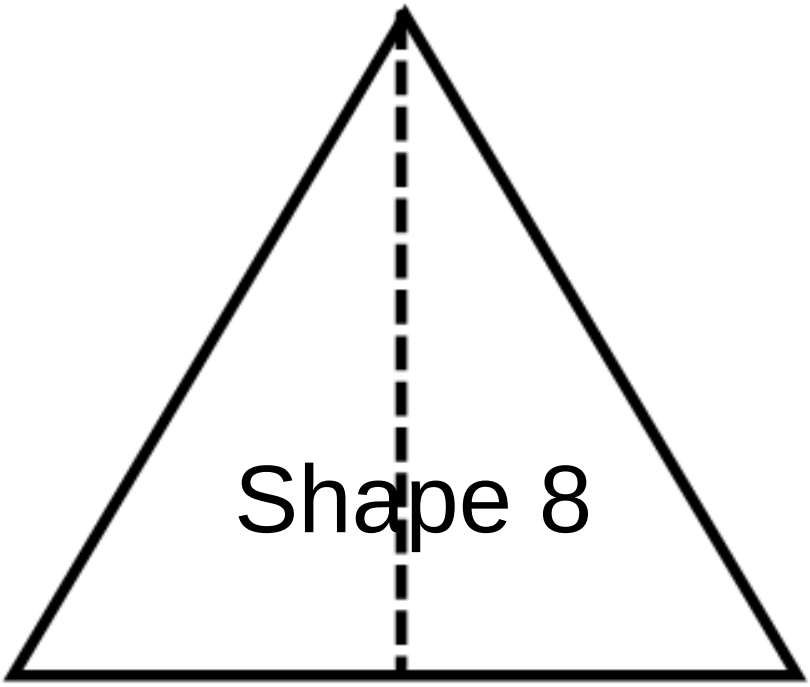

Shape 3

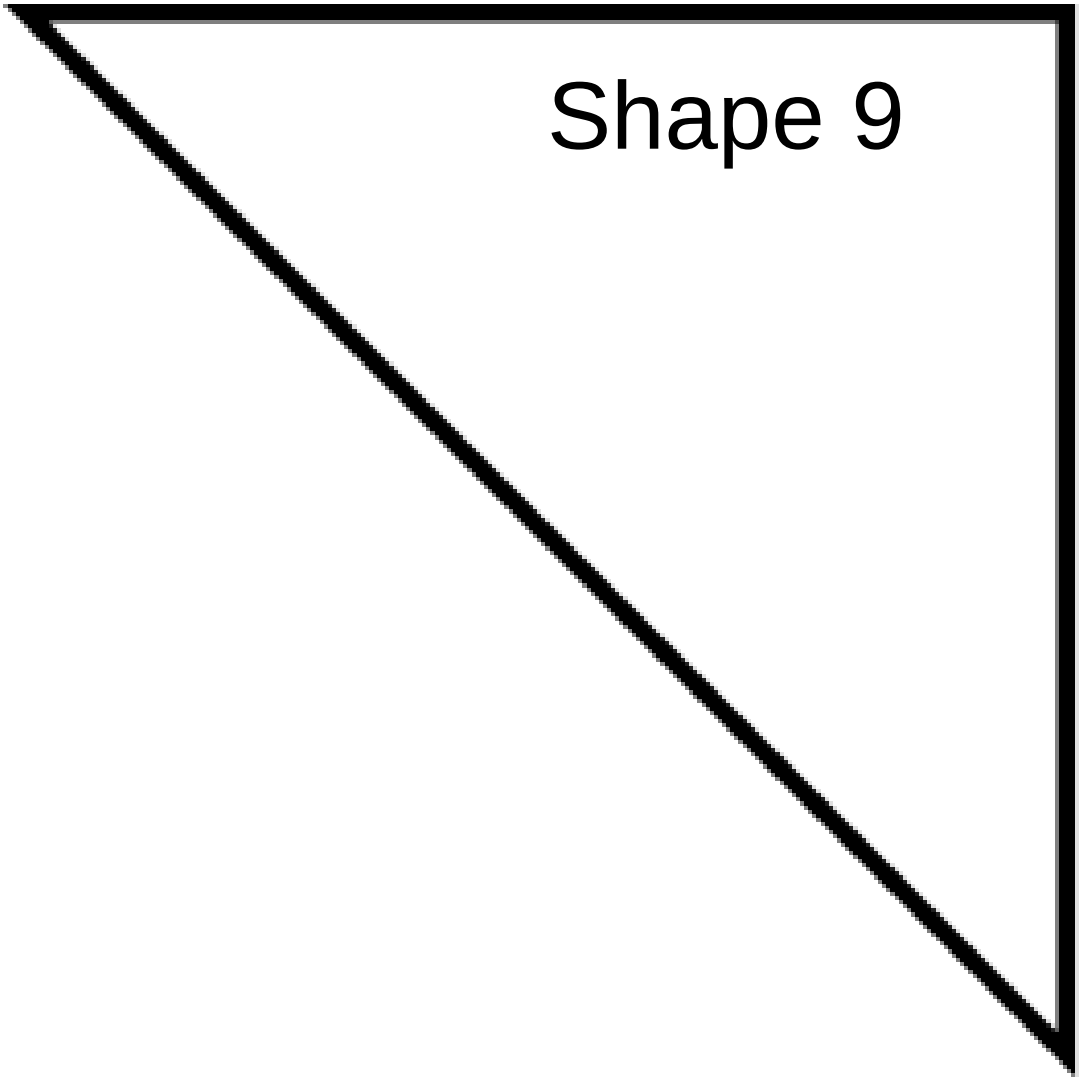

Shape 4


Shape 5


Shape 6


Shape 7


Shape 8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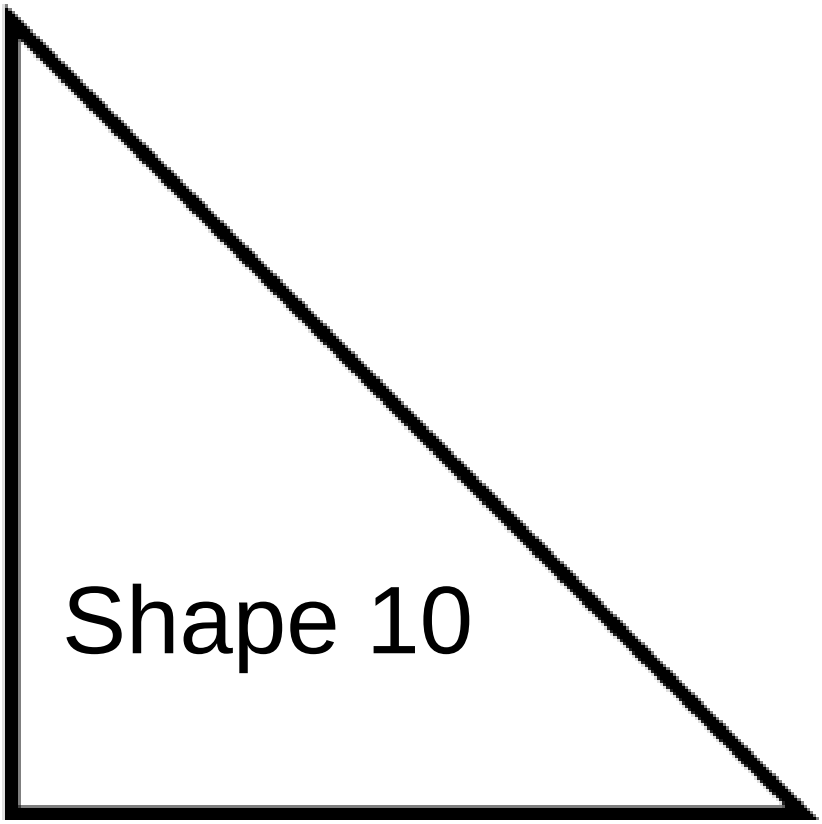
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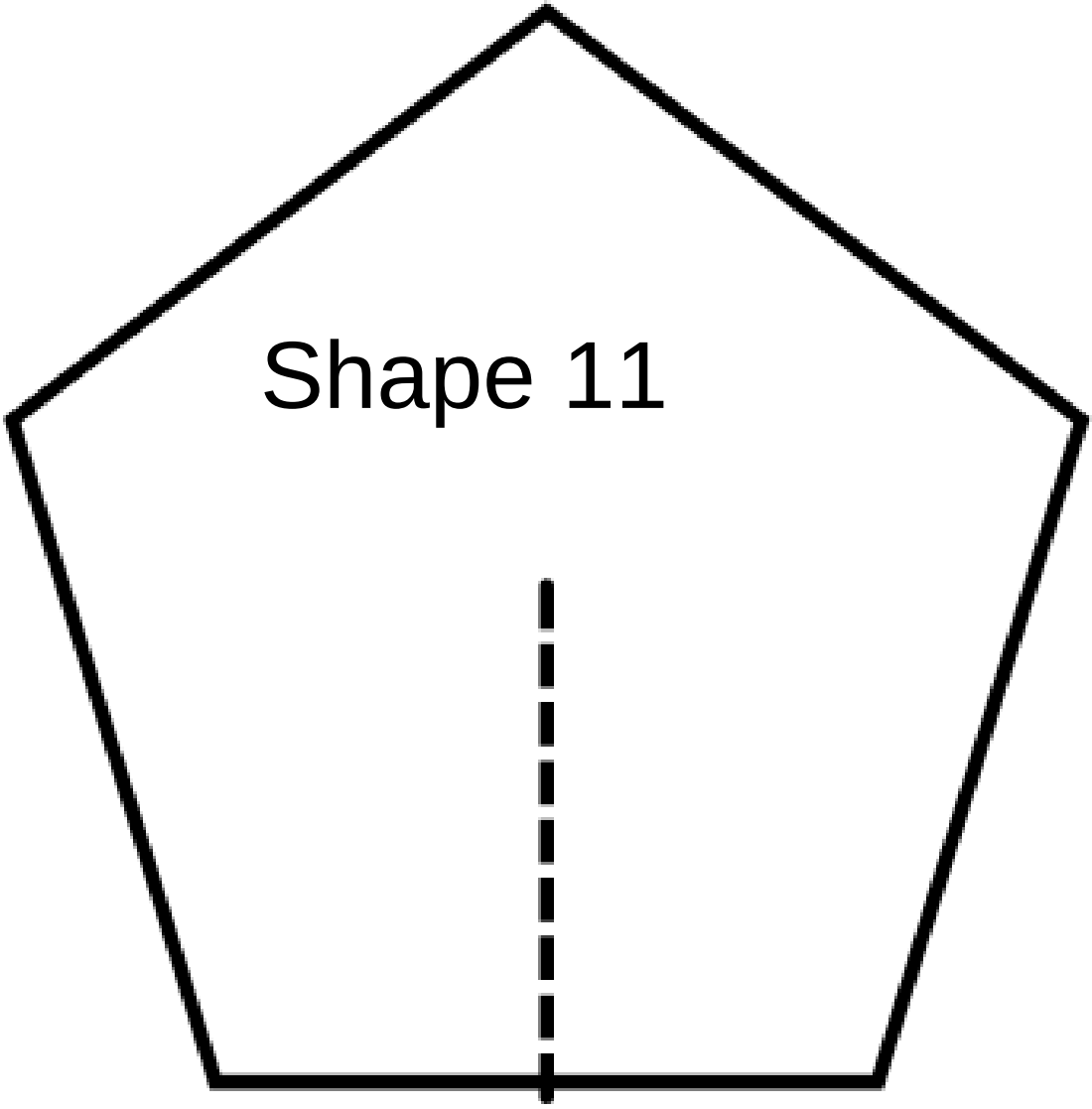
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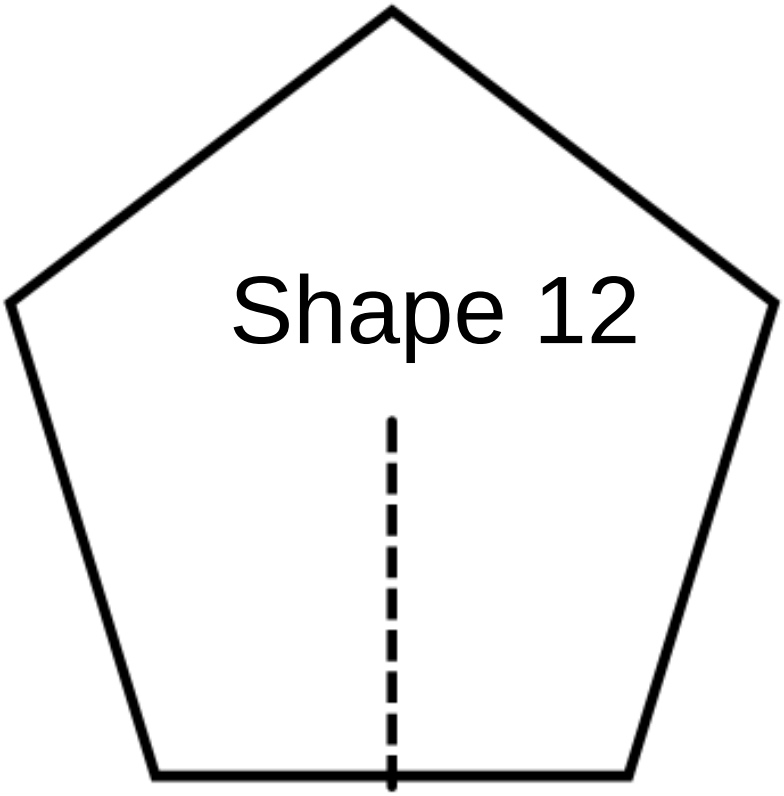
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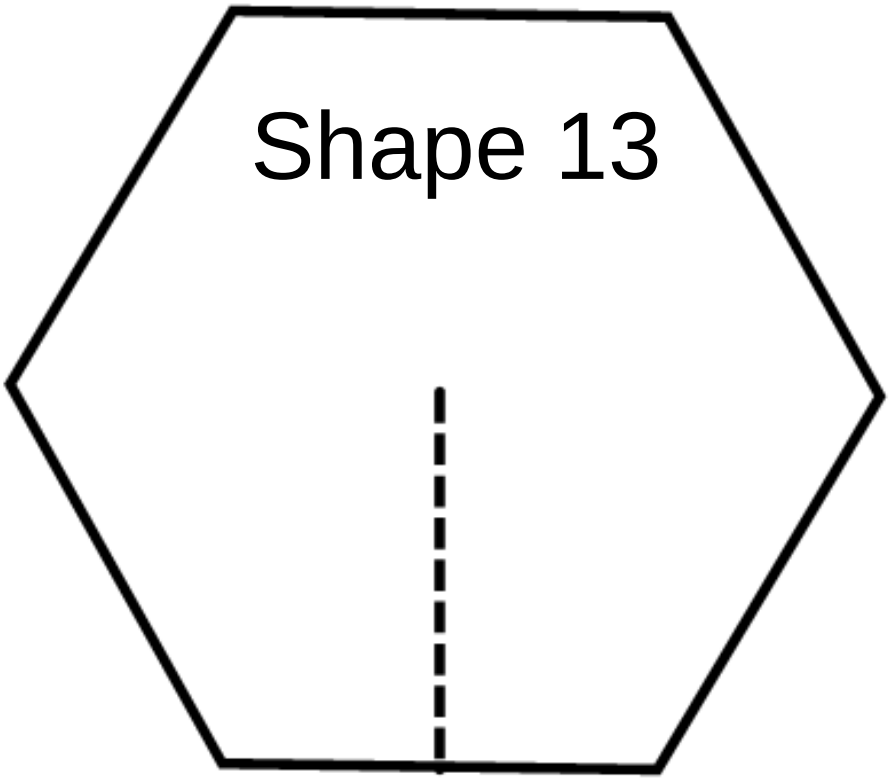
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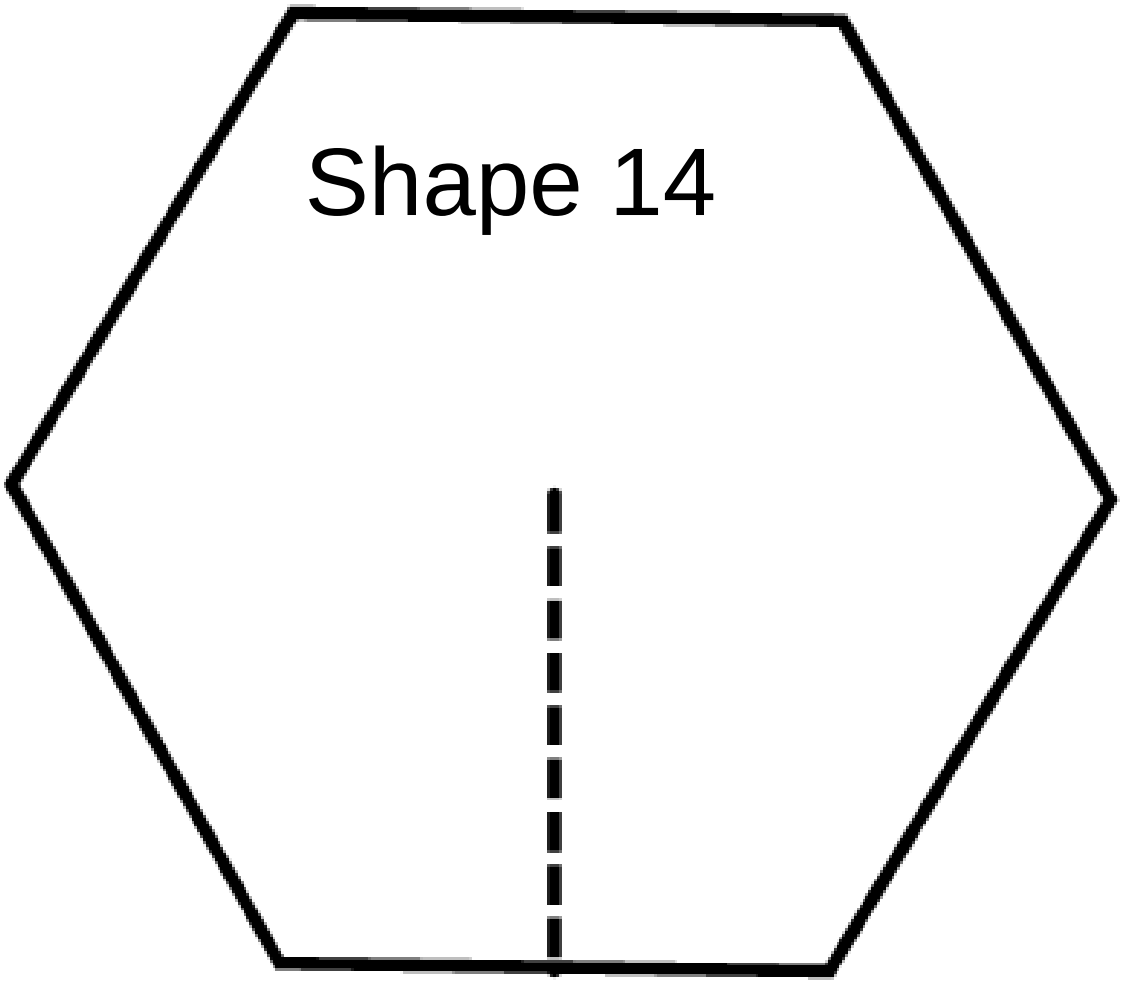
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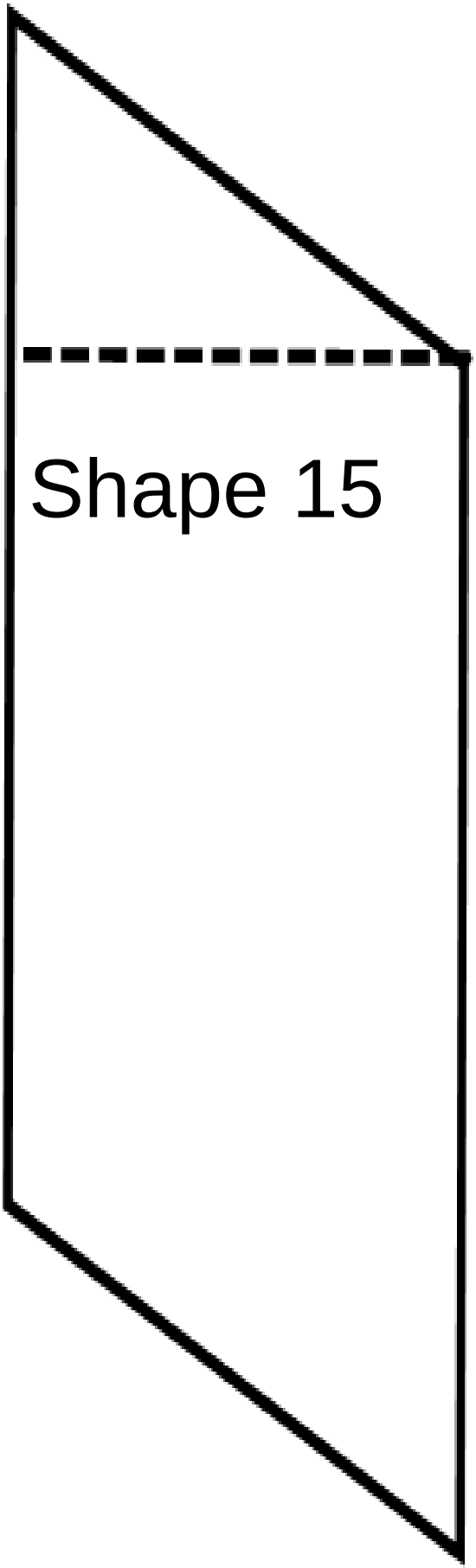
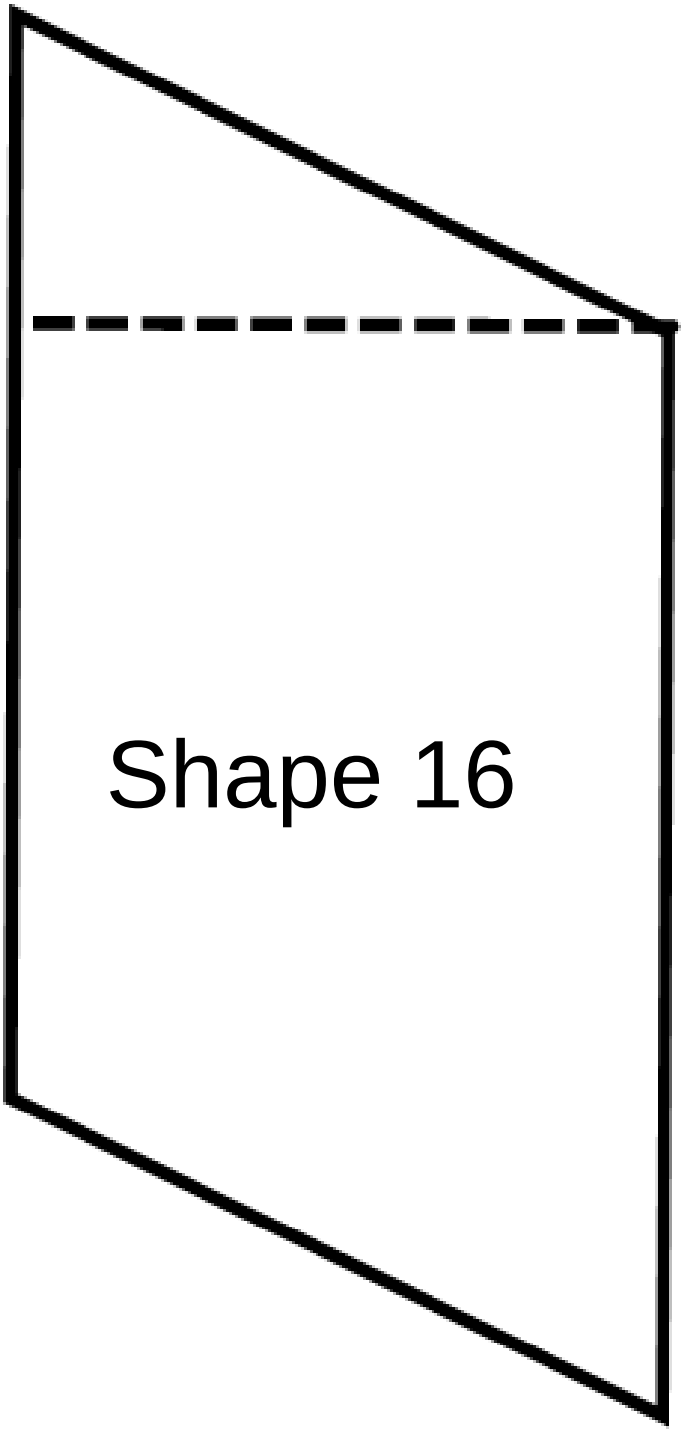
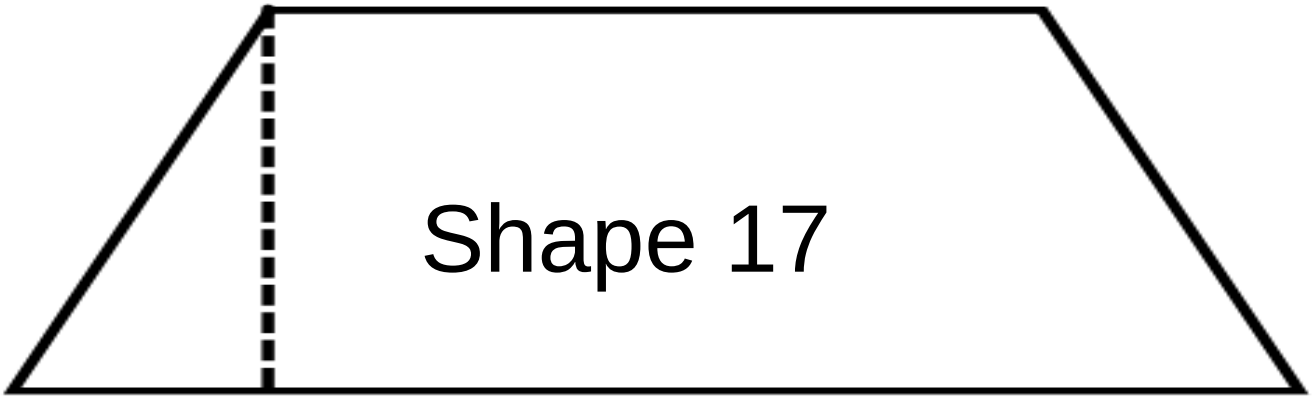
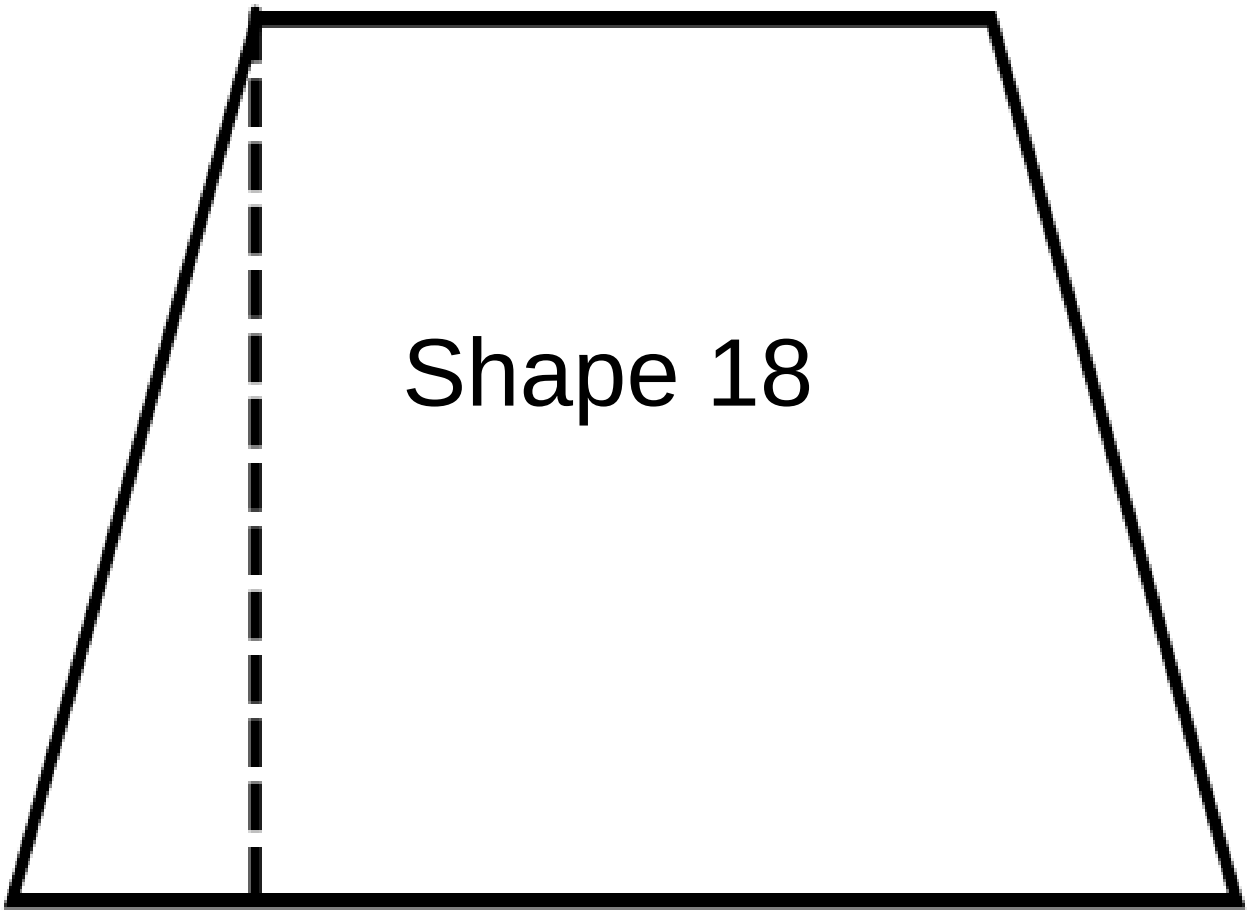
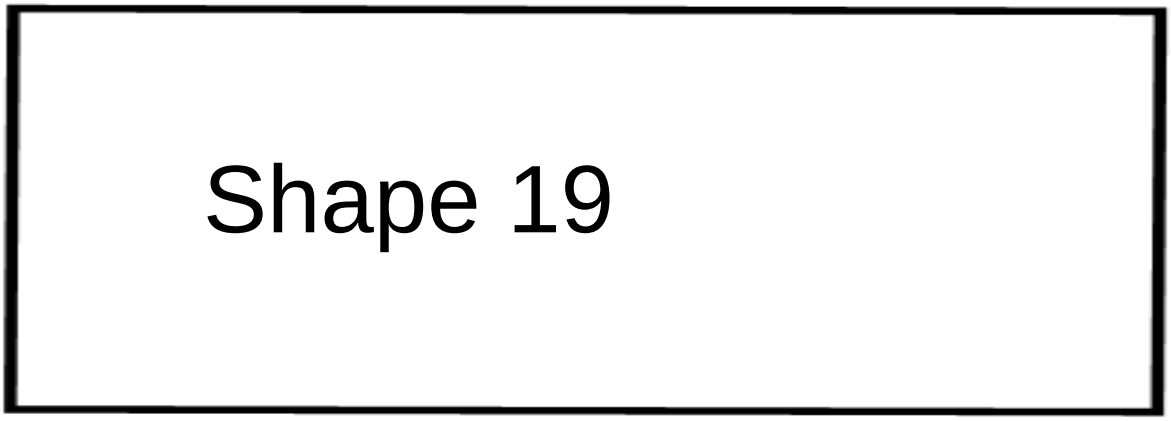
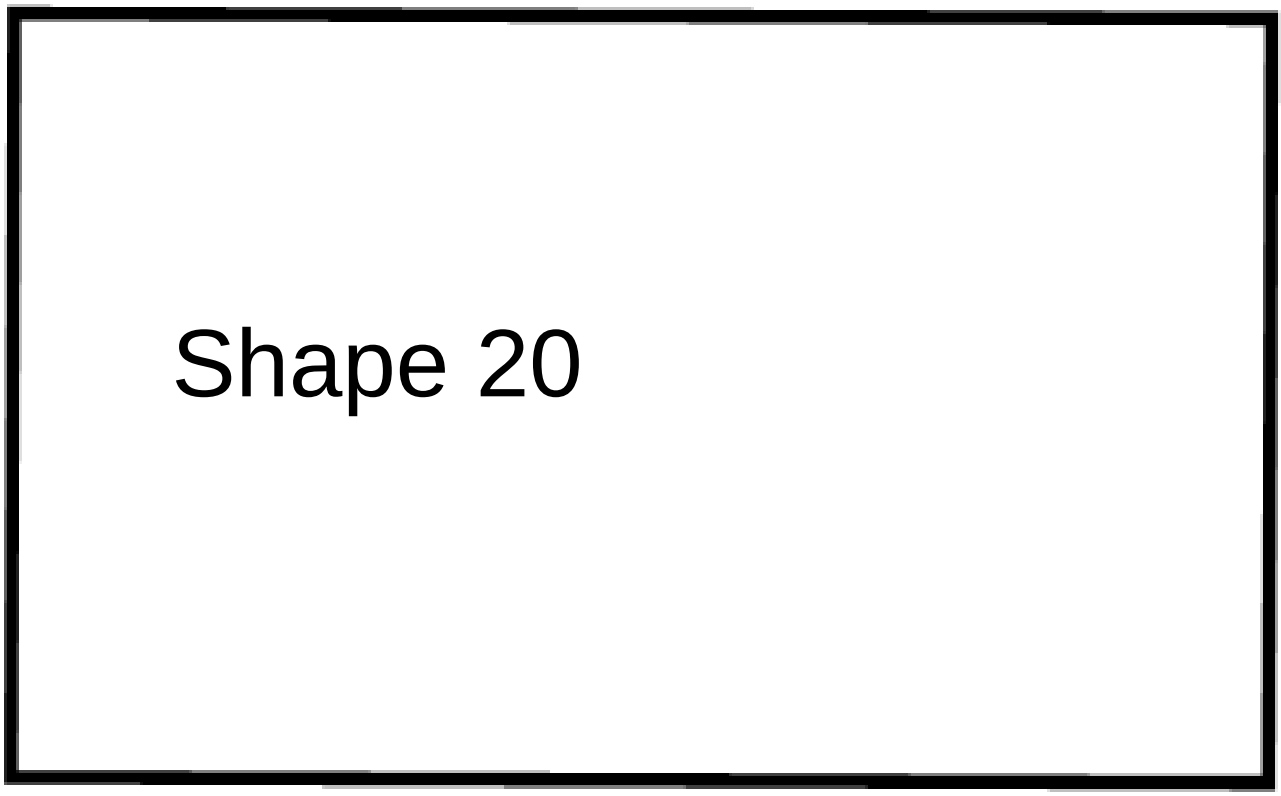

Shape 15

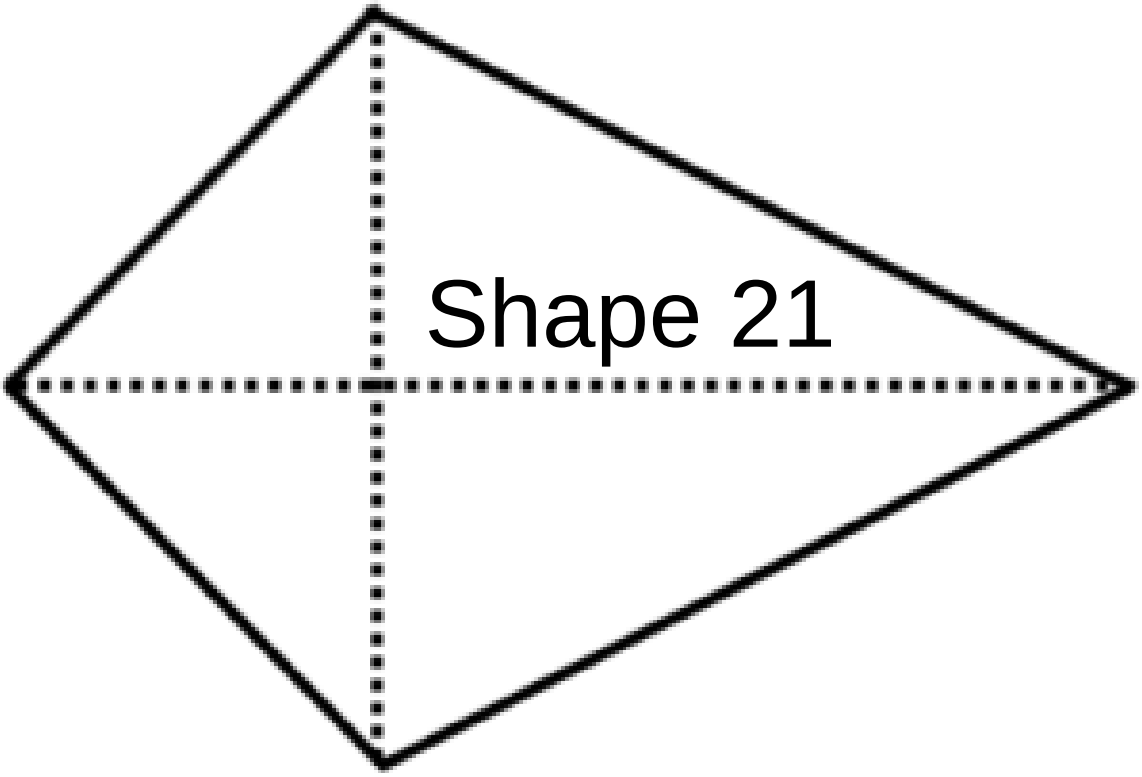

Shape 16

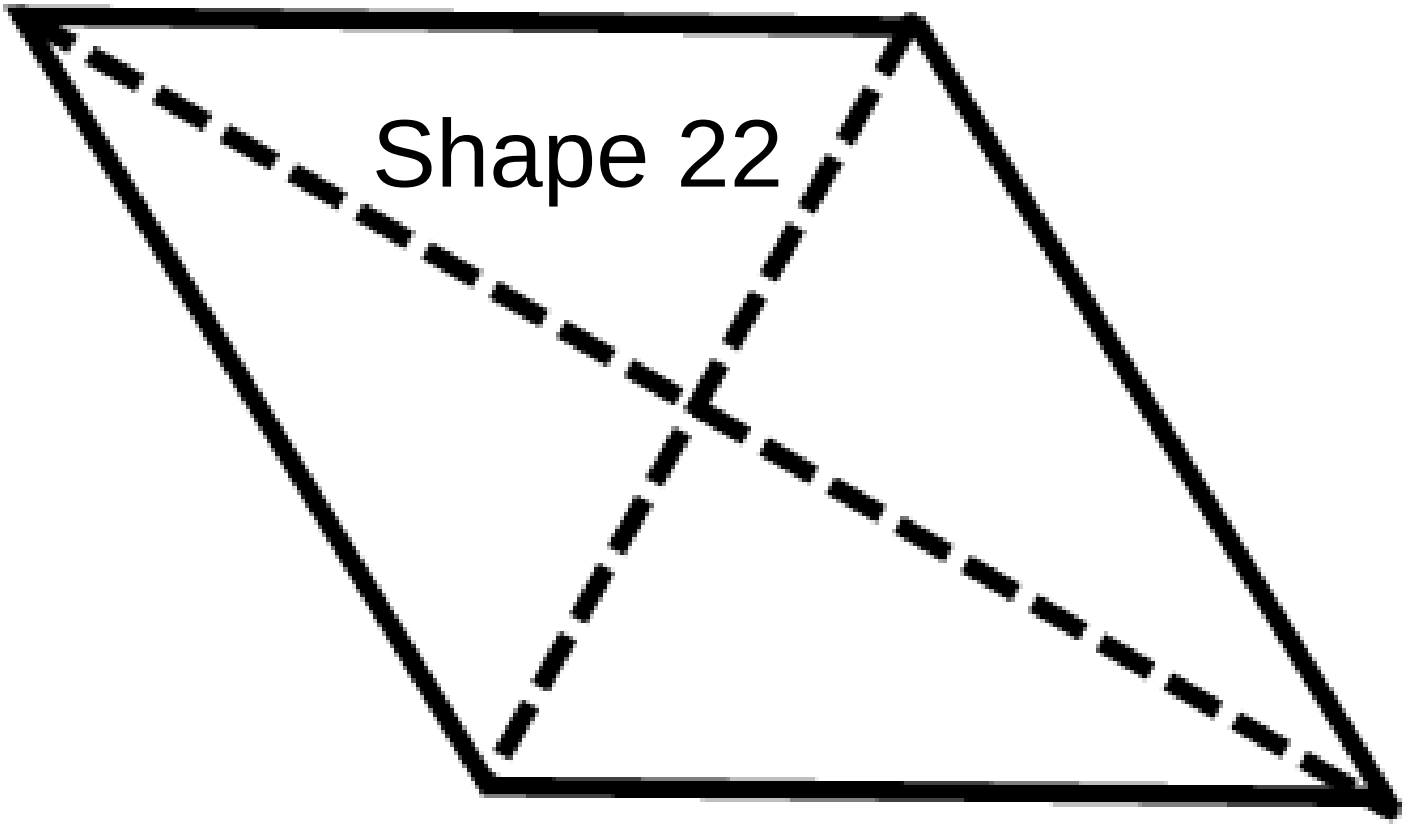

Shape 17


Shape 18


Shape 19


Shape 20

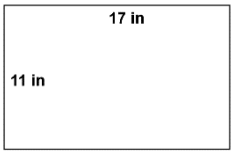

Shape 21


Shape 22

Geometry
Quarter 4 Project: Dartboard
SOLUTIONS to the Charts

Area of the Dartboard

Work to find the area of the dartboard:



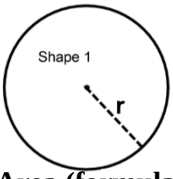
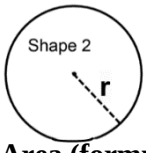
$\frac{11in}{1}\frac{2.54cm}{1in} \approx 27.9cm$

$\frac{17in}{1}\frac{2.54cm}{1in} \approx 43.2cm$

$A = bh \approx (27.9cm)(43.2cm) \approx 1{,}205.3cm^2$

**Measure to the insides of the sides of each shape.*
**Measure to the center of a point.*

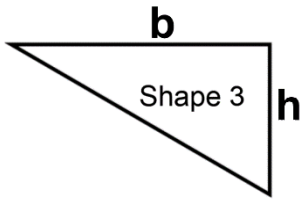
Measurements/Work Chart

Shape 1 **Shape Name:** Circle **Dimensions (labeled picture and measurements)** r ≈ 7.1 cm  **Area (formula and work)** $A = \pi r^2$ $A = \pi(7.1\text{ cm})^2$ $A \approx 158.4\text{ cm}^2$ **TP =** **EP =**	**Shape 2** **Shape Name:** Circle **Dimensions (labeled picture and measurements)** r ≈ 5.0 cm  **Area (formula and work)** $A = \pi r^2$ $A = \pi(5.0\text{ cm})^2$ $A \approx 78.5\text{ cm}^2$ **TP =** **EP =**

Shape 3 **Shape Name:** Right Triangle

Dimensions (labeled picture and measurements)

b ≈ 11.3 cm
h ≈ 6.5 cm



Area (formula and work)

A = ½ bh

A ≈ ½ (11.3 cm)(6.5 cm)

A ≈ 36.7 cm^2

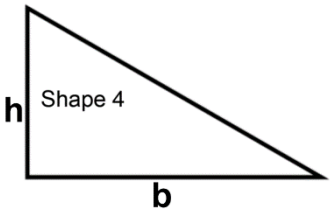
TP =

EP =

Shape 4 **Shape Name:** Right Triangle

Dimensions (labeled picture and measurements)

b ≈ 16.1 cm
h ≈ 9.3 cm



Area (formula and work)

A = ½ bh

A ≈ ½ (16.1 cm)(9.3 cm)

A ≈ 74.9 cm^2

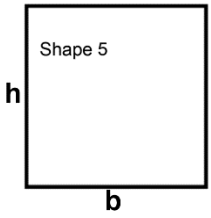
TP =

EP =

Shape 5 **Shape Name:** Square

Dimensions (labeled picture and measurements)

b ≈ 12.3 cm
h ≈ 12.3 cm



Area (formula and work)

A = bh

A ≈ (12.3 cm)(12.3 cm)

A ≈ 151.3 cm^2

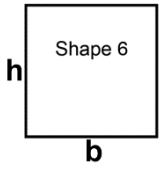
TP =

EP =

Shape 6 **Shape Name:** Square

Dimensions (labeled picture and measurements)

b ≈ 8.3 cm
h ≈ 8.3 cm



Area (formula and work)

A = bh

A ≈ (8.3 cm)(8.3 cm)

A ≈ 68.9 cm^2

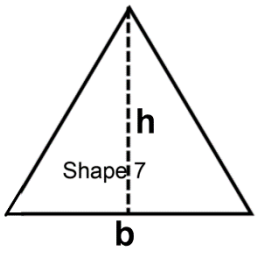
TP =

EP =

Shape 7 **Shape Name:** Triangle (Isosceles, non-right)

Dimensions (labeled picture and measurements)

b ≈ 13.5 cm
h ≈ 11.3 cm



Area (formula and work)

A =½ bh

A ≈ ½ (13.5 cm)(11.3 cm)

A ≈ 76.3 cm^2

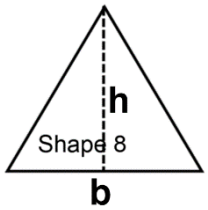
TP =

EP =

Shape 8 **Shape Name:** Triangle (Isosceles, non-right)

Dimensions (labeled picture and measurements)

b ≈ 10.2 cm
h ≈ 8.5 cm



Area (formula and work)

A =½ bh

A ≈ ½ (10.2 cm)(8.5 cm)

A ≈ 43.4 cm^2

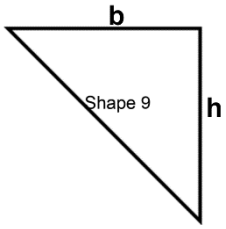
TP =

EP =

Shape 9 **Shape Name:** Right Triangle

Dimensions (labeled picture and measurements)

b ≈ 13.4 cm
h ≈ 13.6 cm



Area (formula and work)

A =½ bh

A ≈ ½ (13.4 cm)(13.6 cm)

A ≈ 91.1 cm^2

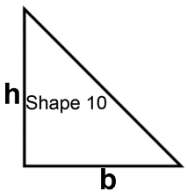
TP =

EP =

Shape 10 **Shape Name:** Right Triangle

Dimensions (labeled picture and measurements)

b ≈ 10.2 cm
h ≈ 10.2 cm



Area (formula and work)

A =½ bh

A ≈ ½ (10.2 cm)(10.2 cm)

A ≈ 52.0 cm^2

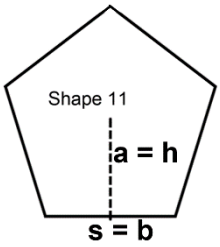
TP =

EP =

Shape 11 **Shape Name:** Pentagon

Dimensions (labeled picture and measurements)

b ≈ 8.7 cm
h ≈ 6.5 cm



Area (formula and work)

A = n ½ bh = ½ nsa

A ≈ 5 ½ (8.7 cm)(6.5 cm)

A ≈ 141.4 cm^2

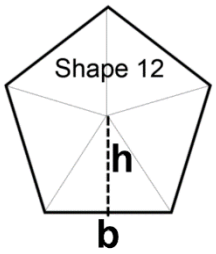
TP =

EP =

Shape 12 **Shape Name:** Pentagon

Dimensions (labeled picture and measurements)

b ≈ 6.2 cm
h ≈ 4.7 cm



Area (formula and work)

A = n ½ bh

A ≈ 5 ½ (6.2 cm)(4.7 cm)

A ≈ 72.9 cm^2

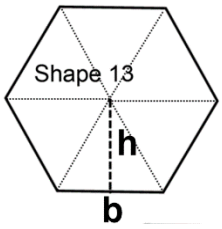
TP =

EP =

Shape 13 **Shape Name:** Hexagon

Dimensions (labeled picture and measurements)

b ≈ 5.7 cm
h ≈ 5.0 cm



Area (formula and work)

A = n ½ bh

A ≈ 6 ½ (5.7 cm)(5.0 cm)

A ≈ 85.5 cm^2

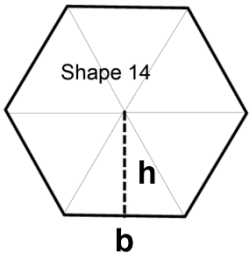
TP =

EP =

Shape 14 **Shape Name:** Hexagon

Dimensions (labeled picture and measurements)

b ≈ 7.2 cm
h ≈ 6.2 cm



Area (formula and work)

A = n ½ bh

A ≈ 6 ½ (7.2 cm)(6.2 cm)

A ≈ 133.9 cm^2

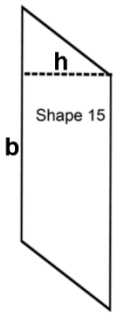
TP =

EP =

Shape 15 **Shape Name:** Parallelogram

Dimensions (labeled picture and measurements)

b ≈ 18.0 cm
h ≈ 6.8 cm



Area (formula and work)

A = bh

A ≈ (18.0 cm)(6.8 cm)

A ≈ 122.4 cm^2

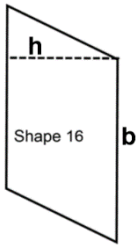
TP =

EP =

Shape 16 **Shape Name:** Parallelogram

Dimensions (labeled picture and measurements)

b ≈ 14.2 cm
h ≈ 8.5 cm



Area (formula and work)

A = bh

A ≈ (14.2 cm)(8.5 cm)

A ≈ 120.7 cm^2

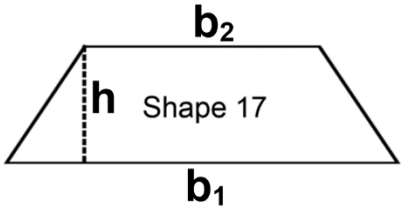
TP =

EP =

Shape 17 **Shape Name:** Trapezoid

Dimensions (labeled picture and measurements)

b_1 ≈ 17.0 cm
b_2 ≈ 10.3 cm
h ≈ 5.0 cm



Area (formula and work)

A = ½ h (b_1 + b_2)

A ≈ ½ (5.0 cm)(17.0 cm + 10.3 cm)

A ≈ 68.3 cm^2

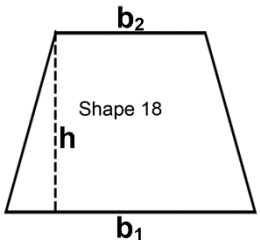
TP =

EP =

Shape 18 **Shape Name:** Trapezoid

Dimensions (labeled picture and measurements)

b_1 ≈ 15.2 cm
b_2 ≈ 9.5 cm
h ≈ 11.3 cm



Area (formula and work)

A = ½ h (b_1 + b_2)

A ≈ ½ (11.3 cm)(15.2 cm + 9.5 cm)

A ≈ 139.6 cm^2

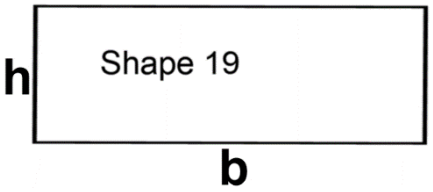
TP =

EP =

Shape 19 **Shape Name:** Rectangle

Dimensions (labeled picture and measurements)

b ≈ 15.2 cm
h ≈ 5.2 cm



Area (formula and work)

A = bh

A ≈ (15.2 cm)(5.2 cm)

A ≈ 79.0 cm^2

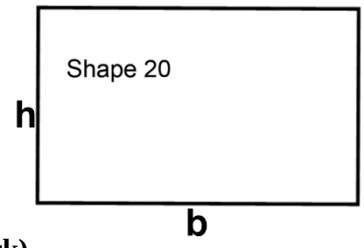
TP =

EP =

Shape 20 **Shape Name:** Rectangle

Dimensions (labeled picture and measurements)

b ≈ 16.6 cm
h ≈ 10.0 cm



Area (formula and work)

A = bh

A ≈ (16.6 cm)(10.0 cm)

A ≈ 166.0 cm^2

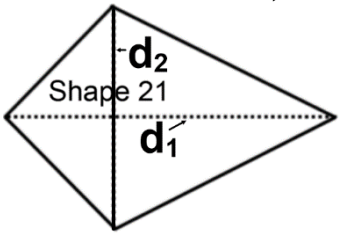
TP =

EP =

Shape 21 **Shape Name:** Kite

Dimensions (labeled picture and measurements)

d_1 ≈ 14.7 cm
d_2 ≈ 9.8 cm



Area (formula and work)

A =½ (d_1)(d_2)

A ≈ ½ (14.7 cm)(9.8 cm)

A ≈ 72.0 cm^2

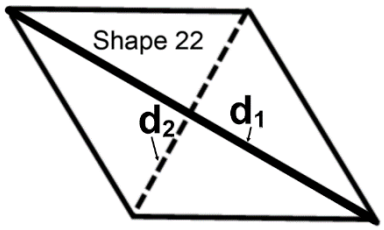
TP =

EP =

Shape 22 **Shape Name:** Rhombus

Dimensions (labeled picture and measurements)

d_1 ≈ 20.5 cm
d_2 ≈ 11.4 cm



Area (formula and work)

A =½ (d_1)(d_2)

A ≈ ½ (20.5 cm)(11.4 cm)

A ≈ 116.9 cm^2

TP =

EP =

Suggestions

- The point of this Geometric Probability lesson is for students to discover that the probability of a dart hitting any of the shapes is the same as the ratio of each area to the total dartboard area.
- First, have students select their shapes and trace them on the dartboard. It is helpful if in a class ALL students select one of their shapes to be the same, for instance #1.
- Second, have them take a picture of the dartboard and create their GeoGebra file. They should follow the directions on the GeoGebra HELPS sheet as they create a random point generator. Note that GeoGebra updates the look of their website, but the Geometry Classic often looks similar. So, even if the HELPS sheet is not exactly how the current GeoGebra site looks like, the steps should still be similar.
- Third, have students find EP. After all students have created a dartboard and a GeoGebra file, have them all calculate the experimental probability for their similar shape (i.e., Shape #1). For students who may not have yet finished their GeoGebra file, send them a link to a finished GeoGebra file so that they can all participate in this step together. Students may use this link to access a GeoGebra Dartboard with a random point generator: https://www.geogebra.org/classic/K67t4uFJ
  Each student should count the number of points in the similar shape (i.e., Shape #1). The teacher can create a Google Sheet with all the students' numbers. Then, the teacher shows the students how to type in a formula to average the numbers. The average EP (experimental probability) should be very close to the TP (theoretical probability). Have a class discussion about how important it is to have many trials (experiments) rather than taking just one trial (experiment) to determine a probability that is close to the theoretical probability.
- Here is a sample of the Google Sheets with some suggestions: https://docs.google.com/spreadsheets/d/1c5thWAkzr0x2EbCXbWb8vtFlhA4QsijGAFv4y48zHPw/edit?usp=sharing
  I do not share this file with students. I want each student to have the opportunity to create his/her own spreadsheet.
- The measurements in the solutions are rounded to the tenths place. This creates great discussions in the classroom on accuracy when rounding is done within a problem. Note that dimension measurements of the shapes may vary if the format of the SHAPES pages is changed.
- This project can be modified for all levels of students and classes. The teacher has a lot of options with this project; discretion can be made in determining what parts of the project would be best for student learning.
  - The teacher can guide students through the project when more help is needed for the students.
  - The modified 45 point rubric can be used for students who would not yet be ready to create a GeoGebra file.
  - The entire project can be assigned and students can work in class for a period and then do the rest on their own.
  - The entire project can be done in the classroom.
  - The teacher could use just part of the lesson plan and teach the students TP and EP in even 30 minutes!
  - Teachers who want to allow students to create and make it more of a STEAM project can have students create a theme to the dartboard. Students could trace the shapes on colored paper, cut out the colored shapes, and glue them onto a colored dartboard. Students could draw on the shapes and color a design.
  - Students can do more coding for this project! Instead of counting the points in each shape, they can create a code so that GeoGebra counts them! Here are the steps that you would take for each of your 6 shapes:
    - Use the circle tool or the polygon tool to draw a shape that is congruent to your shape. GeoGebra will call that shape something. Let's say that it is named c.
    - Sequence(IsInRegion(Element(l1,i),c),i,1,100,1)
    - CountIf(x==true,l2)

- Lesson Extension: Use Geometric Probability as a tool to find the area of non-polygonal shapes.
    - Trace your hand on an 11 inch by 17 inch sheet of paper.
    - Follow the GeoGebra programming steps as you did for your shapes lesson.
    - Calculate the Experimental Probability (EP) of your hand.
    - Use a proportion to solve for the area of your hand. Set the EP fraction equal to the ratio of your unknown hand area to the known area of the dartboard.