The School and University Partnership for Educational Renewal in Mathematics
An NSF-funded Graduate STEM Fellows in K–12 Education Project
University of Hawai'i at Manoa, Department of Mathematics

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Hawaiian Feather Work: Capes, Helmets, Lei, and Sacred Cordons

Introduction

Ancient Hawaiian feather work demanded respect; these pieces were only worn by the ali'i. These capes took hundreds of thousands of feathers and multiple generations in order for them to be crafted. Although feather capes were the most difficult to create, the kā'ei Kapu ō Liloa (sacred cordon) was the most prestigious and highest rank of authority in ancient Hawai'i. Feather capes were not only used for cosmetic purposes, but in battles of war as well.

These feather works were creating by creating bundles of 6-10 feathers and tying those bundles in overlapping rows to a netted foundation of plant fiber. Red, green, black, and yellow feathers were used in the crafting of these pieces; patterns included triangles, lines, semicircles, rectangles, and more. Yellow feathers were seen as most prestigious and king Kamehameha owned an all yellow feather cape which still exists to see.

Grade Levels and Topics

This activity is intended for students, grades 2nd–3rd and 6th. The first part is intended for younger students, while the second and third parts are intended for 6th grade students.
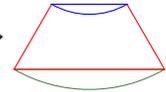
Elementary Geometry:

- **Recognition and creation of simple shapes(part 1):** Circles, rectangles, triangles, trapezoids, etc...

- **Reflectional Symmetry(part 1):** A type of symmetry where one half is the reflection of the other half. In other words, you can fold the image and have both sides match exactly; the line for which you fold over is called the *line of symmetry*. In this lesson, the students will be drawing a line of symmetry on the capes.

- **Proportions(part 2):** A part, share, or number considered in comparative relation to a whole. In this lesson, proportions will be used in order to answer problem **7.1**. Students will use the idea of proportions in order to calculate how red, yellow, and black feathers were used in the creation of the feather capes, cordons, and helmets. How this will be done is by finding the percentage of the cape that a certain color takes up and taking that same percentage of the total number of feathers used.

- **Composite shapes(part 2 & 3):** A composite shape is object composed of a combination of two or more basic shapes. This lesson focuses on the concept of composite shapes in order for the students to determine the area of the capes. To solve the problems in parts 1 and 2, students may need to take away overlapping areas in order to find the area of the figure they are working with. For example, you can show

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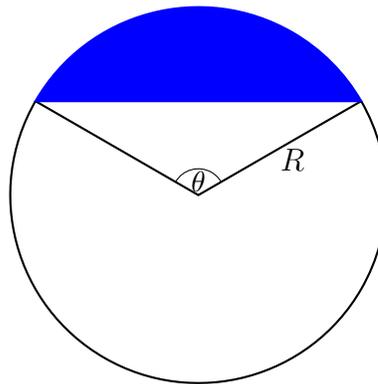the students how to find the area of this shape   we can change   →   .
Then, to find the area of the original shape, we calculate the area of shapes we used to comprise the image:

+   −   =

- **Circular Segments(part 2 & 3):** The area of a circular segment (blue) in the following circle is:

$$\text{Area} = \frac{R^2}{2}\left(\theta - \sin\theta\right)$$

1   Materials and Resources

- **Part1**

    - Paint (Preferably red, black, yellow, and green): Acrylic paint works best however watercolors would be less of a mess.

- **Part 2 & 3**

    - Red, yellow, black, and green construction paper
    - Red, yellow, black, and green feathers.
    - Scissors
    - Metric ruler
    - Protractor
    - Gel glue or two sided tape

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Elementary Geometry Part 1 Discussion

- Prior to showing them this hand out, review with the students what a circle, square, rectangle, and trapezoid looks like. You may also want to discuss with the students what a crescent shape is.

- When the students receive the following worksheet, they should be discussion in groups which simple shapes they see and where those shapes appear.

Elementary Geometry Part 2: Discussion

- Discuss with the students how break apart a composite shapes into simple shapes in order to calculate the area. For example, the following problems have the students find the area of ancient Hawaiian capes. The students should be in groups to discuss how they will do this, but if some groups are having difficulty, have them break the shape up into two hemispheres and one trapezoid.

- Discuss with the students how proportions can be very useful in solving problems when only certain information is known. For example, if you have a gallon of chocolate milk, but you know $\frac{1}{8}$ of it is chocolate syrup then the amount of chocolate syrup used is a pint.

Elementary Geometry Part 3: Discussion

- Discuss with the students how break apart a composite shapes into simple shapes in order to calculate the area. For example, the following problems have the students find the area of ancient Hawaiian capes. The students should be in groups to discuss how they will do this, but if some groups are having difficulty, have them break the shape up into two hemispheres and one trapezoid.
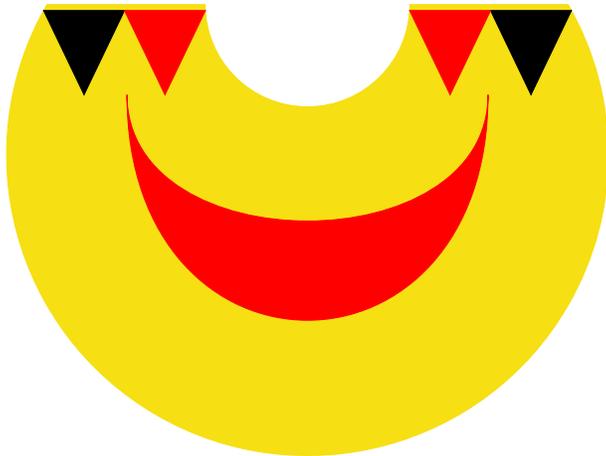
1. What shapes can you spot in the following feather capes? Draw the shapes you see on the cape.

   (a)

   (b)

   (c)

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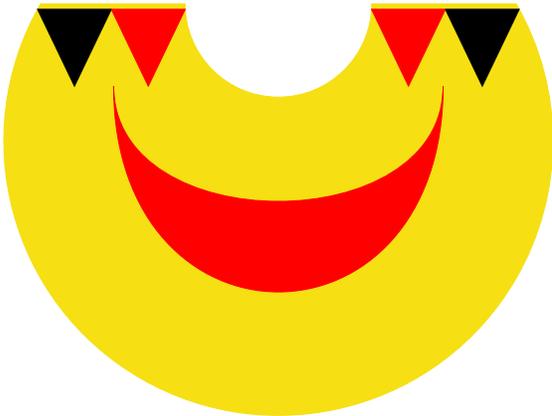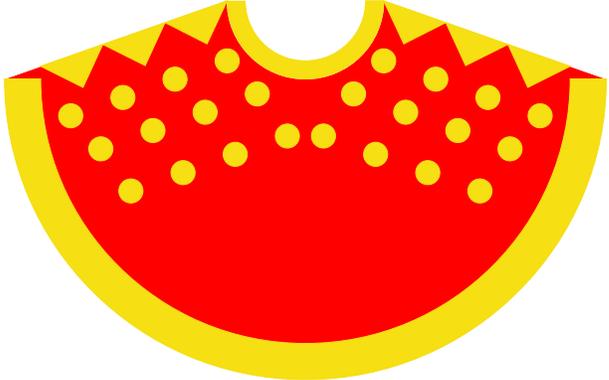University of Hawai'i at Manoa, Department of Mathematics

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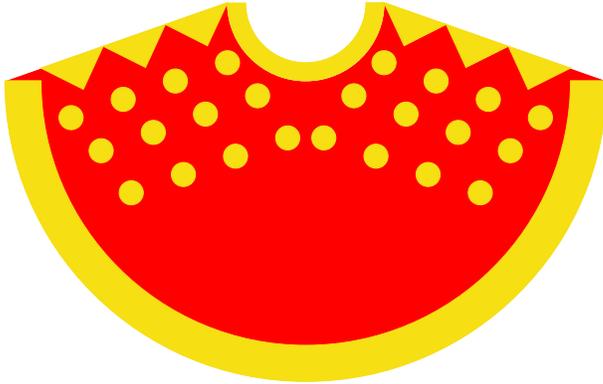
2. Here are a few feather capes and a cordon. Draw all the lines of symmetry on each of the following feather works:

Activity

Now you are going to create your own feather cape! Use red, yellow, black, and/or green paint to create a feather cape that is symmetric over the dotted line. First cut out the cape. Then paint half of your cape design on one half of the dotted line. Finally fold your cape over the line and make sure the unpainted half is touching the painted half and open it to reveal your cape!
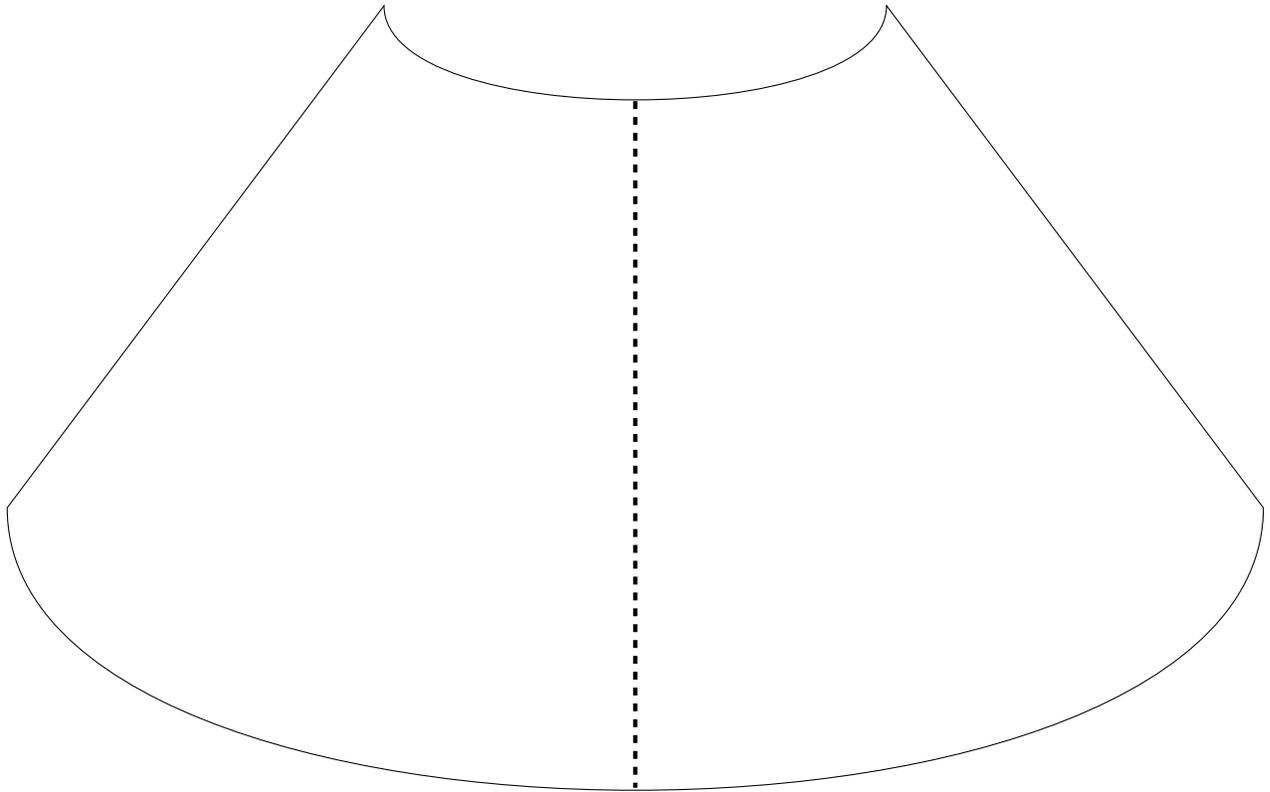
1. Create an equation for the area taken up by the red, yellow, and black feathers for the following capes.
   Example:
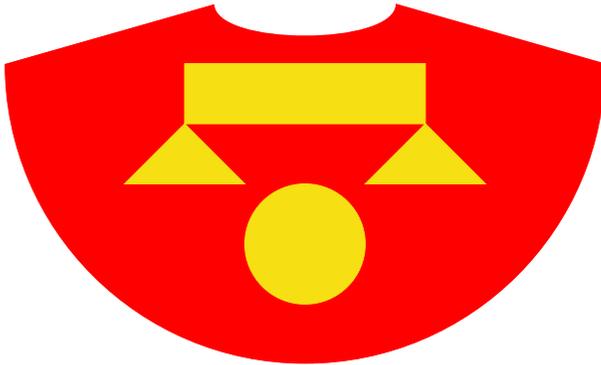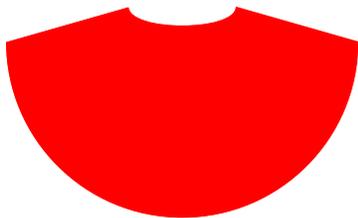
⬤ + 2·▲ + ▬ = Yellow Area

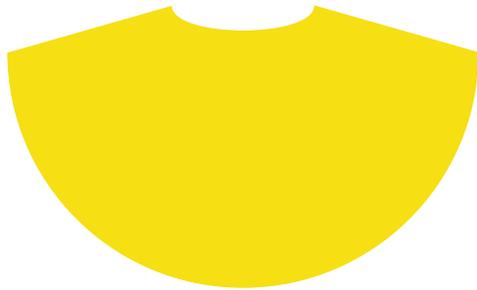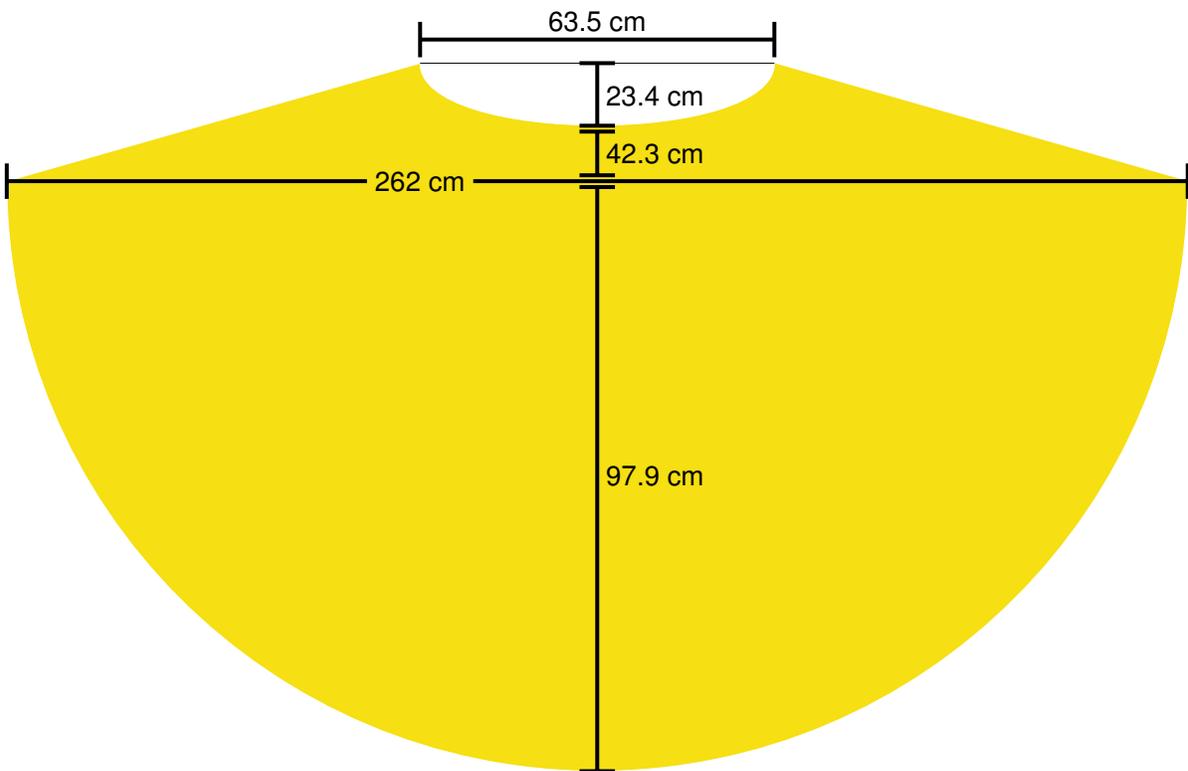− ⬤ − 2·▲ − ▬ = Red Area

(a)
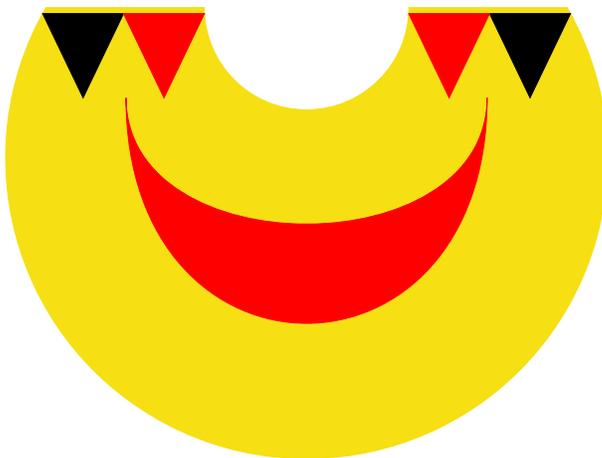
(b)

(c)
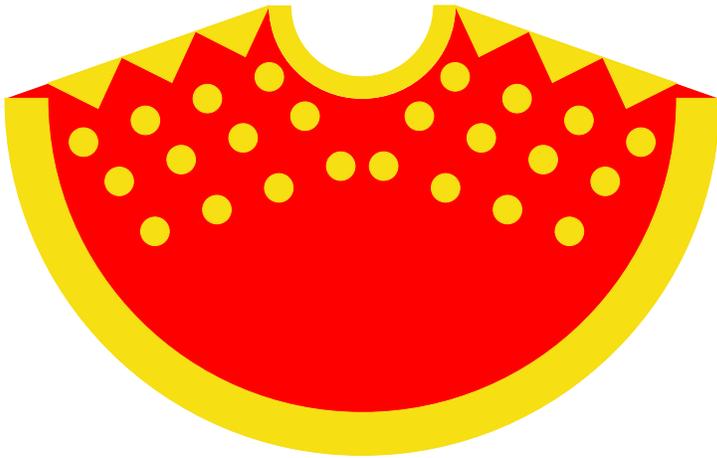
2. Find the area that the black, red, and yellow feathers take up. Then assuming that these feathers are evenly distributed along the cape, how many black feathers, red feathers, and yellow feathers will it take to create the following feather capes:
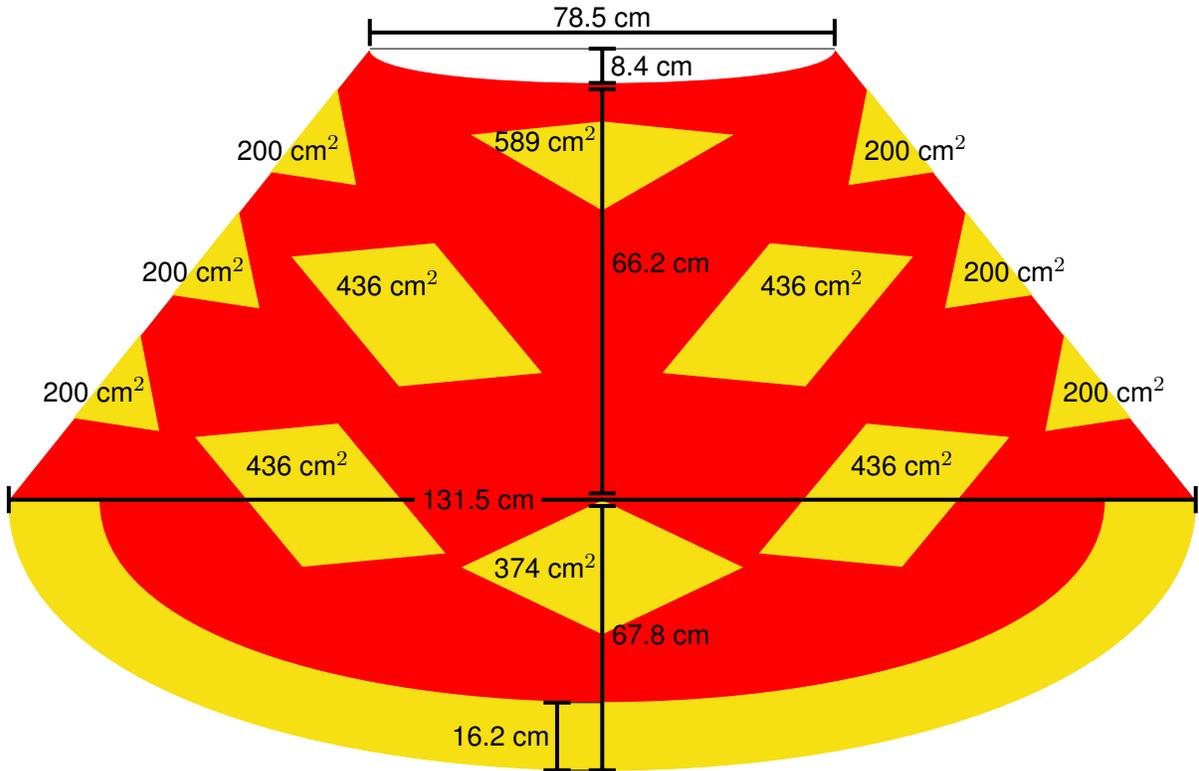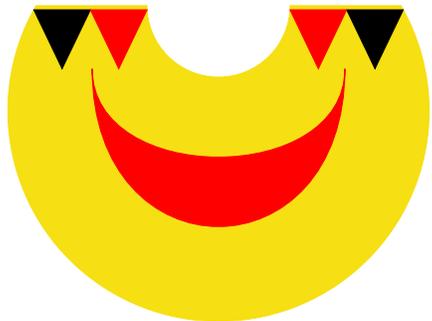
(a)
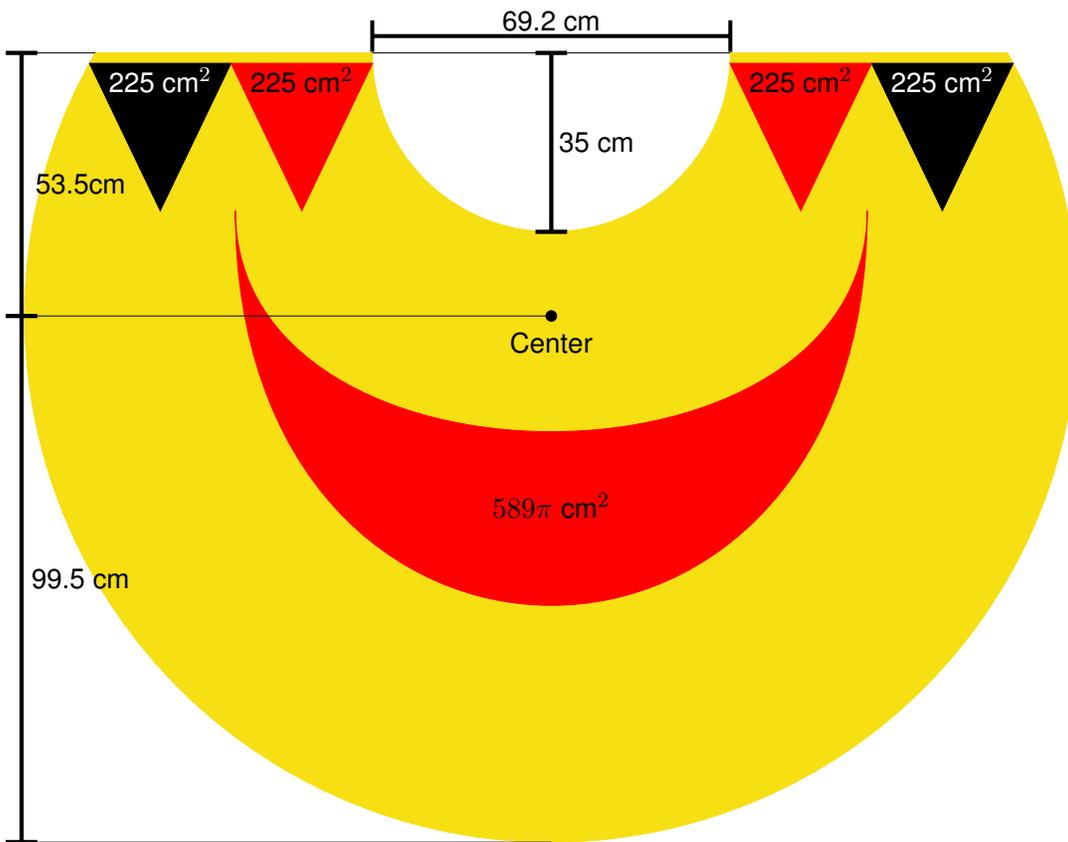

Total Feathers Used: $450,000$

(b)

Total Feathers Used: 192,500

78.5 cm

8.4 cm

200 cm^2

589 cm^2

200 cm^2

200 cm^2

436 cm^2

436 cm^2

66.2 cm

200 cm^2

200 cm^2

436 cm^2

436 cm^2

131.5 cm

374 cm^2

67.8 cm

16.2 cm

(c)

Total Feathers Used: 243,000

69.2 cm

225 cm² 225 cm² 225 cm² 225 cm²

35 cm

53.5cm

Center

589π cm²

99.5 cm

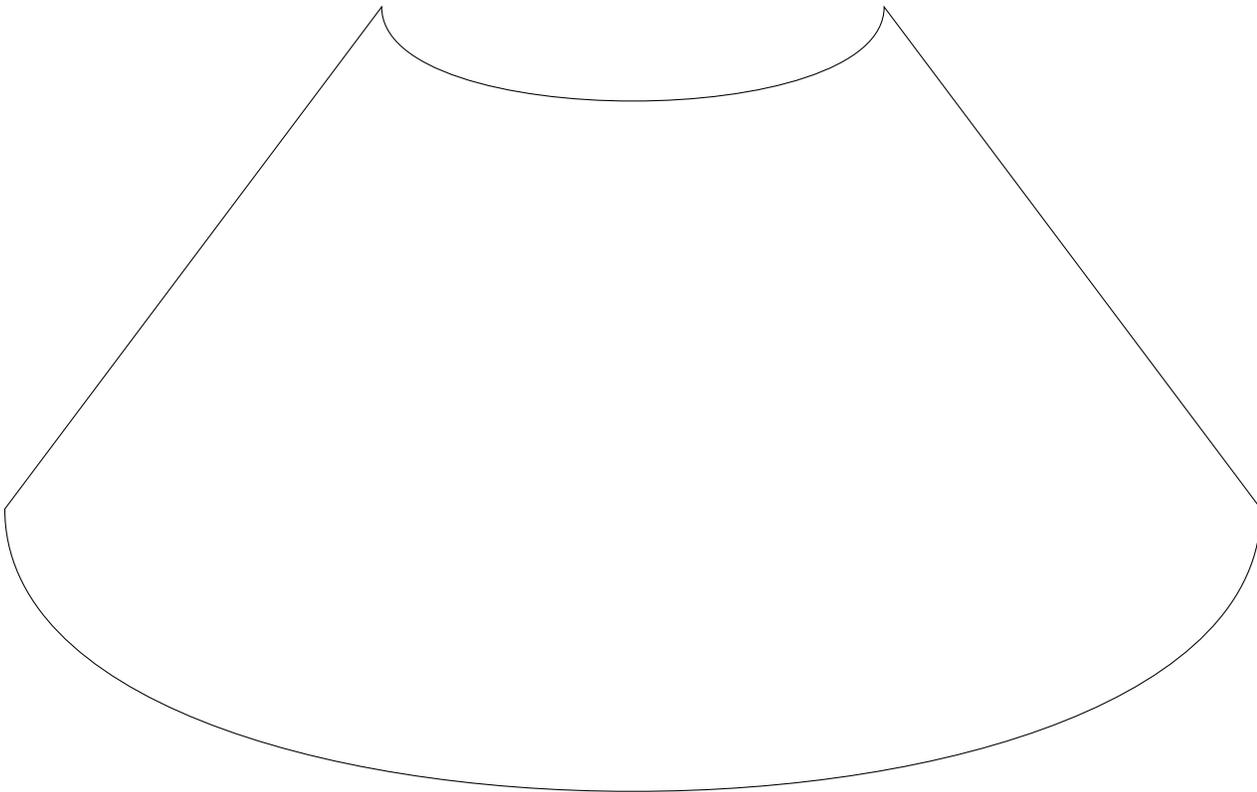**Activity**

Now to make a mini feather cape!

1. In groups of 2-3 design a feather cape in the outline bellow.

2. create the feather cape on a sheet of red, yellow, black, or green construction paper.

3. With the remaining colored sheets of construction paper, cut out the designs you and your group members need in order to complete the cape.

4. Find the area of black, red, green, and yellow construction paper showing in cm^2, be sure to right the measurements used in calculation on the outline you first used to design the cape.

5. For every 1 cm^2 of red, black, yellow, and green construction paper showing gather 6 feathers of the respective colors and attach them to the construction paper cape.
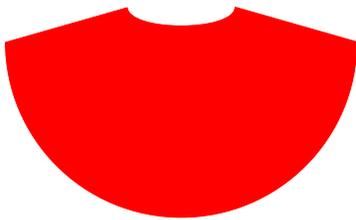
1. Create an equation for the area taken up by the red, yellow, and black feathers for the following capes.
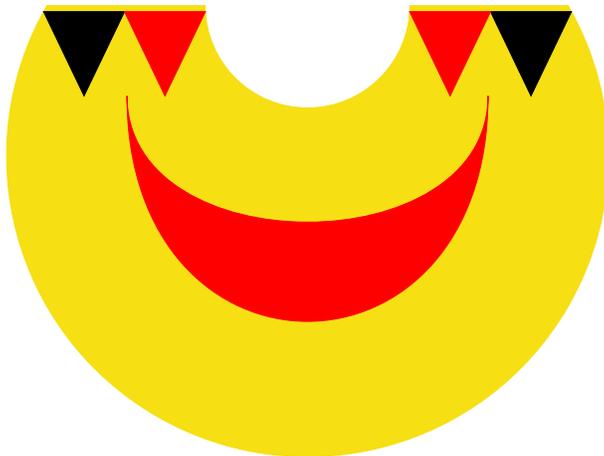   **Example:**
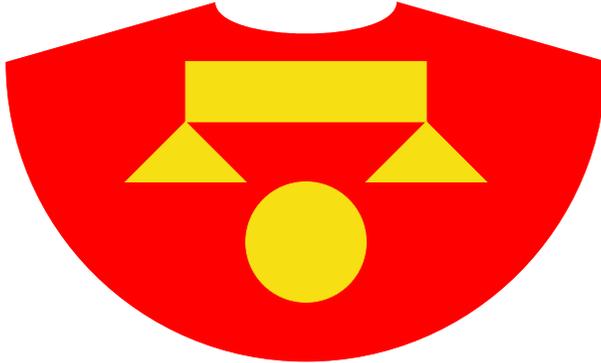
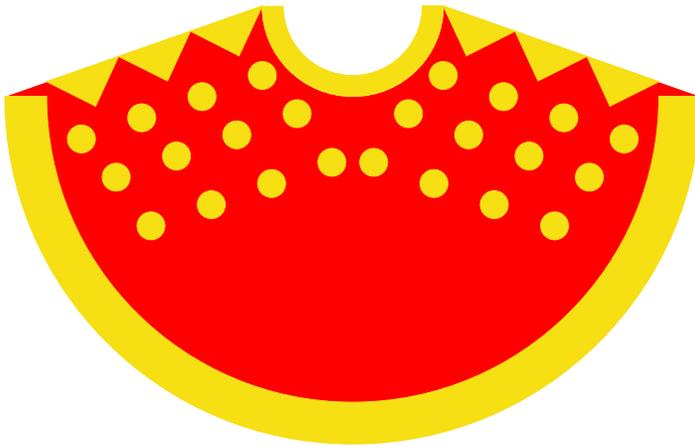   ⬤ + 2·▲ + ▭ = Yellow Area

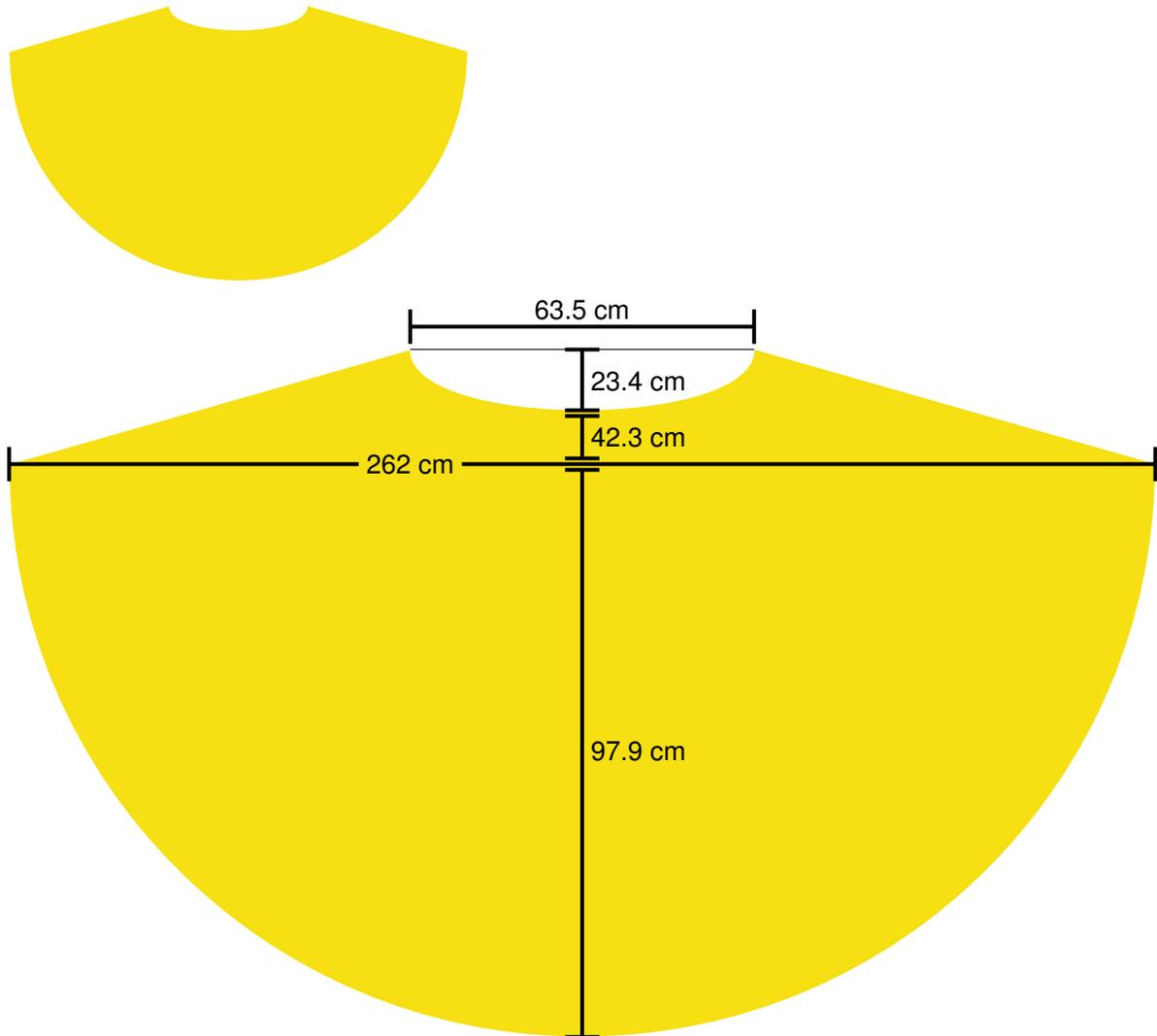   ⬤ − ⬤ − 2·▲ − ▭ = Red Area

   (a)

(b)

(c)

2. Full length feather capes can take hundreds of thousands of feathers and multiple generations for them to be completed. The capes are crafted by first bundling up 6-10 feathers and then connecting those bundles to a larger netted foundation of plant fiber to create the final cape. Assuming that a bundle of 9 feathers takes up one square centimeter, figure out how many red, yellow, and black feathers were used in the creation of the following capes:

(a)

63.5 cm

23.4 cm

42.3 cm

262 cm

97.9 cm

(b)

69.2 cm

225 cm^2 225 cm^2 225 cm^2 225 cm^2

35 cm

53.5cm

Center

99.5 cm

589π cm^2
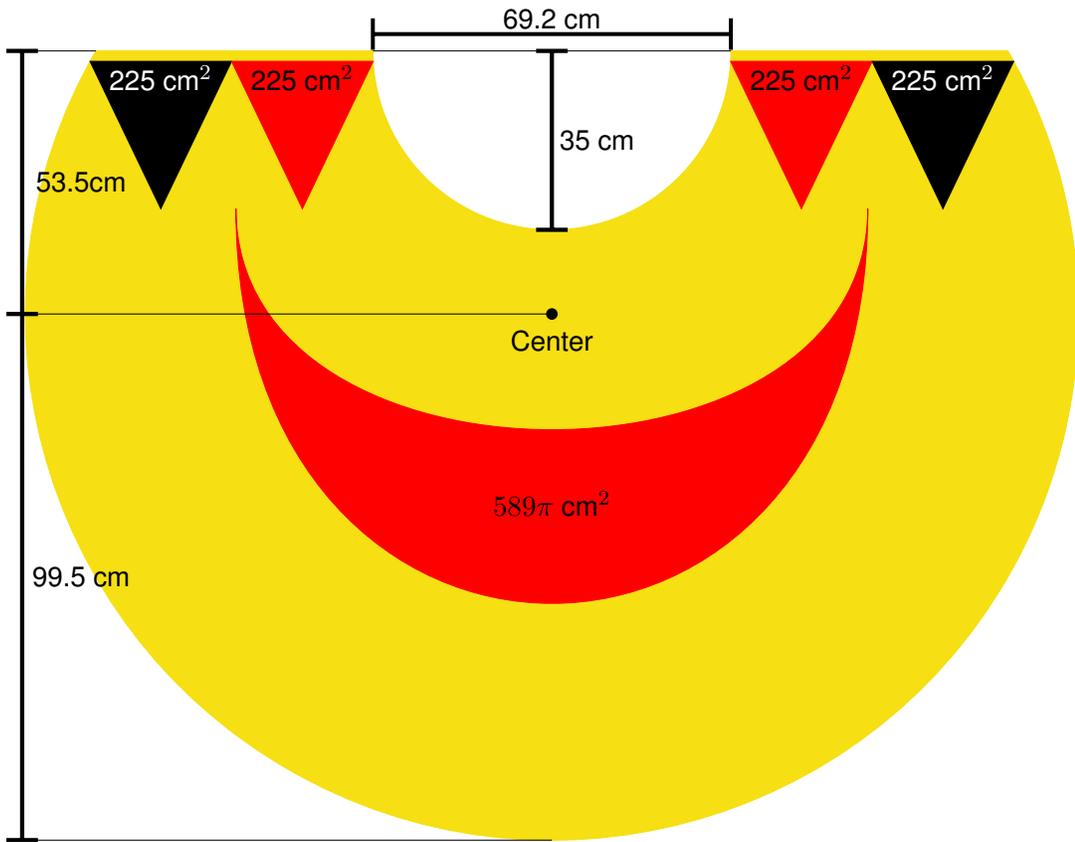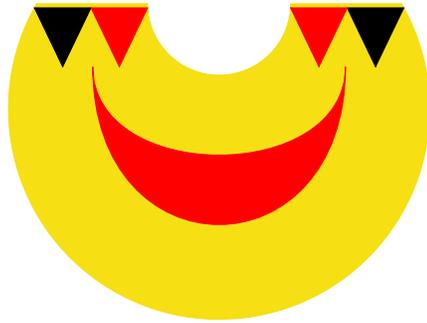
(c)
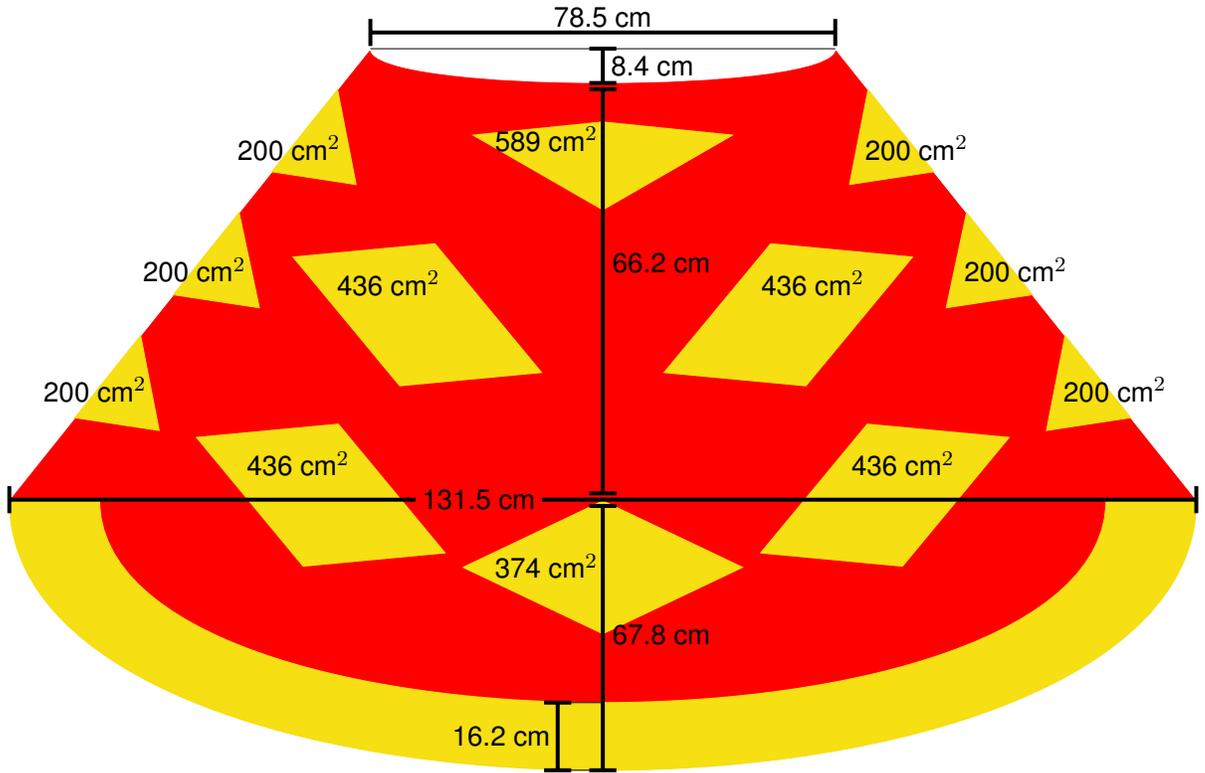
3. The following is an image of a kāʻei Kapu ō Liloa (sacred cordon) and a model of what it looks like laid out, with measurements. It is estimated to have 35,500 feathers used in its creation. Determine the area of the kāʻei Kapu ō Liloa, area of the yellow region, area of the red region, and use this information to calculate how many red feathers and how many yellow feathers were used. Assume that a bundle of 60 feathers can fill a 1 in^2 region.

Activity

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2. create the feather cape on a sheet of red, yellow, black, or green construction paper.

3. With the remaining colored sheets of construction paper, cut out the designs you and your group members need in order to complete the cape.

4. Find the area of black, red, green, and yellow construction paper showing in cm^2, be sure to right the measurements used in calculation on the outline you first used to design the cape.

5. For every 1 cm^2 of red, black, yellow, and green construction paper showing gather 6 feathers of the respective colors and attach them to the construction paper cape.

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Answer Key

1. (a) Triangles, hemisphere, and circles
   (b) Triangles and crescent
   (c) Circles, trapezoids, hemispheres, triangles, and rectangle.
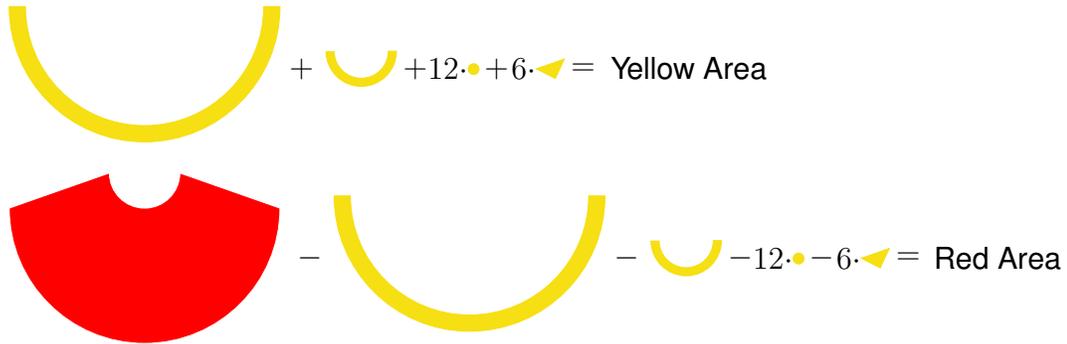
2.

Geometry (Proportions):

1. (a)

(b)

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(c)

$$+ \; \cup \; +12\cdot\bullet+6\cdot\blacktriangleleft = \text{ Yellow Area}$$

$$- \; \cup \; - \; \cup \; -12\cdot\bullet-6\cdot\blacktriangleleft = \text{ Red Area}$$
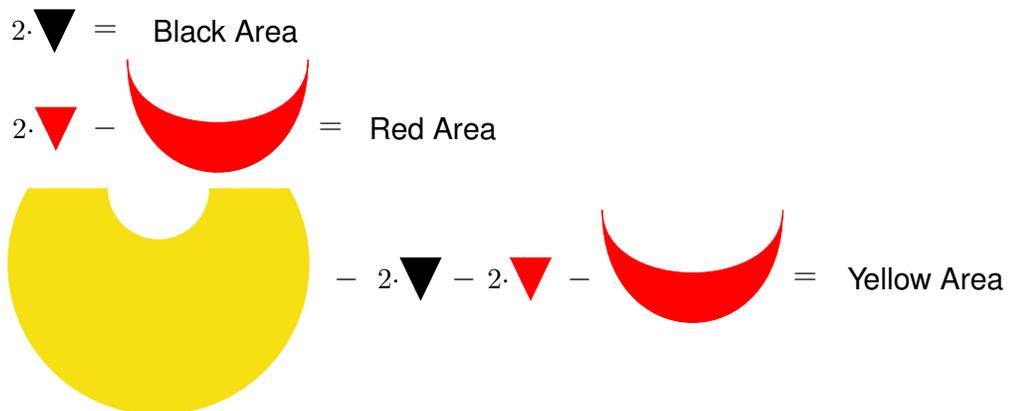
2. (a) $(.5)(23.4 + 42.3)(63.5 + 262) - (23.4)(31.75)\pi + 12824.9\pi = 10692.675 + 12081.95\pi \approx 48649.24036$,
so the area of the yellow region (whole cape) is about 48649.24036 cm^2.

(b) Cape area: $7833 + 4128.15\pi \approx 20801.9657$
Yellow region: $3909 + 950.535\pi \approx 6895.193773$
Red Region: $(7833 + 4128.15\pi) - (3909 + 950.535\pi) = 3924 + 3177.615\pi \approx 13906.77194$

(c) Cape area: $\dfrac{753239\pi}{90} - \sin\left(\dfrac{26}{45}\pi\right) \approx 26292.03091$
Black region: 450 cm^2
Yellow region: $\dfrac{753239\pi}{90} - \sin\left(\dfrac{26}{45}\pi\right) - (450 + 450 + 589\pi) \approx 23541.63284$
Red region: $450 + 589\pi \approx 2300.398073$

Geometry:

1. (a)

$$2\cdot\blacktriangledown \;=\; \text{Black Area}$$

$$2\cdot\blacktriangledown \;-\; \text{\textcolor{red}{◠}} \;=\; \text{Red Area}$$

$$- \; 2\cdot\blacktriangledown - 2\cdot\textcolor{red}{\blacktriangledown} - \text{\textcolor{red}{◠}} = \text{Yellow Area}$$

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(b)

$+\ 6\cdot\blacktriangle\ +\ \blacktriangledown\ +\ \blacklozenge\ +\ 4\cdot\blacksquare\ =$ Yellow Area

$-\ \smile\ -\ 6\cdot\blacktriangle\ -\ \blacktriangledown\ -\ \blacklozenge\ -\ 4\cdot\blacksquare\ =$ Red Area

(c)

$+\ \smile\ +12\cdot\bullet+6\cdot\blacktriangleleft=$ Yellow Area

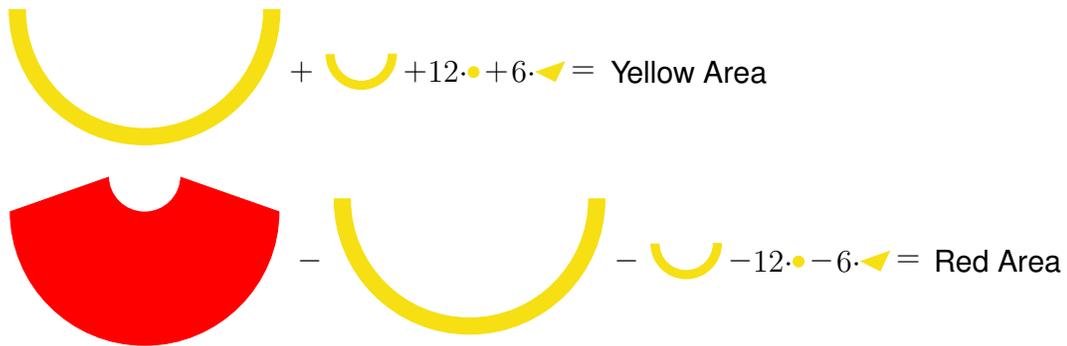$-\ \smile\ -\ \smile\ -12\cdot\bullet-6\cdot\blacktriangleleft=$ Red Area
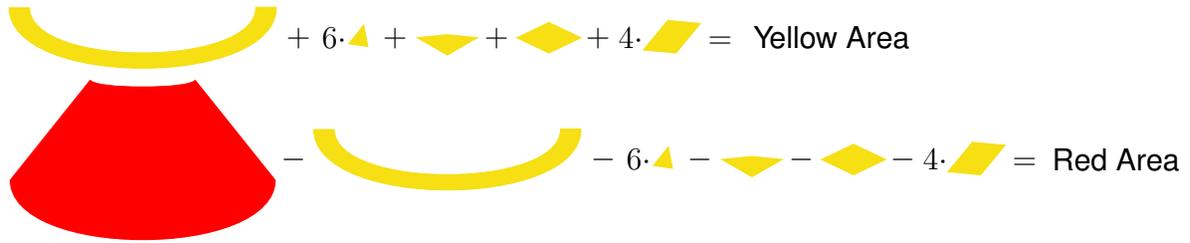
2. (a) $437,841$ yellow feathers

   (b) $62,057$ yellow feathers; $125,161$ red feathers

   (c) $4,050$ black feathers; $211,875$ yellow feathers; $20,704$ red feathers

3. Total Area $= \left(11\text{ ft} \times \frac{12\text{ in}}{1\text{ ft}}\right) \times 4.5\text{ in} = 594\text{ in}^2$
   Yellow Region $= 2 \times (132\text{ in} \times 1\text{ in}) + 3 \times (2.5\text{ in} \times 1\text{ in}) = 171.5\text{ in}^2$
   Red Region $=$ Total Area $-$ Yellow Region $= 594\text{ in}^2 - 171.5\text{ in}^2 = 422.5\text{ in}^2$
   Red Feathers: 60 feathers $\times$ 422.5 = 25350 feathers
   Yellow Feathers: 60 feathers $\times$ 171.5 = 10290 feathers