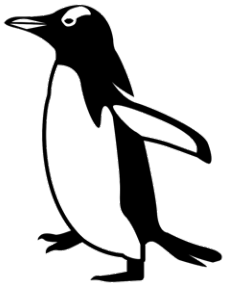


Outdoor Living

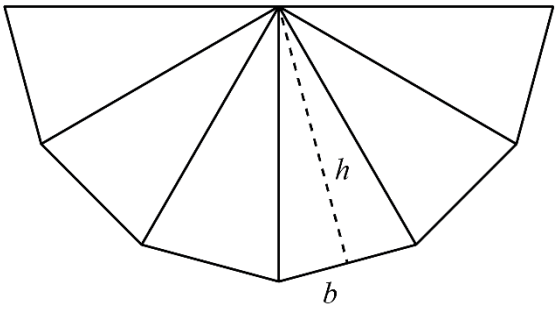
African Penguins

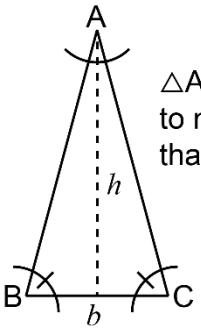
People often think of penguins as living only in frigid, polar climates, but the African penguins living at the Dallas Zoo do not require extremely low temperatures. This means that they can be viewed in outdoor habitats, such as the one here. The waters of their native south African coast are cold however, and African penguins appreciate the shade and cool water provided by this habitat.

1. Look up at the roof of this enclosure. It doesn't cover the entire pool, providing for both a shady area as well as an open area for the penguins. The pattern you see above you consists of several triangles. The picture to the right highlights one of these triangles. What type of triangle do you think each one is – isosceles or equilateral?
   Hint: An isosceles triangle has two equal sides and angles. An equilateral triangle has three equal sides and three equal angles.

*Photo SEQ Photo * ARABIC \r 1 1 - Closeup of the penguin exhibit roof, highlighting one of the triangles that make up the roof. PC: Jonathan Edquid*

2. A drawing of the roof is provided. Notice that the roof forms a straight line. Use it to help you calculate how many degrees the triangle was repeatedly rotated to make the roof. This measurement is equal to the measurement of ∡A.
   Hint: What is the degree measurement of a straight line?





△ABC is repeated to make the thatched roof

$b = 8$ *feet*
$h = 15$ *feet*

3. Use your knowledge of triangles to label the measurements of ∡B and ∡C.
   Hint: What is the sum of the interior angles of a triangle?

4. If the Zoo needed to replace the roof, how much thatched material must be purchased? Use the measurements given on the diagram to calculate the amount of thatching needed.
   Hint: We want to know how much space the thatching takes up. What quantity is that? What is the formula for calculating that quantity?

5. African penguins spend most of their life in the water. The cool waters off the coast of South Africa, where the African penguins live, range in temperature from 41-68°F. The penguins will move ashore to breed, molt, and rest. What is the average temperature of these waters?

6. How would you go about estimating the volume of water in the penguin water system? What measurements would you need to take? What assumptions would you need to make in your calculation? Discuss with a partner.
   Hint: What shape is the water system? What height is the water level?

Artificial Nest Project

The number of African penguins has been dwindling for decades. There were once a million pairs of breeding birds, located primarily in South Africa and Namibia; now, there are only 25,000 pairs. This is mostly due to overfishing, climate change, and the harvesting of guano, or penguin poop. African penguins typically make their nests in heaps of dried guano that have been built up for decades, providing the right protection and temperature control to raise young chicks. But guano also makes good fertilizer because it's high in nitrogen, so people started harvesting it, leaving the birds without the building material for their nests.

Source: *https://www.fastcompany.com/90129376/penguin-centered-design-is-a-real-thing*

7. Sketch and label what your design for a penguin nest would look like if you were working to engineer artificial nests for the African penguins.

8. Observe an artificial nest. Compare with a photo of an African Penguin in its guano burrow. If you were part of the design team that built these nests, what information would you want to have before engineering the nest?

Source: Saving Penguins https://www.savingpenguins.org/the-penguins-story

You can learn more about this exciting project by scanning the QR code to watch a 1-minute video. https://www.fastcompany.com/90129376/penguin-centered-design-is-a-real-thing

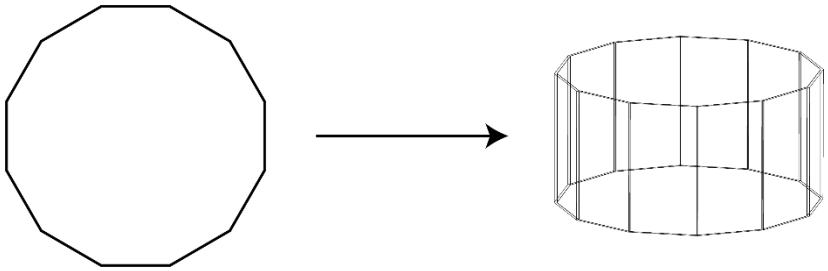
Kevin Graham is an associate curator for the Dallas Zoo and is project lead for the development of the artificial penguin nests. Hear from Kevin and learn more about the artificial nest program and the role the Dallas Zoo plays at https://www.savingpenguins.org/

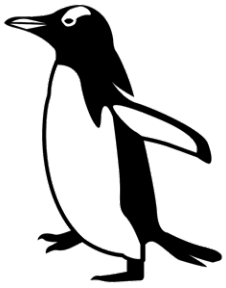
Take it Home

How much water is in the penguins' pool?
Let's come up with a strategy to figure this out. First let's examine the shape of the pool. Count the number of sides. There are six sides making up about half the pool. Let's assume the total volume would be the volume of a column with 12-sides. How do we calculate this volume? Look carefully and see if you can see what other simpler solid shape makes up this 12-sided solid shape. Discuss with a friend. There are 7.481 gallons in one cubic foot.

Hints:

- Compare the structure of the pool with the structure of the roof. What similarities do you see?
- Set up a proportion to estimate the distance from the pool walls to the pool center.





Outdoor Living

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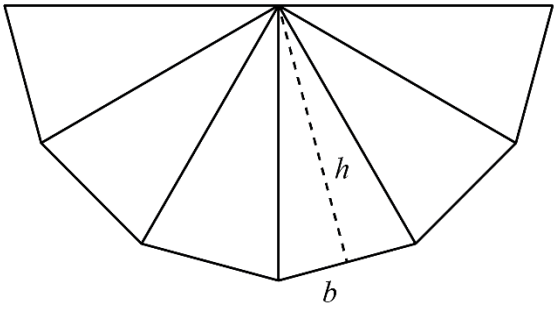
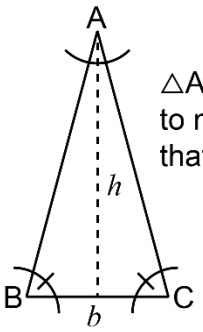
1. Look up at the roof of this enclosure. It doesn't cover the entire pool, providing for both a shady area as well as an open area for the penguins. The pattern you see above you consists of several triangles. The picture to the right highlights one of these triangles. What type of triangle do you think each one is – isosceles or equilateral?
   Hint: An isosceles triangle has two equal sides and angles. An equilateral triangle has three equal sides and three equal angles.
   Isoceles. They cannot be equilateral triangles because if they were, the six center angles would form a complete 360 degrees. Each angle in an equilateral triangle is 60 degrees.

*Photo SEQ Photo * ARABIC \r 1 1 - Closeup of the penguin exhibit roof, highlighting one of the triangles that make up the roof. PC: Jonathan Edquid*

2. A drawing of the roof is provided. Notice that the roof forms a straight line. Use it to help you calculate how many degrees the triangle was repeatedly rotated to make the roof. This measurement is equal to the measurement of ∡A.
   Note: It may be helpful to some learners to have a copy of the drawing cut into smaller pieces to manipulate to deepen their understanding of the triangle rotations.

   Hint: What is the degree measurement of a straight line? (180°)





△ABC is repeated to make the thatched roof

$b = 8$ *feet*
$h = 15$ *feet*

The 180° is divided into 6 sections for the 6 triangles
180°/6 = 30° rotation

3. Use your knowledge of triangles to label the measurements of ∡B and ∡C.
   Hint: What is the sum of the interior angles of a triangle? (180°)
   ∡B and ∡C *have the same measurements because this is an isosceles triangle (180°-30°)/2 = 75°*
4. If the Zoo needed to replace the roof, how much thatched material must be purchased? Use the measurements given on the diagram to calculate the amount of thatching needed.
   Hint: We want to know how much space the thatching takes up. What quantity is that? What is the formula for calculating that quantity? (This is area. The formula for area of a triangle is (1/2)(base)(height).
   Area of one triangle = (1/2)(8 feet)(15 feet) = 60 square feet
   Area of roof = 6(area of one triangle) = 360 square feet
5. African penguins spend most of their life in the water. The cool waters off the coast of South Africa, where the African penguins live, range in temperature from 41-68°F. The penguins will move ashore to breed, molt, and rest. What is the average temperature of these waters?
   (41+68 F)/2 = 54.5°F average water temperature
6. How would you go about estimating the volume of water in the penguin water system? What measurements would you need to take? What assumptions would you need to make in your calculation? Discuss with a partner.
   Hint: What shape is the water system? What height is the water level? How much water is in the penguins' pool?
   Answers will vary. Encourage learners to notice that the water system is made up of a polygon. If they count the number of sides on the visitor side, there are 6. This 6-sided structure seems to represent one half of the solid. So they can assume the water system is a 12-sided solid. Or they could assume it's a circle and use string to measure half the circumference of the circle. Encourage learners to take measurements they think they will need and to make sketches they will need. They can take measurements using arm span, foot stride, etc.

Artificial Nest Project

The number of African penguins has been dwindling for decades. There were once a million pairs of breeding birds, located primarily in South Africa and Namibia; now, there are only 25,000 pairs. This is mostly due to overfishing, climate change, and the harvesting of guano, or penguin poop. The latter has been especially detrimental: African penguins typically make their nests in heaps of dried guano that have been built up for decades, providing the right protection and temperature control to raise young chicks. But guano also makes good fertilizer because it's high in nitrogen, so people started harvesting it, leaving the birds without the building material for their nests.
Source: https://www.fastcompany.com/90129376/penguin-centered-design-is-a-real-thing.

7. Sketch and label what your design for a penguin nest would look like if you were working to engineer artificial nests for the African penguins.

Designs will vary.
Answers will vary.

8. Observe an artificial nest. Compare with the photo of African Penguin in its guano burrow. If you were part of the design team that built these nests, what information would you want to have before engineering the nest?

Source: Saving Penguins https://www.savingpenguins.org/the-penguins-story

Answers will vary. Encourage learners to discuss about what the goal of the project is. For example, we'd need real measurements of the guano nests to make sure the ones we engineer were the right size. The AZA design team obtained nest measurements that were taken from guano nests on Dassan Island in 1978 by researchers. They compared these measurements with the only remaining active guano nests in an extremely small portion of Bird Island and found the overall dimensions to be very similar to 40 years ago. This allowed them the confidence that the design aspects they put in place would meet the physical needs of the birds.

You can learn more about this exciting project by scanning the QR code to watch a 1-minute video.
https://www.fastcompany.com/90129376/penguin-centered-design-is-a-real-thing

Kevin Graham is bird supervisor for the Dallas Zoo and is project lead for the development of these artificial penguin nests. Hear from Kevin and learn more about the artificial nest program and the role the Dallas Zoo plays at https://www.savingpenguins.org/.

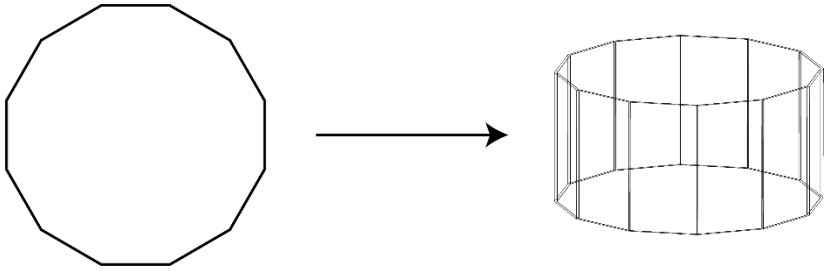
Take it Home

How much water is in the penguins' pool? Learners should measure or estimate the width of one side of the penguin pool and the depth of the water while at the zoo before attempting this challenge.
Let's come up with a strategy to figure this out. First let's examine the shape of the pool. Count the number of sides. There are six sides making up about half the pool. Let's assume the total volume would be the volume of a column with 12-sides. How do we calculate this volume? Look carefully and see if you can see what other simpler solid shape makes up this 12-sided solid shape. Discuss with a friend. There are 7.481 gallons in one cubic foot.

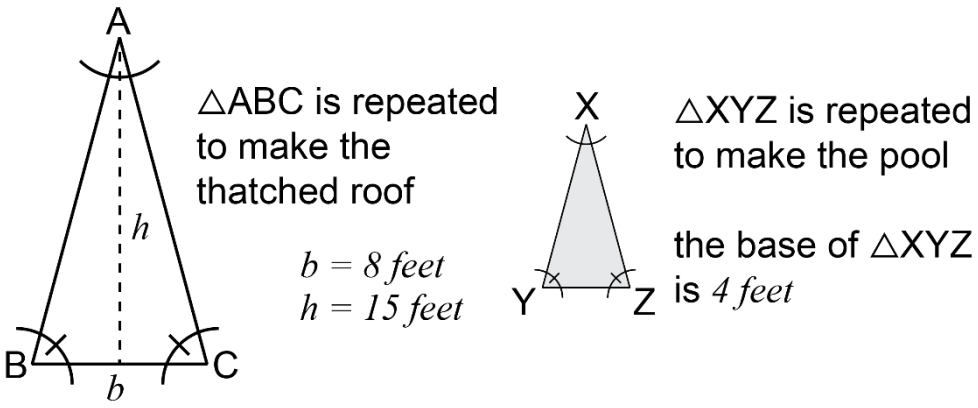
Hints:

- Compare the structure of the pool with the structure of the roof. What similarities do you see?

- Set up a proportion to estimate the distance from the pool walls to the pool center.



We can calculate the volume of the 12 triangular prisms that we can imagine making up the 12-sided shape.
Volume of 1 triangular prism = (area of triangle)(height of water in tank)
Vol of triangular prism = (1/2)(base)(height triangle)(height of water in tank)



The base of ⊿XYZ is 4 feet (as measured by the long side of a piece of paper).

Since ⊿XYZ and ⊿ABC have the same angle measurements, they are similar triangles and have the same proportions. Therefore, the ratio of base: height for each triangle is the same. We can set up a proportion to calculate the height (distance from pool wall to pool center) of ⊿XYZ.

$$\frac{8\ feet}{15\ feet} = \frac{4\ feet}{pc}$$

$$pc = \frac{4\ feet \times 15\ feet}{8\ feet} = 7.5\ feet$$

$$Vol_{pool} = 12 \times area\ of\ triangle \times height\ of\ water\ in\ tank$$

$$Vol_{pool} = 12 \times \frac{1}{2} \times 4feet \times 7.5feet \times 3feet = 540\ cubic\ feet$$

$$540\ cubic\ feet\ \times 7.481 \frac{gallons}{cubic\ foot} = 4039\ gallons$$

Going Further

Here is an article with a fun engineering project idea. The article is based on an interview with Kevin Graham, North American project lead for the African Penguin Artificial Nest Project and Dallas Zoo associate curator.
https://superscience.scholastic.com/issues/2017-18/030118/picky-penguins.html#770L