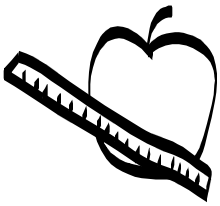


A Delicate Arch

Arches National Park Quarter

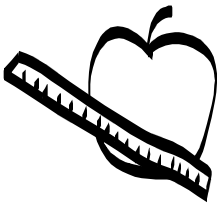
Grades Seven and Eight

OBJECTIVES

Students will solve problems involving the circumference of a circle. Students will solve problems involving scale drawings of geometric figures. Students will use research methods and create models to investigate practical problems and questions.

MATERIALS

- 1 overhead projector or equivalent technology (optional)
- 1 overhead transparency (or photocopy) of each of the following:
  - "Arches National Park Quarter" page
  - "Arches Formation Sequence" graphic organizer
- Copies of the following:
  - "Arches Formation Sequence" graphic organizer
  - "Arches Exit Slip"
  - "Arches and Semicircles" worksheet (2 pages)
  - "Arches and Scale" worksheet
  - "Arches Competition Score" worksheet
- 1 class map of the United States
- Locate texts that contain information on arches and Arches National Park, such as:
  - *Arches National Park by Day and Night* by Grant Collier
  - *The National Parks: America's Best Idea* by Dayton Duncan and Ken Burns
  - *Arches and Canyonlands National Parks Pocket Guide* by Damian Fagan
  - *Guide to National Parks of the United States* by National Geographic
  - *Moon Spotlight Arches and Canyonlands National Parks: Including Moab* by W.C. McRae, Judy Jewell
  - *Our National Parks* by David Mensch
  - *Our National Parks* by Readers Digest
  - *National Geographic Complete National Parks of the United States* by Mel White
- Locate texts that contain information on bridges and arch bridges, such as:
  - *How We Build Bridges* by Neil Ardley
  - *Bridges: A History of the World's Most Famous and Important* by Judith Dupre
  - *Encyclopedia of Bridges and Tunnels* by Stephen Johnson
- Chart paper, whiteboard or interactive whiteboard

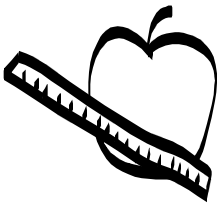


A Delicate Arch

- Computers with Internet access
- Assorted weights such as weights from a balance scale or weight set
- Pictures of arch bridges and arches from Arches National Park
- Calculators
- Rulers
- Graph paper
- Clay
- Clay modeling tools such as tooth picks, plastic spoons or ice pop sticks
- Index cards for numbering arches
- Parchment paper

PREPARATIONS

- Make an overhead transparency or equivalent of each of the following:
  - "Arches National Park Quarter" page
  - "Arches Formation Sequence" graphic organizer
- Make copies of each of the following:
  - "Arches Formation Sequence" graphic organizer (1 per student)
  - "Arches Exit Slip" (½ sheet per student)
  - "Arches and Scale" worksheet (1 per student)
  - "Arches and Semicircles" worksheets (2 pages, 1 each per student)
  - "Arches Competition Score" worksheet (1 per student)
- Locate texts that contain information on arches and the Arches National Park (see examples under "Materials").
- Locate texts that contain information on bridges and arch bridges (see examples under "Materials").
- Arrange to use the school computer lab for one or two sessions.
- Bookmark Internet sites that contain information about Arches National Park and arches, such as:
  - www.nps.gov/arch/index.htm
  - www.nps.gov/arch/photosmultimedia/geologyvideo.htm
  - www.recreation.gov/recAreaDetails.do?contractCode=NRSO&recAreaId=2573&agencyCode=128
- Locate pictures of arches in Arches National Park and examples of arch bridges.
- Check the "Arches Exit Slip" after Session 1 for clarification.
- Grade the "Arches and Semicircles" worksheet after Session 2.



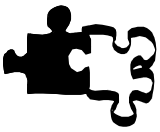
A Delicate Arch

GROUPINGS

- Whole class
- Individual work
- Pairs

CLASS TIME

Four 45- to 60-minute sessions, total 3 to 4 hours



CONNECTIONS

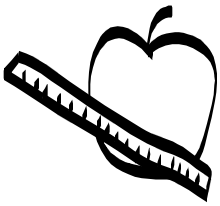
- Math
- Science
- Language Arts

NATIONAL STANDARDS/COMMON CORE

- Common Core State Standards (CCSS)
  - Math.Content.7.G.A.1: Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
  - Math.Content.7.G.B.4: Know the formulas for the area and circumference of a circle and use them to solve problems.
  - ELA.Literacy.W.7.2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- National Science Teachers Association (NSTA)
  - MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- National Council for Teachers of Mathematics (NCTM)
  - Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

TERMS AND CONCEPTS

- Quarter
- Span
- Obverse (front)
- Semicircle
- Reverse (back)
- Arch
- Circumference

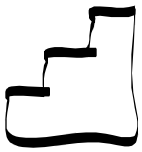


A Delicate Arch

BACKGROUND KNOWLEDGE

Students should have a basic knowledge of:

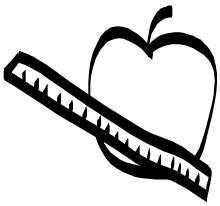
- Ratios
- Diameter
- Scale
- Circles
- Pi
- Formulas
- Hypothesis
- Proportions
- Fraction/decimal conversion



STEPS

Session 1

1. Display and examine the "Arches National Park Quarter" page. Locate this site on a class map. Note its position in relation to your school's location.
2. As background information, explain to the students that the United States Mint began to issue the quarters in the America the Beautiful Quarters® Program in 2010. By the time the program ends in 2021, there will be a total of 56 quarter designs. Each design will focus on a different national site—one from each state, territory and the District of Columbia.
3. Tell the students that the front of a coin is called the "obverse" and the back is called the "reverse." Have the students identify the images in the design. This design depicts Delicate Arch, a 65-foot freestanding natural arch. It is a widely recognizable Utah landmark, depicted on postage stamps and license plates. The Olympic torch relay for the 2002 Winter Olympics passed through this arch. The Lasal Mountains are visible in the background.
4. Have the students define the word "arch" (a curved formation with an opening formed by erosion and weathering). Have the students share what they know about Arches National Park. Take notes on chart paper if desired.
5. Display or have the students search the Arches National Park Web site at www.nps.gov/arch/index.htm. View some of the pictures of arches found on the site or in selected texts. Ask the students if they know how the arches were formed. Record answers on chart paper.
6. Distribute the "Arches Formation Sequence" graphic organizer to the students. Explain that they will be watching a short video on the formation of the arches and writing the steps in the formation of the arches on their "Arches Formation Sequence" graphic organizer. Review the definition of "sequence" and the sequence words on the graphic organizer.
7. Play the video at www.nps.gov/arch/photosmultimedia/geologyvideo.htm for the students or have them watch the video on their own device. Play the video more than once if necessary. Allow time for the students to complete the "Arches



A Delicate Arch

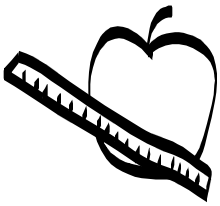
Formation Sequence" graphic organizer. Answers may include (especially the last five steps):

- Techtonic plates move, raising the Rocky Mountains
- Faulting and subsidence create the Paradox Basin
- Salt water floods the basin repeatedly
- Evaporation leaves salt layer (over 5,000 feet thick)
- Rock from mountain erosion covers the salt
- Pressure forces the salt to flow westward
- Flow is blocked by faults, forming salt wall 2 miles high
- Loose rock covers wall 1 mile thick
- Techtonics force the deeper rock to bend and form a dome
- Joints (cracks) form in the bent rock
- Colorado rivers erode the loose rock covering
- Water seeps through cracks and dissolves some salt
- Rock cover collapses, forming Salt Valley
- Rock erodes around the valley's edge, forming fins
- Fins erode, leaving sand between fins
- Carbonic acid wears away the rock, causing openings in weaker rock
- Weaker rock falls away, enlarging the openings
- Arches continue to erode (and collapse)

8. When the students have finished, complete the displayed "Arches Formation Sequence" graphic organizer.
9. Ask the students where else they have seen arches. Record their responses on chart paper or the board. Guide the students if necessary to include arch bridges.
10. Display some pictures from selected Web sites or texts of arch bridges. Emphasize the fact that arch bridges were one of the first bridge designs widely used. The Romans, for example, were well known for their use of arches in their bridge and building construction.
11. Have the students complete the "Arches Exit Slip."

Session 2

1. Review the Web sites, exit slips and charts from the previous session.
2. Distribute the "Arches and Semicircles" worksheets. Explain to the students that they will be treating all the arches as if they were semicircles rather than ellipses. Ask the students for the definition of "semicircle" (a half of a circle). Have the students record the definition and draw an example on page 1 of the "Arches and Semicircles" worksheet.



A Delicate Arch

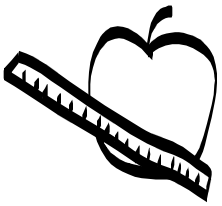
3. Review the definitions of "diameter," "radius" and "pi" with the students (see the answer key). Have the students write the definitions and draw the example on page 1 of the "Arches and Semicircles" worksheet.
4. Define "circumference" and give the formula for finding the circumference of a circle. Have the students write the definition and the formula on the worksheet.
5. Using the park Web site or a selected text, display some pictures of Tower Arch.
6. Read the sample problem. Have the students set up the equation and solve it.
7. Assign the problems on page 2 of the "Arches and Semicircles" worksheet to the students. Allow time for the students to solve the problems. When they finish, collect the worksheets so you can grade them.

Session 3

1. Return the graded "Arches and Semicircles" worksheets to the students. Review the pictures, definitions and formulas from the previous sessions.
2. Discuss the arches from Arches National Park. Explain to the students that they are going to construct arches from clay. Distribute the "Arches and Scale" worksheet and graph paper.
3. Review scale with the students. Explain to the students that they will use scale from the size of actual arches for their construction. Complete the "Arches and Scale" worksheet sample problems with the students.
4. Allow time to research the arches and calculate the scale for the clay arches.
5. Allow the students time to create the arches from clay.

Session 4

1. Take pictures of the completed arches to display on a bulletin board or space in the classroom. Explain to the students that they will have a voluntary competition to determine whose arch can hold the most weight.
2. Assign numbers and display the arches that will be part of the competition. Distribute the "Arches Competition Score" worksheet. Have each student write their hypothesis and share it with a partner. Have the students record the necessary information in the first 3 columns on the "Arches Competition Score" sheet.
3. Use weights and determine which arch can hold the most weight. Have the students record the results on the "Arches Competition Score" sheet. Have the students complete the reflection on the score sheet.
4. Display the winner of the competition. Have the students discuss their reflections and why the winning arch was able to hold more weight.
5. Have the students discuss reasons why the National Park Service would not want people to climb on the arches.



A Delicate Arch

ASSESSMENTS

- Use the "Arches and Semicircles" worksheets to assess the students' ability to find the circumference of a circle.
- Use the "Arches Competition Score" sheet to assess the students' understanding of using the scientific process.
- Use the "Arches Exit Slip" to assess the students' understanding of the formation of the arches.

ENRICHMENTS/EXTENSIONS

- Have students discuss variables that can increase the load-bearing capacity of arches, such as different densities of clay, using an armature or arch thickness.
- Have students build other types of bridges from other materials and compare the strength of the different bridges.
- Have students create a multimedia presentation about the arches in Arches National Park or about arch bridges. Include the dimensions of the arch or the bridge.
- Have students work backwards by measuring the arch and its span and dividing the two to determine if pi is always used to find the answer.
- Have students set up ratios of distance under the arch and the span (diameter). Compare the different ratios to determine if they are equivalent.
- Have students calculate length of arches based on their actual elliptical shape.

DIFFERENTIATED LEARNING OPTIONS

- Allow students to work in pairs or small groups on the building of the arches.
- Install the arches as a diorama with an illustrated background.
- Simplify the measurements in the problems.

Name _____

Arches Formation Sequence

Directions: Watch the video on the formation of the arches at Arches National Park. Write or draw five steps you observed in the chart below.

First

_____

_____

_____

_____

Then

_____

_____

_____

_____

Next

_____

_____

_____

_____

Then

_____

_____

_____

_____

Last

_____

_____

_____

_____

Name _____

Arches Exit Slip

What are the **3** most important things you learned about the formation of the arches at Arches National Park?

_____

_____

_____

What are **2** things you learned in constructing your own arch?

_____

_____

What is **1** question you still have about arches or Arches National Park?

_____

United States Mint Lesson Plans

Name _____

Arches Exit Slip

What are the **3** most important things you learned about the formation of the arches at Arches National Park?

_____

_____

_____

What are **2** things you learned in constructing your own arch?

_____

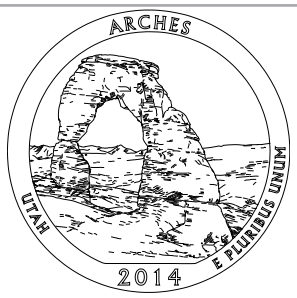
_____

What is **1** question you still have about arches or Arches National Park?

_____

Name _____

Arches Competition Score



Directions: Observe the different arches in the competition. Record the dimensions of each arch. Make a hypothesis about which arch will hold the most weight. Place weights on the arches and record the results. Answer the reflection question when the competition is over.

Hypothesis: Which arch will hold the most weight? _____

Arch	Span	Length	Total Weight	Place Order

Reflection: Why did the arch in first place hold the most weight?

_____

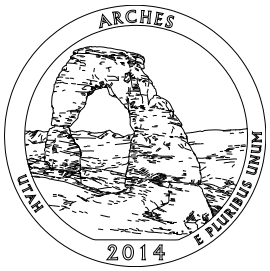
_____

_____

Name _____

Arches and Semicircles

Page 1



DEFINITIONS

Semicircle _____

_____

Diameter _____

_____

Radius _____

_____

Circumference _____

_____

Pi _____

_____

SAMPLE

Jason and Melissa hiked to the Tower Arch in Arches National Park. Tower Arch has an inner span of 92 feet at the bottom of the arch. If Tower Arch were a semicircle, how long would the circumference of the opening be?

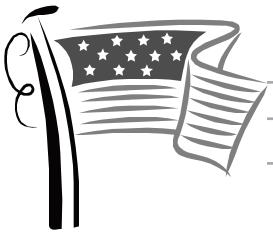
Draw a diagram of the arch and label the different lengths.

- Diameter
- Radius
- Height
- Circumference of the opening

Important information:

Set up an equation using the circumference of a circle.

Solve the equation to determine your answer.



Name _____

Arches and Semicircles
Page 2

Directions: Solve the following problems. Be sure to show your work.

1. Delicate Arch in Arches National Park is shown on the quarter. If it were a semicircle with a span of 33 feet, how long would the circumference of the opening be?

2. If a semicircular arch has a span of $3\frac{3}{4}$ feet, how long would the circumference of the opening be?

3. Wall Arch was the 12th largest arch in Arches National Park until it collapsed in 2008. If it had been a semicircle with a span of 71 feet, how long would the circumference of the opening be?

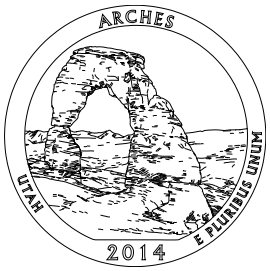
4. Landscape Arch in Arches National Park is said to be the longest natural rock span in the world. If it were a semicircle with a 290.8-foot span, how long would the circumference of the opening be?

5. Skyline Arch is on top of the rocks of Devil's Garden and can be seen from many areas of the park. If it were a semicircle and the arch had a span of 71.5 feet, how long would the circumference of the opening be?

Name _____

Arches and Semicircles

Page 1, Key



DEFINITIONS

Semicircle _A half of a circle_____

_____

Diameter _The distance through the center of something (such as a circle) from one side to the other_____

Radius _A straight line from the center of a circle or sphere to any point on the outer edge_____

Circumference _The outer edge of a shape or area _____

_____

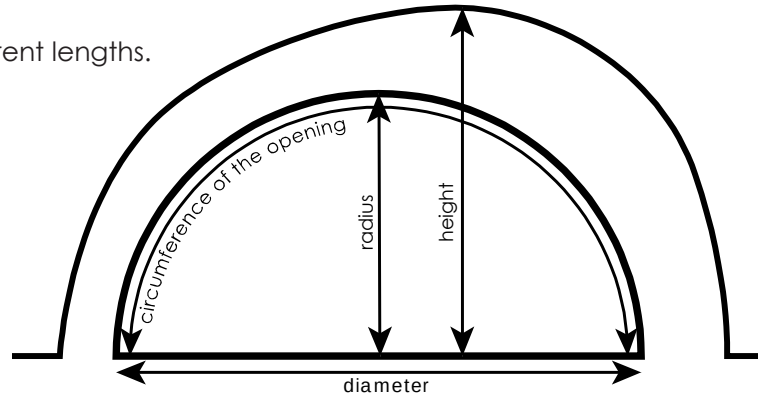
Pi _The symbol (π) denoting the ratio of the circumference of a circle to its perimeter; rounded to 3.14 (but computers calculate to more than 200 billion decimal places).

SAMPLE

Jason and Melissa hiked to the Tower Arch in Arches National Park. Tower Arch has an inner span of 92 feet at the bottom of the arch. If Tower Arch were a semicircle, how long would the circumference of the opening be?

Draw a diagram of the arch and label the different lengths.

- Diameter
- Radius
- Height
- Circumference of the opening



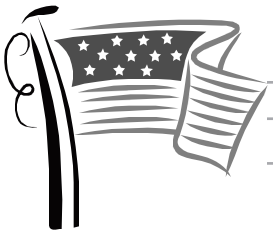
Important information:

Set up an equation using the circumference of a circle.

C = πd	Circumference equals pi times diameter.
C = 3.14 x 92	Pi is 3.14. The diameter is 92 feet.

Solve the equation to determine your answer.

C = 3.14 x 92	
C = 289.8	Multiply for full circumference.
289.8 / 2 = 144.9 feet	Divide in half for semicircle circumference.



Name _____

Arches and Semicircles

Page 2, Key

Directions: Solve the following problems. Be sure to show your work.

1. Delicate Arch in Arches National Park is shown on the quarter. If it were a semicircle with a span of 33 feet, how long would the circumference of the opening be?

   C = 3.14 x 33 = 103.62 / 2 = 51.81 feet

2. If a semicircular arch has a span of 3¾ feet, how long would the circumference of the opening be?

   C = 3.14 x 3.75 = 11.78 / 2 = 5.89 feet

3. Wall Arch was the 12th largest arch in Arches National Park until it collapsed in 2008. If it had been a semicircle with a span of 71 feet, how long would the circumference of the opening be?

   C = 3.14 x 71 = 222.94 / 2 = 111.47 feet

4. Landscape Arch in Arches National Park is said to be the longest natural rock span in the world. If it were a semicircle with a 290.8-foot span, how long would the circumference of the opening be?

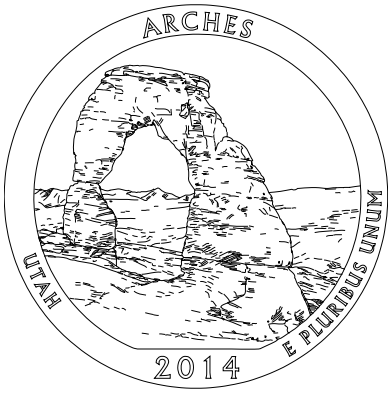
   C = 3.14 x 290.8 = 913.11 / 2 = 456.56 feet

5. Skyline Arch is on top of the rocks of Devil's Garden and can be seen from many areas of the park. If it were a semicircle and the arch had a span of 71.5 feet, how long would the circumference of the opening be?

   C = 3.14 x 71.5 = 224.51 / 2 = 112.26 feet

Name _____

Arches and Scale



Directions: If you want to make a scale drawing or a model of an arch, you must set up a proportion and solve it for each measurement. Use the process below, which solves a proportion for the height of Tower Arch, to calculate the span of the arch.

HEIGHT

For the proportion on your graph paper, 1 inch will be equal to 10 feet. If the actual height of Tower Arch is 43 feet, what is the height on the graph paper in inches?

Step 1: Set up a proportion

1 inch is to 10 feet as x inches is to 43 feet.

(Inch) $\frac{1}{10} = \frac{x}{43}$ (Scale height in inches)
(Feet) (Actual height in feet)

Step 2: Solve the proportion

$1 * 43 = 10 * x$
$43 = 10x$
$4.3 = x$

The arch's scaled height on graph paper is 4.3 inches.

SPAN

Now solve the proportion for the arch's 92-foot span in the scale drawing.

Step 1: Set up a proportion

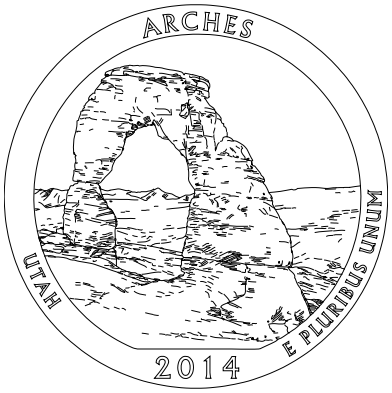
Step 2: Solve the proportion

The arch's scaled span is _____ inches.

You can now draw your arch to scale on your graph paper and make your clay model from the drawing.

Name _____

Arches and Scale
Key



Directions: If you want to make a scale drawing or a model of an arch, you must set up a proportion and solve it for each measurement. Use the process below, which solves a proportion for the height of Tower Arch, to calculate the span of the arch.

HEIGHT

For the proportion on your graph paper, 1 inch will be equal to 10 feet. If the actual height of Tower Arch is 43 feet, what is the height on the graph paper in inches?

Step 1: Set up a proportion

1 inch is to 10 feet as x inches is to 43 feet.

(Inch) $\frac{1}{10} = \frac{x}{43}$ (Scale height in inches)
(Feet) (Actual height in feet)

Step 2: Solve the proportion

$1 * 43 = 10 * x$
$43 = 10x$
$4.3 = x$

The arch's scaled height on graph paper is 4.3 inches.

SPAN

Now solve the proportion for the arch's 92-foot span in the scale drawing.

Step 1: Set up a proportion

1 inch is to 10 feet as x inches is to 92 feet.

(Inch) $\frac{1}{10} = \frac{x}{92}$ (Scale span in inches)
(Feet) (Actual span in feet)

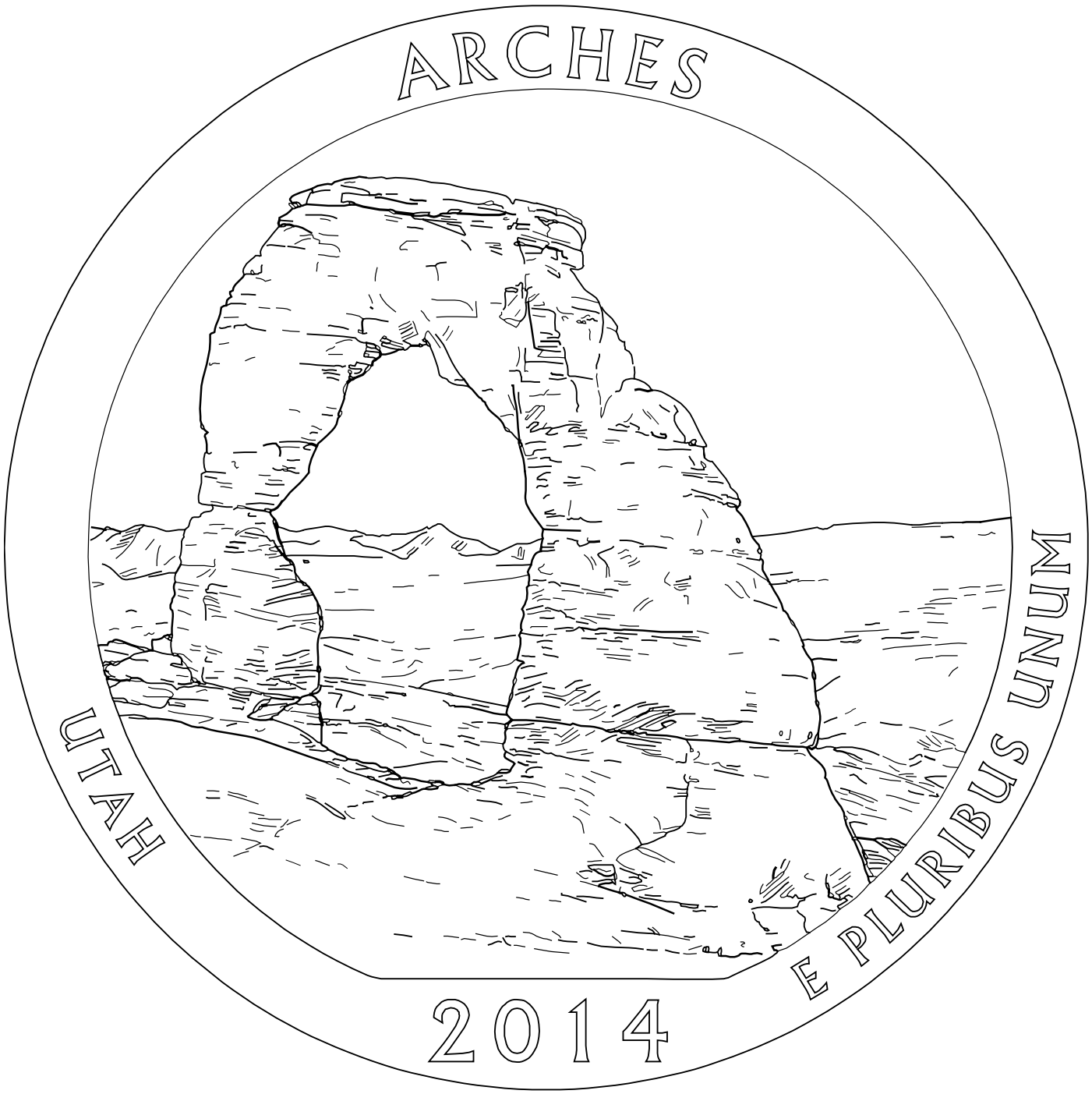
Step 2: Solve the proportion

$1 * 92 = 10 * x$
$92 = 10x$
$9.2 = x$

The arch's scaled span is 9.2 inches.

You can now draw your arch to scale on your graph paper and make your clay model from the drawing.

Arches National Park Quarter



The United States of America