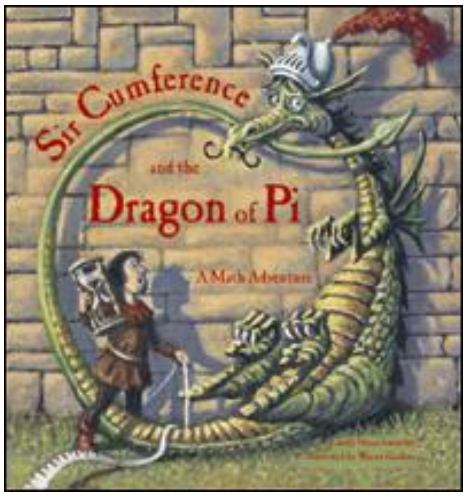
The Circle's Measure



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Modified from original lesson plan from
Utah Education Network

Overview

Students will learn about the connection between the circumference and diameter of circles.
Students will understand the concept known as Pi.
Students will estimate and calculate the circumference and the area of circles.
Students will become familiar with geometry vocabulary.
Students will differentiate between and use appropriate units of measure.

Mathematics Benchmarks

3-4 program

Data Analysis and Probability

A. Gather and organize data from surveys and classroom experiments, including data collected over a period of time.

Mathematical Processes

A. Apply and justify the use of a variety of problem-solving strategies; e.g., make an organized list, guess and check

D. Use mathematical strategies to solve problems that relate to other curriculum areas and the real world; e.g., use a timeline to sequence events; use symmetry in artwork.

G. Use reasoning skills to determine and explain the reasonableness of a solution with respect to the problem situation.

5-7 program

Number, Number Sense and Operations

D. Use models and pictures to relate concepts of ratio, proportion and percent.

Measurement

C. Identify appropriate tools and apply appropriate techniques for measuring angles, perimeter or circumference and area of triangles, quadrilaterals, circles and composite shapes, and surface area and volume of prisms and cylinders.

Geometry and Spatial Sense

B. Draw circles, and identify and determine the relationships among the radius, diameter, center and circumference.

8-10 program

Number, Number Sense and Operations

G. Estimate, compute and solve problems involving real numbers, including ratio, proportion and percent, and explain solutions.

Measurement

C. Apply indirect measurement techniques, tools and formulas, as appropriate, to find perimeter, circumference and area of circles, triangles, quadrilaterals and composite shapes, and to find volume of prisms, cylinders, and pyramids.

Time

Depending on any extensions, time can be limited to on one (1) 45-60 minute class.

Materials:

For teacher:

- *Sir Cumference and the Dragon of Pi: A Math Adventure*
- *The Circles Measure* overhead
- *Saving Sir Cumference* overhead

For each group:

- Several circular objects (e.g., soda cans, records, CD's, wastebaskets, paper plates, coins, etc.) You may ask students to bring objects from home.
- 1 recipe Dragon's Breath: 1 Erlenmeyer flask filled with 100 ml of water and 2 drops of green food coloring, sealed with a rubber stopper. Attach a copy of "The Circle's Measure" to each flask.
  Note: If flasks are not available, you may use sealed jars or bottles.

For each student/ group:

- *Saving Sir Cumference* worksheet
- Measuring tape (metric), or measuring sting
- Pencil
- String, yarn or drywall tape
- Centimeter grid paper

Additional Resources

Books

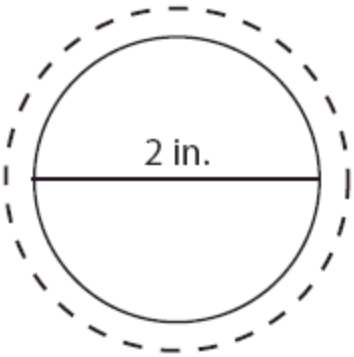
- *Fractals, Googols and Other Mathematical Tales*, by Theoni Pappas; ISBN 0933174896
- *Sir Cumference and the First Round Table: A Math Adventure*, by Cindy Neuschwander and Wayne Geehan; ISBN 1570911606
- *Sir Cumference and the Dragon of Pi: A Math Adventure*, by Cindy Neuschwander and Wayne Geehan; ISBN 1570911649
- *Sir Cumference and the Great Knight of Angleland: A Math Adventure*, by Cindy Neuschwander and Wayne Geehan; ISBN 157091169X
- *How Big Is a Foot?*, by Rolf Myller; ISBN 0440404959

Background for Teachers:

In this lesson, students make a valuable connection between the circumference and diameter of circles. For any given diameter, the circumference of the object is diameter x π. This relationship is often expressed in the formula,

Circumference = pi x diameter
or
$c = \pi \times d$

Thus, if an object has a diameter of 2 in., the circumference of that object is approximately 6.28 in.



circumference = 2 x π
= 6.28 in.

Pi (π) was probably discovered sometime after people started using the wheel. The people of Mesopotamia (now Iran and Iraq) certainly knew about the ratio of diameter to circumference. The Egyptians knew it, as well. They gave it a value of 3.16. Later, the Babylonians figured it to 3.125. But it was the Greek mathematician Archimedes who really got serious about the ratio. He was the one who figured that the ratio was less than 22/7, but greater than 221/77. But pi wasn't called "pi" until William Jones, an English mathematician, started referring to the ratio with the Greek letter pi, or "p", in 1706. Even so, pi really didn't catch on until the more famous Swiss mathematician, Leonhard Euler, picked up on it in 1737. Thus, pi evolved through the contribution of several individuals and cultures.

Before beginning this activity, students should understand how to identify and measure the diameter and circumference of an object. They should also be familiar with metric and standard units of measurement.

Instructional Procedures:

Invitation to Learn
Arrange students in groups of three to four. Introduce *Sir Cumference and the Dragon of Pi*. Have students listen carefully to the story as you begin reading (pages 1-12 only).

Instructional Procedures

1. Abruptly stop the book and display The Circles Measure (overhead) for the class to read. Tell the students that instead of continuing the book, it is their job to solve the riddle and save Sir Cumference before he is slain by the knights.
2. Carefully reveal the Erlenmeyer flasks and place one flask near each group of students. Tell the students not to touch the flasks.
   Note: The students will be curious to know what is in each flask. Allow them to remain curious and reassure them that they will soon learn more about the flasks.

3. Give a Saving Sir Cumference worksheet to each student. Students complete Part A individually (Think). Encourage students to share their ideas and thoughts with their group (Pair). Allow 2-3 students to discuss their ideas with the class (Share).
   Note: This time dedicated to class discussion is critical. If a student does not bring up circumference and diameter, help them make this connection.
4. After the students understand that circumference and diameter are the two measurements involved in this problem, open *Sir Cumference and the Dragon of Pi* and tell the students that we will now read to find out what the boy, Radius, has done (pages 14-18 only).
5. By now the students may understand that there is a connection between diameter and circumference and that the answer is very close to 3. If this is not generally understood, hold a brief discussion before moving on.
6. Experiment with various objects to find the true answer to the problem. Direct the students' attention to Part B of the worksheet. Model how to measure the circumference and diameter of an object *in centimeters* and record the data in a table. (String or yarn may be used to wrap around circular objects and then held against a measuring tape.) Give several objects to each group of students. Students may work in groups to make the measurements, but should record the data individually.
7. Circulate around the room as groups work on the tables, taking notes on the various strategies students are using. When a group finishes, direct them to begin Part C of the assignment.
   Note: You could save some time by doing Part C as a class. Create a coordinate grid on a large piece of grid paper prior to the start of the activity. Have each group plot their data points on the class graph.
8. When most students have completed Part C, regain the attention of the class and discuss their findings. Guide the discussion by asking the following questions:
   a. By looking at the data, can you see any relationships? (The graphs should be very close to a straight line, which indicates that there is a direct/linear relationship between diameter and circumference.)
   b. How much bigger is the circumference than the diameter? (About three times bigger.)
9. Encourage the students to find a more exact number. After the students have identified a more exact number (3.1 or 3.2) you may introduce the symbol π (*pi*) to represent the ratio of the circumference to diameter of a circle.

   $$\pi \approx \frac{22}{7} \approx 3.14$$

   Note: For our purposes, 3.14 is a close enough approximation of pi, however, for the curious student, the value of π to nine decimal places is 3.141592654. This is still an approximate of the number whose decimal expansion has no end.
10. Have students test their claim by finding the diameter and circumference of a new object. Then complete Part D.

Optional: After students have solved the problem, tell them that they have found the dose required to change Sir Cumference back into a knight. Reward the students by reading the remainder of the book.

Extensions:

- Challenge students to write their own mathematical poem or riddle using the words *circumference*, *pi*, and *diameter*.
- Hold a *pi* competition. Challenge students to memorize as many digits of *pi* as possible. One week later, ask students to write down the number *pi* as accurately as possible. The student(s) with the number written down correctly and with the most digits wins!
- National Pi Day is March 14th (3.14). March 14th is also Albert Einstein's birthday.
- Hand out five index cards to each student or group of students. Write the words *circumference, radius, diameter, area*, and *volume* on the board. Ask the students to write one word on the top of each card. Encourage students to use a thesaurus or other reference material to write synonyms, definitions, and examples of each word on the back of the card. Students then arrange the cards in a manner that makes sense to them. (The students may arrange alphabetically, from least to greatest, or cluster the cards in groups.) Have several groups present and justify their arrangements.

Family Connections

Encourage students to test their family members' knowledge of pi, diameter, and circumference the next time they eat pizza or pie.

Assessment Plan

- Make informal observations while students work in groups. Observe the ways in which they select and measure items. Make sure that they demonstrate a sound understanding of the concepts.
- Use the *Teacher Assessment Sheet* to keep a record of each student's level of understanding. This rubric focuses on concepts of reasoning, and is derived from the intended learning outcome for this activity.
- *Saving Sir Cumference* worksheets.

The Circle's Measure Labels

Copy onto cardstock, cut out and attach to Erlenmeyer flasks.

The Circle's Measure Measure the middle and circle around, Divide so a number can be found. Every circle, great and small— The number is the same for all. It's also the dose, so be clever, Or a dragon he will stay… forever…	**The Circle's Measure** Measure the middle and circle around, Divide so a number can be found. Every circle, great and small— The number is the same for all. It's also the dose, so be clever, Or a dragon he will stay… forever…
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Name ____

The Circle's Measure

Measure the middle and circle around,
Divide so a number can be found.
Every circle, great and

Saving Sir Cumference

Help Radius and Lady Di of Ameter save Sir Cumference! The answer to this problem lies in the poem. Can you solve the riddle?

Part A

Carefully read the poem, The Circle's Measure. Then answer the following questions:

1. What do you think is meant by " measure " the middle and the circle?

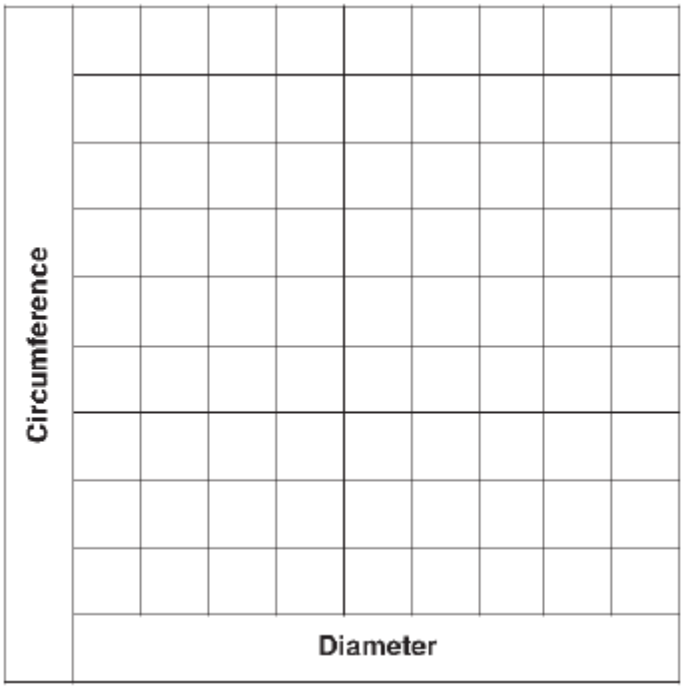
2. According to this poem, what two numbers should you " divide"?

Part B

Use a measuring tape to find the diameter and circumference of several objects. Discuss with your group how to record your data. Create a table below.

Part C

Use a piece of centimeter paper to make a coordinate graph like the one below. Use the horizontal axis for diameter and the vertical for circumference. Plot Data points for each object your group measured on the graph.



Part D

Study the table and your graph. Look for patterns and relationships that allow you to predict the circumference using diameter. Test your ideas on other circular objects. Once you think you have found a pattern, answer the question below:

1. What is the relationship between the diameter and the circumference of a circle?

2. What dose should radius give Circumference? How do you know this is the correct dose?

Teacher Assessment Sheet

As you observe students, add their name into the appropriate box below.

1 does not generalize from one situation to another has difficulty explaining the activity records answers to problems without checking for validity does not see patterns or relationships has difficulty getting correct answers and justifying answers	2 can generalize to a few situations can explain the procedures of the activity rarely checks for validity or requires reminders to do so has difficulty recognizing patterns and relationships sometimes struggles to get correct answers and justify them	3 can generalize to many situations can explain the procedures of the activity and higher reasoning often checks for validity recognizes patterns and relationships with guidance from others gets correct answers and but has difficulty justify them	4 can generalize to most situations can explain the procedures and his/ her reasoning almost always checks for validity independently recognizes patterns and relationships gets correct answers and can justify them	5 makes generalizations to all situations can explain procedures and his/ her reasoning always checks for validity of results independently recognizes patterns and relationships gets correct answers and can justify them clearly to other students

The Circle's Measure

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Divide so a number can be found.
Every circle, great and small—
The number is the same for all.
It's also the dose, so be clever,
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forever...

1-CENTIMETER GRID PAPER