

A Chording We Will Go

By *Bruce H. Hemp* for Blue Ridge Public Television
Fort Defiance High School

Grade Level: 8-12

Time Allotment: One 90 min. block

Overview: Students will explore the relative size of circular objects from the microscopic to the size of the sun. Prerequisites: Students should have a working knowledge of Geometer's Sketchpad, or be able to construct perpendicular bisectors. Students should also be able to interpret numbers written in scientific notation.

Subject Matter: Geometry, Space Science, ratio and proportions

Learning Objectives:

Given the chords of an arc, students will find the center of the circle.

Standards:

This lesson addresses the following Virginia SOL's which can be found at:

<http://www.pen.k12.va.us/VDOE/Instruction/Math/geometrycf.doc>

- G.10 The student will investigate and solve practical problems involving circles, using properties of angles, arcs, chords, tangents, and secants. Problems will include finding arc length and the area of a sector, and may be drawn from applications of architecture, art, and construction.
- G.11 The student will construct a line segment congruent to a given line segment, the bisector of a line segment, a perpendicular to a given line from a point not on the line, a perpendicular to a given line at a point on the line, the bisector of a given angle, and an angle congruent to a given angle.
- ES.4 The student will investigate and understand the characteristics of the Earth and the solar system.
- 6.14 The student will identify, classify, and describe the characteristics of plane figures, describing their similarities, differences, and defining properties.
- 6.16 The student will construct the perpendicular bisector of a line segment and an angle bisector.

Media Components:

Video/Technology

- *Math Vantage #10*: "Going Around in Circles" (available from BRPTV)
- Geometer's Sketchpad
- Computer with Internet access
- Smart Board and Science Gallery (found in Notebook section)

Web Sites:

- <http://www.nineplanets.org/>
- <http://school.discovery.com/lessonplans/programs/scale/>
- <http://commtechlab.msu.edu/sites/dlc-me/zoo/zqq0221.html>
- www.topscience.org

Materials:

For the Teacher:

- TV and VCR
- Smart Board and presentation device
- Geometer's Sketchpad loaded onto the computer(s)
- Handout: Ordering Distance with Sticky Tabs and Answer Key (TOPS Learning Systems, Canby, OR 97013) Permission to use this was given by Ron Marson, the author and publisher of the booklet Scaling the Universe, which contains this activity. For more information go to www.topscience.org.
- Masking Tape

For the Student:

- Flattened circular coffee filters or paper plates, one for each student or each pair of students. Or, you may give students a piece of paper with a fairly large circle drawn on it to simulate the plate. Ironing the coffee filters makes great circles.
- Compass and straight edge for each student or Geometer's Sketchpad.
- An arc of a broken plate for every pair of students. Arcs should be large enough so students can draw two chords on them. Do not use Corelle dinnerware- it shatters.
- Paper upon which to trace the broken plate arc.

Prep for Teachers

- Prior to teaching, have all Internet sites bookmarked and Geometer's Sketchpad loaded for easy access throughout the lesson.
- You should preview the video clip and cue *Math Vantage #10: "Going Around in Circles"* to the section 2:27 minutes after the beginning of the program where you hear the hostess, Ellen Withrow say, "Some of these can be a lot of fun" and you see the roller coaster. You will also see the word "Radical" written on the screen.
- Familiarize yourself with the lesson format and be sure to have all materials ready as listed in the materials section.
- When using media, provide students with a **FOCUS FOR MEDIA INTERACTION**, a specific task to complete and/or information to identify during or after viewing of video segments, websites, or other multimedia elements.
- Flatten paper plates by pressing down the edges with a wooden ruler or by ironing them.
- Cut out and prepare sticky tabs activity. Use only the ones that say "RADIUS" since this lesson deals with circles.

- Locate the *Planet Sizes* picture in *Solar System* folder in the Science Gallery of the Smart Board Notebook. Save the picture to a file so that students will have access to it if they are each using Geometers Sketchpad.

Introductory Activity: Setting the Stage

1. **Say:** “In the field of science, we need to understand the relative size of things. Some objects are very small, such as the radius of an atom, and other things are astronomically large such as the radius of the observable universe. The smallest objects are classified as being subatomic or microscopic; everyday objects that we can see and touch are on a human scale; larger objects and distances such as the radius of the moon or the distance to the planets are on a solar system scale and then the distances to the distant stars and the galaxies are measured using the astronomical scale. Different units such as microns, centimeters, kilometers, astronomical units and light years are used for each scale, but as long as we use the same units when comparing objects, we can understand their relative size.”
2. **Say:** “To help us understand and visualize the vast differences in sizes of objects in our world, we will attempt to order a set of objects from least to greatest according to the length of their radii.”
3. Follow the directions on the ORDERING DISTANCE with Sticky Tabs activity. Have students each take a tab and sort them from the shortest to the longest radius.
4. Check the accuracy of the tab placement with the DISTANCE TABS answer key.

Learning Activity Part 1

Provide a Focus for Media Interaction by saying: “All of these objects that we have sorted have been classified according to the size of their radii. In order to perform this next activity, we will need to know additional geometric terms associated with circles.”

1. Use the cued video, *Math Vantage #10 “Going Round in Circles”*.

Provide a Focus for Media Interaction by saying: “Today we are going to study circles and learn a bit more about their properties. We will be viewing a portion of a video that describes some of the terms we will be using today. I want you to look and listen for some of the curves used at an amusement park and tell me why roller coasters no longer follow a circular path.”

PLAY *Math Vantage #10, “Going Round in Circles”* and **PAUSE** after you hear Ellen say “Good thing they redesigned roller coasters into teardrops.”

ASK: “So, what were the shapes used and why didn’t circles make good roller coasters?” (teardrops, spirals, cork screws, and circles; the circular roller coaster lost speed at the top of its climb and caused upside down riders to almost fall out of their seats)

2. **Provide a Focus for Media Interaction** by saying: “Please listen as Ellen describes how a circle is created.” **RESUME** video and **PAUSE** when you hear Ellen say “Take a center point and a fixed distance. The circle is the path of moving points that are always that distance, which is called the radius, from the center point.”

ASK: “How do you create a circle?” (take a center point, and a fixed distance and create a path of points that are a fixed distance from the center)

3. **Provide a Focus for Media Interaction** by saying: “Now I want you to be able to tell me what part of a circle is called?” **RESUME** video and **PAUSE** the video when you hear Ellen say, “The path of this ride is just part of a circle. The path is called an arc. It’s time to rock”.

ASK: “So what is a part of the circle called?” (an arc)

4. **Provide a Focus for Media Interaction** by saying: “Listen to the next segment so you will be able to define a chord and central angle.” **RESUME** video and **PAUSE** the video when you hear Ellen say, “The straight line between where a rider is on one side of the arc to the other side, is a chord. The two radii from the center to the end points of the chord create what is called a central angle.”

ASK: “What is a chord?” (the straight line between two points on the circle) “What is a central angle?” (the central angle connects the center of the circle to the ends of the chord)

5. **Provide a Focus for Media Interaction** by saying: “I want you to listen for three final terms. First, what is the name of the chord that passes through the center of the circle, second, what is half of a circle called, and third, what type of arc is larger than 180 degrees?” **RESUME** video and **STOP** the video when you hear Ellen say, “The arc is getting bigger and bigger and bigger it is now a half circle or a semicircle and the chord is now a diameter passing through the center of the circle. We can turn that into a full 360-degree spin; now that’s a major arc.”

ASK: “What is the chord going through the center of a circle called?” (diameter) “What is half of a circle called?” (semicircle) “What is an arc that is larger than 180 degrees called?” (a major arc)

Learning Activity Part 2

A. Compass and Straight Edge Construction

- Hand students a flattened circular coffee filter or paper plate and ask them to brainstorm about how we could determine the size of the plate, its radius, and the center. (Accept all answers)
- Show students how to construct the perpendicular bisector of two chords and discover that the intersection of the bisectors is the center of the circle.
Step 1: Using a ruler, draw two chords on the filter, plate, or circle.
Step 2: Using a compass, construct a perpendicular bisector of each chord.
Step 3: Extend the perpendicular bisectors until they intersect. This is the center of the circle.
Step 4: Construct a segment from the center of the circle to a point on the circle. This is the radius. Measure the length of this radius.

B. Geometer’s Sketchpad Construction

- Demonstrate the same construction using Geometer’s Sketchpad.
Step 1: Draw a circle with the circle tool.
Step 2: Put 4 points on the circle; connect each pair of points with a segment so that you have two chords drawn.
Step 3: Highlight one chord, and construct the midpoint.
Step 4: Highlight the midpoint and the chord; construct the perpendicular bisector.
Step 5: Repeat steps 3 and 4 for the second chord.
Step 6: Identify the intersection of the perpendicular bisectors. This is the center

of the circle.

Step 7: Highlight the center and one of the points on the circle; construct the segment. This is the radius. Highlight the radius and measure its length.

Step 8: Drag the chords and notice that the intersection of the perpendicular bisectors is still at the center of the circle.

Learning Activity Part 3:

- Tell students that it is easy to find the center of a circle if we have the entire circle, but how can you find the radius (and therefore determine the size of the circle) if you only have a piece of the circle?
- Show a broken piece of a plate and have students brainstorm ways to figure out how big the original plate was.
- Trace the arc of the plate on a piece of paper and have students do the constructions described in Learning Activity Part 2 A, steps 1-4.
- After locating the center, measure the radius.

Culminating Activity:

Say: “Now that we can determine the size of objects we can pick up and hold, how would you find out how large something is that we can’t touch? How large, for example, is Jupiter? Saturn? The Sun?”

Go to the Smart Board Gallery, open the Science Folder then click on the *Solar System* and open the image titled, *Planet Sizes*. Show students the picture of the solar system. Copy the picture into Geometer’s Sketch Pad (right click on the picture and go to “Properties” then deselect “Arrow Selectable” to freeze the picture so that you can perform Geometer’s Sketchpad commands on the picture.) Next, have students find the center and radius of several of the larger planets such as Saturn and Jupiter by performing constructions on the planets as described in Learning Activity Part 2 B. Measure the radii of these planets and have students find the radial ratio of Saturn to Jupiter. Compare answers. Then have students go to <http://www.nineplanets.org/> and research the actual diameters (or radii) of the planets on which they did their constructions. Have students find the ratio of the researched radii of Saturn to Jupiter and compare the ratio of their constructed radii, to the researched radii.

Note: *How close were they? (The constructed radial values I got with Sketchpad were: Saturn: 1.84 cm, Jupiter 2.21 cm and the Sun was 21.58 cm. The ratio of Saturn to Jupiter was $1.84\text{cm} / 2.21\text{cm} \approx 0.83$.) The ratio of the radii (half the cited diameter from nineplanets.org) is $60268\text{ km} / 71492\text{ km} \approx 0.84$. Of course the measured sizes will vary depending on how you have oriented and dragged the picture into Geometer’s Sketchpad but the ratios should be close.*

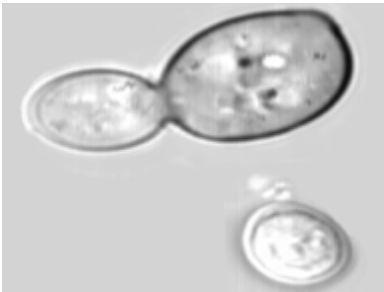
Cross Curricular Extensions:

Biology:

Suppose now we are looking for the measurement of very, very small circles. Using the Digital Blue microscope hooked to the smart board, find a very small circular object such as dissolved yeast molecules that cannot be seen with the naked eye. Copy the image of it from the microscope camera into Geometer’s Sketchpad and repeat the construction of

the perpendicular bisectors of two chords. Or if you do not have a microscope, go to this web site and copy the yeast image into Geometer's Sketchpad and find the radius of the circular image in the lower left corner. Use the fact that the entire image width is 24 microns (or 24 micrometers; one micrometer is 1×10^{-6} meters) to determine the radius of the yeast molecule.

<http://commtechlab.msu.edu/sites/dlc-me/zoo/zqq0221.html>



Art:

Have students use circles in art and find the center of the circle.

History:

Have students determine the usefulness of the wheel and its impact on society.

Physics:

Discover the properties of circular motion, or planetary motion.

Mathematics:

<http://school.discovery.com/lessonplans/programs/scale/> Use this site to learn about scaling and performing calculations using scientific notation.

Community Connections:

- Have an archeologist come visit the class and discuss what stories fragments of pottery can tell us.
- Invite a biologist to come speak to the class about cell structure and discuss how the sizes of microscopic organisms are determined.
- Have an astronomer visit and discuss the astronomical scale of the universe.