

Discovering Pi Using Tape Measures, Cabri Jr., and the TI-Navigator Teacher Instructions

In this activity, students will measure the circumference and diameter of several round objects. Then students will use Cabri Jr. to construct the diameter of a circle & measure the circumference and diameter of the constructed circle. They will send in their measurements using the TI-Navigator Activity Center and discover the relationship between the circumference and diameter. Students will note why all student-measured points do not lie exactly on a line and why all Cabri-measured points do lie exactly on a line. Then they will use the Manual Regression function of the calculator to fit the points to the line $y=\pi x$, or $C=\pi d$.

Student Handout, Section I. Have students write responses to the questions in the first section. Spend a few minutes letting them share responses with the whole class.

The question about the circular disk is from the 1996 12th grade NAEP Assessment. Information from the question from the NAEP website is included below.

Source: Finding the center of a circular disk, NAEP website,
<http://nces.ed.gov/nationsreportcard/about/>

Scoring Guide

Solution: Four possible correct responses are listed below:

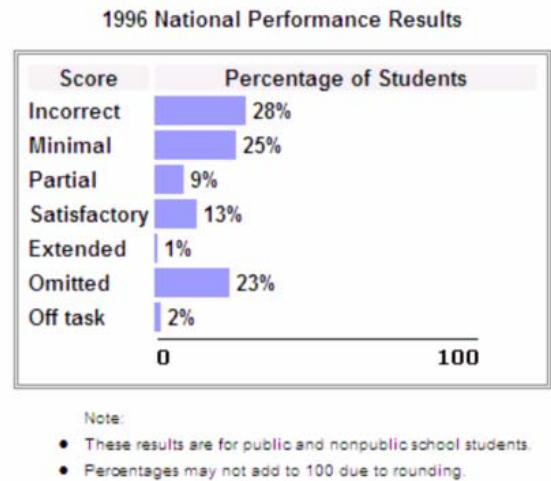
- Fold the disk in half two different ways. The intersection of the fold lines is the center of the circle. Folding the disk into semicircles causes the folds to be diameters. Since both diameters have to contain the center, the point they have in common is the center.
- Fold the disk to form a diameter and then locate the midpoint of the diameter by folding it to bisect the diameter. The midpoint of the diameter is the center of the circle.
- Fold a chord and then fold the chord in half. Repeat with another chord. The second fold is the perpendicular bisector of the chord and passes through the center. The point where the perpendicular bisectors of the 2 chords intersect is the center.
- A description of a ruler and compass construction similar to c above, i.e., the perpendicular bisector of 2 chords.

In this question, a student has to describe a geometric process for finding the center of a circle. The student is given a circular disk to use as an aid in answering the question. Geometric properties, definitions, and principles are to be used in describing the process for finding the center of a circle. Full credit is earned when a complete process is described. Varying levels of partial credit are earned depending on how much of the process the student is able to correctly communicate.

Score & Description

- Extended: Locates the center by folding or compass and straight edge construction and explains clearly and completely what geometric properties lead to the decisions involved in the method chosen.

- Satisfactory: Locates the center by folding or by compass and straight edge construction and gives an explanation that describes the procedure but does not include formal geometric principles or does not use appropriate terminology.
- Partial: Locates the center by folding or describes a compass and straight edge construction of the perpendicular bisectors of 2 non-parallel chords; explanation may be incomplete or incorrect. OR Explains a drawing of 2 diameters or the perpendicular bisector of 2 non-parallel chords; explanation must be complete and correct.
- Minimal: A response that shows a line that appears to include the center of the circle; e.g., a diameter or the perpendicular bisector of a chord. No explanation required.
- Incorrect: Incorrect response.



Student Handout, Section II. I have used this part of the activity in my classroom for several years. We have always called it “Round-Up Day.” Students bring round food to measure (and eat) such as round crackers, cookies, bagels, snack cakes, hard candy, etc. Students who dress western-style get a few bonus points. Alternately, one could have students measure a variety of round lids or other round objects. Note: In the past, I had a 3rd column for the ratio of circumference to diameter. I got groups of students to find the average of the ratios for about ten measured objects; only a few usually realize that their answer should be close to π . When I check their list, I look for items for which the ratio is obviously off (this usually happens on small objects) and have students measure those items again, if there is time. This activity is now much-enhanced with the TI-Navigator System!

Student Handout, Section III. In the next section of the activity, students will measure the circumference and diameter of a circle constructed in Cabri Jr. Depending on the time you have, you could have students construct the diameter of a circle themselves (see Activity: Constructing a Diameter of a Circle).

If you do not have time for students to construct the circle and diameter, then use the Navigator to force send the Application Variable “Pi.8xv” to students (**Tasks/Send to Class/select file/select students/force send**). Students should **quit** the TI-Navigator Home Screen so they can go into **Cabri Jr** and **F1/Open PI**. If there is time, you could **F1/Undo/Explore** and press the right arrow through each step of the construction so that students can review how to construct the diameter of the circle.

Now that students have opened or constructed the circle on their calculator, they need to make the circle a different size from other students in their group. Have every student make the solitary point on the circle “dance.” They should press **ALPHA** to grab the point and make their circle smaller or larger with the arrow keys. Once each student’s circle is a different size from the others in the group, they should press **ENTER** to drop the circle and record the circumference and diameter. Change the size of the circle again to record a second set of data.

Student Handout, Section IV. Have students exit Cabri Jr., execute Navnet and select **1** for Activity Center. As the teacher, you should go into Activity Center and load Round-up.act.

If you do not have the file, the activity has been configured to the following.

Contribute: Lists

Configure List Properties: See picture at right.

Configure Plots: See picture at right.

You can decide whether or not you want to allow students to resubmit their lists. When I did this activity with my students, I found that a few students made an error when they typed in their data, and if I had allowed them to resubmit their lists, they could have corrected their typing mistakes. Instead, these data points turned into outliers in our set of data.

Select the **List-Graph** tab. Start the activity. Have students enter their data in the appropriate lists and **send**. If the window in Activity Center is not appropriate, then **View/Zoom Stat** for an appropriate window.

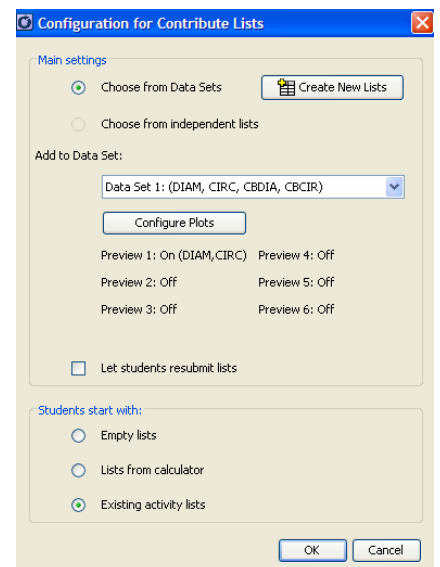
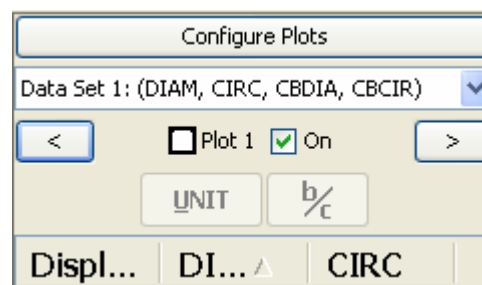
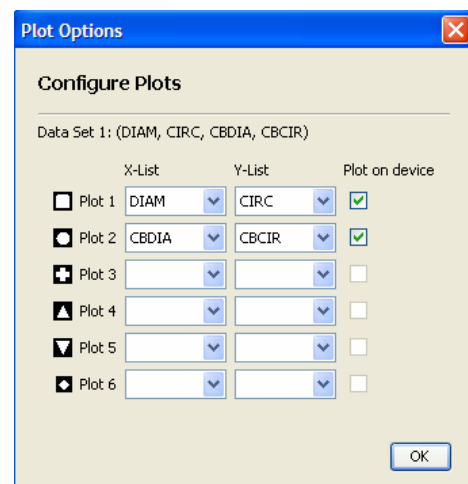
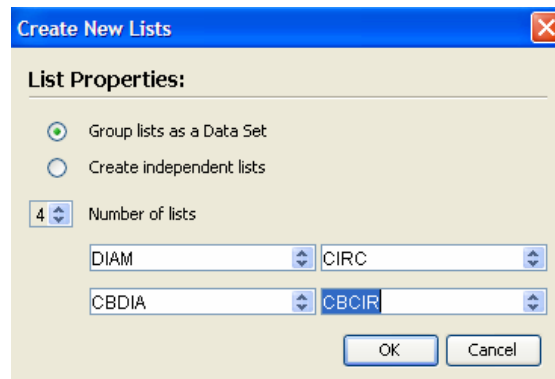
As students begin sending in their data, they will see it showing up on the graph. They will probably notice that the data is linear.

All of the data will be graphed. You can turn off one of the plots by toggling the On switch (see picture at right). Switch to the other plot by pressing either arrow.

If you turn plot 1 off, students should notice that the Cabri-measured data are all on the same line. If you turn plot 1 back on and plot 2 off, students should notice that their measured data have a basic linear shape, but do not all lie on the exact same line. Take the opportunity to discuss error in measurement as the major reason that the data does not lie exactly on the line.

Student Handout, Section V. Stop the activity and reconfigure so that students start with **existing activity lists**. Then start the activity again. The data that you have collected from the class will be sent to the class. If students press PLOT, select Plot1 & DRAW, the CIRC vs. DIAM plot will be turned on for the students on their individual calculators. If students press PLOT, select Plot2 & DRAW, the CBCIR vs. CBDIA plot will be turned on for the students on their individual calculators.

Have students QUIT the Navigator Activity Plot & QUIT NavNet. Then have them go into their $Y=$ editor and clear or turn off any functions they have entered. Press **GRAPH** to view whichever plot you chose. To create the manual line of best fit, press **STAT** \blacktriangleright **ENTER** to create the line of Manual-Fit. Ask students how many points are required in Euclidean geometry to create a



unique line. They should move their cursor to one of the points on the **line of best fit** for the data and press **ENTER**. Then they should move their cursor in any direction to a second point on the **line of best fit** and press **ENTER**. The manual-fit line will appear in the top corner of their screen. They can type in a different slope or y-intercept to better fit the line to the data. When the slope is highlighted, type in the new number for the slope and press **ENTER**. Press the left or right arrow key to highlight the y-intercept, and type in a new number for it. You might ask students what the circumference of a circle with a radius of zero would be so they can see that the line should have a y-intercept of 0.

The line $y=\pi x$ or $C=\pi d$ should be the line of best fit. As the teacher, you can take screen captures of the students' calculators as they are working on their Manual-Fit. Help students understand that for every unit the diameter increases, the circumference will increase by π . The rate of change of the circumference to the diameter is π . π is a ratio of the circumference to the diameter.

As the teacher, you can click on the **Graph-Equation** tab in the Activity Center and add **$y=\pi x$** to the equation list.

Student Handout, Section VI. I usually have students complete the real-world problems outside of class.

Student Handout, Section VII. Since we have talked about how we represent a line in the x-y coordinate plane, I use the opportunity to talk about how we represent a circle in the x-y coordinate plane. Cabri Jr. is a great way to introduce students to this representation. The activity from the TI-Explorations Series is referenced below.

Related Activities: TI Activities Exchange, Exploring the Diameter and Circumference of a Circle, from Getting Started with Geometry & cabrijr.com. In this activity, students draw the line containing the center of the circle and a point on the circle instead of actually constructing the diameter. Students also calculate C/d on the screen so they can see that C/d remains constant (and π) as they change the size of the circle.

TI Activities Exchange, Equations of Circles, Activity 29 from Exploring Mathematics with the Cabri Jr. Application. In this activity, students explore circles in a plane. They investigate the relationship between the equation of a circle, the length of its radius, and the coordinates of its center.

Jennifer Wilson
Northwest Rankin High School
jwilson@rcsd.ms

Objectives: Use arc, angle, and segment relationships to find unknown measure related to circles.

Solve real-world or mathematical problems including perimeter, circumference, and area. Recognize and write the equation of a circle in standard form and identify the center and radius.

I. Connection to Communication

(1-2 minutes) 1. What is π ?

(2-4 minutes) 2. This question requires you to show your work and explain your reasoning. You may use drawings, words, and numbers in your explanation. Your answer should be clear enough so that another person could read it and understand your thinking. It is important that you show all your work.

Describe a procedure for locating the point that is the center of a circular paper disk. Use geometric definitions, properties, or principles to explain why your procedure is correct. Use the disk (on orange paper) provided to help you formulate your procedure. You may write on it or fold it in any way that you find helpful, but it will not be collected.

(1-3 minutes) 3. Does your procedure change if your disk is plastic that is not easily bent? If so, how?

II. Connection to Measurement

You need to measure the diameter and circumference of two circles.

4. Which units will you use?

5. Do the others in your group have to use the same units?

6. Which units will produce the least error?

7. Record your data in the table. Make sure that you use different circles from the others at your table.

DIAM	CIRC

III. Connection to Geometry: Cabri Circles

You need to measure the diameter and circumference of two circles in Cabri, Jr.

8. Follow the directions on the handout to construct the diameter of a circle. Measure the diameter and circumference (record data in table). Make the circle bigger or smaller, and record the second set of data.

CBDIA	CBCIR

IV. Connection to Data Analysis: Collecting the Data

Get back into NavNet and enter the Activity Center. Submit the data from the 4 circles you have measured. Once everyone has submitted data, your teacher will send you the data from the class. **Plot** the Circumference vs. Diameter.

9. How would you describe the general shape of the data?

Quit and exit NavNet.

V. Connection to Algebra: Graphing Conclusions

10. Graph the data using your stat plot editor. What function **represents** the relationship between the Circumference & Diameter of your hand-measured circles?

11. What function **represents** the relationship between the Circumference & Diameter of the Cabri-measured circles?

12. So what is π ?

VI. Connection to Real-World: Who Needs Math?

13. A bicycle mechanic wants to put a strip of plastic between the tube and tire of a 26-in. diameter bicycle tire. To the nearest inch, how long should the strip of plastic be?

14. Three tennis balls are packaged in a pressurized can, one on top of the other. Is the height of the can or its circumference greater? Justify your answer.

15. The diameter of a basketball rim is 18 in. A standard basketball has a circumference of 30 in. About how much room is there between the ball and the rim in a shot in which the ball goes exactly in the center of the rim?

VII. Connection to Representation: Cabri Circles in the Plane

How do we represent circles in the x-y coordinate plane?

