

Activity 1: Creating the construction from the beginning

**Making Hay While the Sun Shines
&
Not Losing It in the Rain
(The Geometry of the Big Round Bale)**



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(with special thanks to Jack Madding for the problem concept)

This activity explores the volume of the hay bale and the percent of loss as the radius of the bale decreases. The extension collects data from the constructed cylinder in a spreadsheet and graphs it. The graphs are modeled with quadratic functions and transformations of quadratic functions can also be addressed. The step-by-step instructions guide the student through the construction from the beginning. Students will benefit greatly by doing the entire construction, but it is also time consuming and may not be appropriate for all students. This activity is also posted with a tns file in a form where the construction is ready for the student to interact with. The activity takes much less time in this form and allows access for many more students to observe the behavior of the cylinder and its volume.

Making Hay While the Sun Shines & Not Losing It in the Rain

(The Geometry of the Big Round Bale)

Much of the hay is baled in big round bales as shown in the picture above. Many of these bales can weigh as much as a ton. Also many of the bales are stored outside, and some of the hay on the outside of the bale deteriorates from the weather. Some of the bales are tied with baling twine, and others, like the one in the picture, are covered with a plastic netwrap to protect them from the elements. We are going to investigate what percent of the hay we might lose due to the weather if the bales are not protected by netwrap and how much that might cost us.

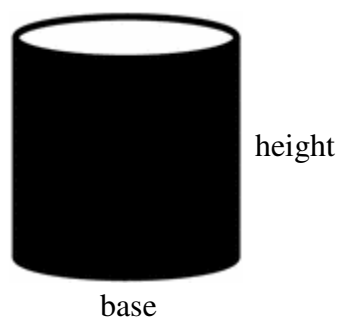


Figure 1

First we are going to sit the bale on its circular base so that we can apply the mathematics formula for volume. For our math purposes the height of the bale will be as shown in figure 1. (Farmers consider the height of the bale as it is laying in the field in the picture above.) Remember that to find the volume of prisms and cylinders, we multiply the area of the base times the height.

Investigation

1. The bale in our problem has a diameter of 6 ft. and a height of 5 ft. Open a new document on TI-Nspire, and use a calculator page to answer questions 1 – 5 on the answer sheet.
2. Next we will explore the volume of the bale as it changes dynamically with the diameter. Add a geometry page by pressing $\text{2nd} + \text{F5}$ and choosing 2:Graphs & Geometry. Hide the axes by pressing $\text{menu} + \text{2} + \text{2}$ for Menu, 2:View, 2:Plane Geometry View. (Figure 2)
3. You will now have a geometry page as shown in Figure 3.

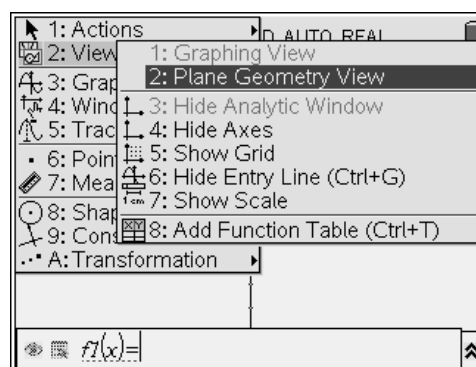


Figure 2

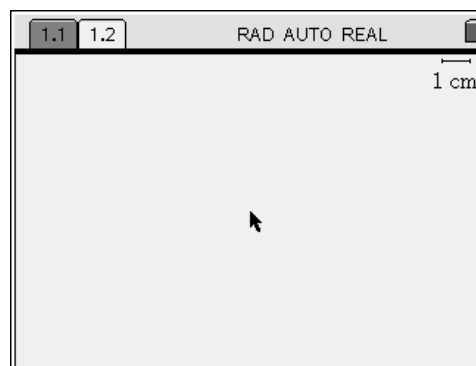


Figure 3

Next we would like to construct the cylinder.

4. Press **menu** **6** **4** for Menu, 6:Points & Lines, 4:Line. (Figure 4)

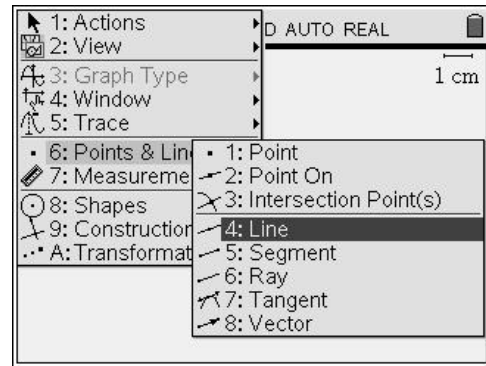


Figure 4

5. Draw a horizontal line about 1/3 of the way from the top. Press **enter** once to begin the line and **enter** again to complete the line. Press **esc** to put the line tool away. (Figure 5)

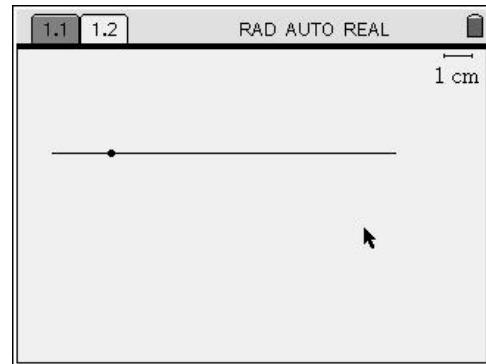


Figure 5

6. Next we want to construct a circle whose radius lies on the line. Press **menu** **8** **1** for Menu, 8:Shapes, 1:Circle. (Figure 6)

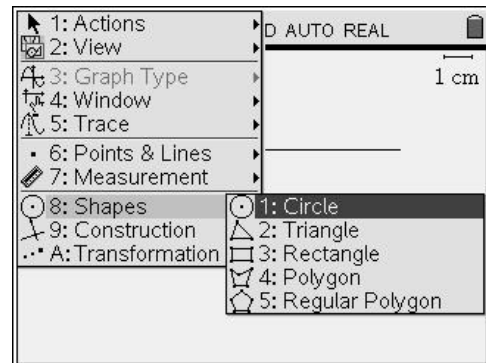


Figure 6

6. Place the circle on the line such that the line completely intersects the circle. First place the center point on the line. To ensure the center pt. is on the line, the text should read, "point on", and the line should be dashed. (Figure 7) Press **enter** and immediately label the point capital "O" by pressing **cap** **O**.

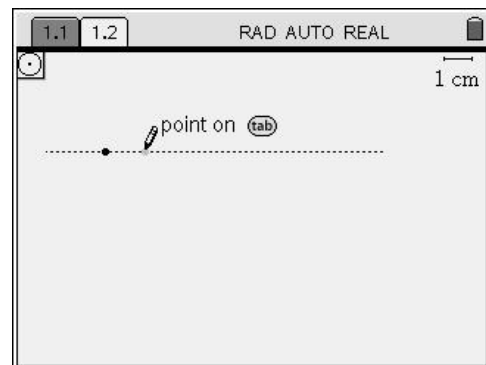


Figure 7

8. Next place the radius point on the line. Again to ensure the radius point is on the line the text should read, “point on”, and the line should be dashed. (Figure 8) Press enter and immediately label the point “X” by pressing CAPS X. Press esc to put the circle tool away.

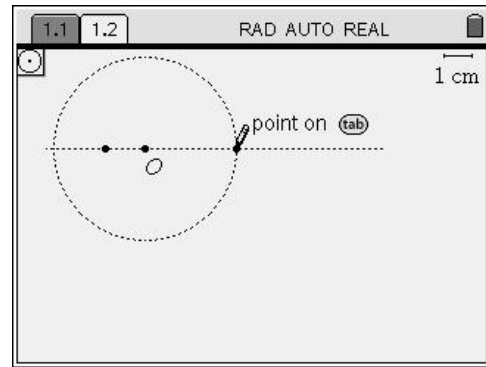


Figure 8

9. Construct the sides of the cylinder using the perpendicular construction tool. Press menu 9 1 for Menu, 9:Construction, 1:Perpendicular. (Figure 9)

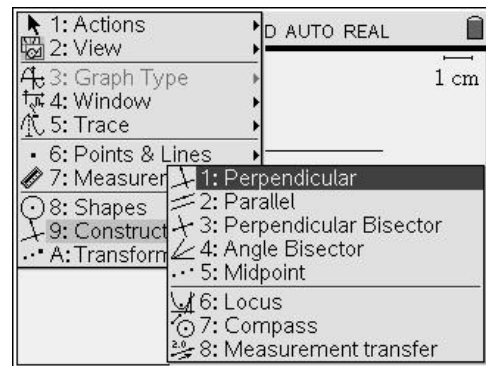


Figure 9

10. Move the cursor to point X until the text reads, “point X”. Press enter . Move the cursor right or left until a dashed perpendicular line appears and the text reads, “line”. Press enter . Repeat this procedure to construct a perpendicular through the center point O. Finally move to the intersection of the line and the left side of the circle until the text reads, “intersection point”. Press enter . Move the cursor right or left as before until a dashed perpendicular line appears and the text reads, “line”. Press enter . There should now be 3 perpendicular lines. (Figure 10) Press esc to put the perpendicular tool away.

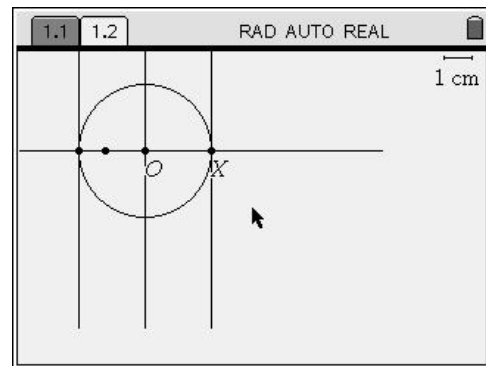


Figure 10

11. Next construct the bottom of the circle by translating the top of the circle. Press menu A 3 for Menu, A:Transformation, 3:Translation. (Figure 11)

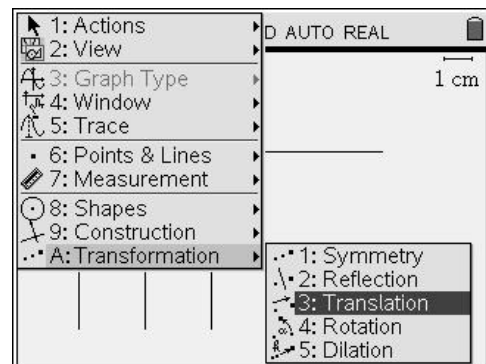


Figure 11

12. Move the cursor until the center point of the circle flashes and the text reads, “point O”. Press enter . Then move the cursor to the circle until the circle flashes and the text reads, “circle”. Press enter . Translate the circle down and position the cursor on the center line. The circle and the center line are both dashed and the text reads, “point on”. (Figure 12) Press enter . Immediately label the center of the bottom circle “Y” by pressing $\text{ctrl} \text{ } \text{enter} \text{ } \text{Y}$. Then press esc to put the translation tool away.

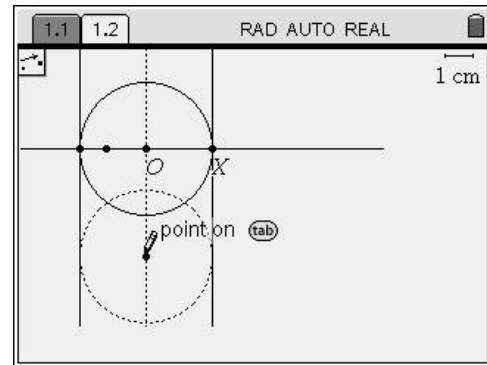


Figure 12

13. Construct segments for the sides of the cylinder, the middle vertical segment OY, and the radius segment OX. Press $\text{menu} \text{ } 6 \text{ } 5$ for Menu, 6: Points & Lines, 5:Segment. To construct segment OX, move the cursor to the center point until the point flashes and the text reads, “point O”. Press enter . Then move the cursor until point X flashes and the text reads, “point X”. (Figure 13) Press enter . Repeat for segment OY.

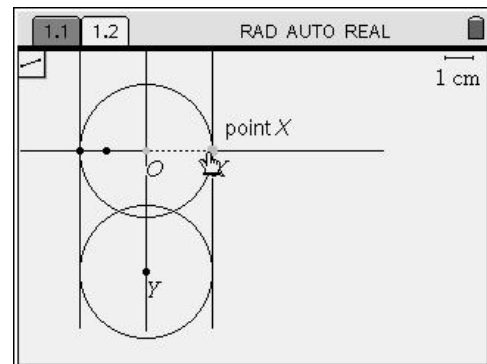


Figure 13

14. For the right side of the cylinder, move the cursor to point X as before and press enter . Then move the cursor to where the bottom circle and the right side intersect and the text reads, “intersection point”. (Figure 14) Press enter . Repeat for the left side of the cylinder. Then press esc to put the segment tool away.

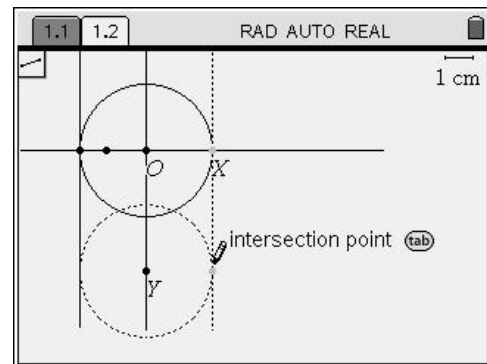


Figure 14

15. Hide the construction lines by pressing $\text{menu} \text{ } 1 \text{ } 2$ for Menu, 1:Action, 2:Hide/Show. Click on the horizontal line, all 3 vertical lines (but not the segments), and all the points except pts. O & X to hide them. Change the center segment, OY, to dashed by moving the cursor to the segment until it flashes and the text reads, “segment OY”. Press $\text{ctrl} \text{ } \text{menu}$ and choose 2:attributes. Arrow down to the middle box & right arrow to choose, “Line style is dashed”. Press enter . (Figure 15)

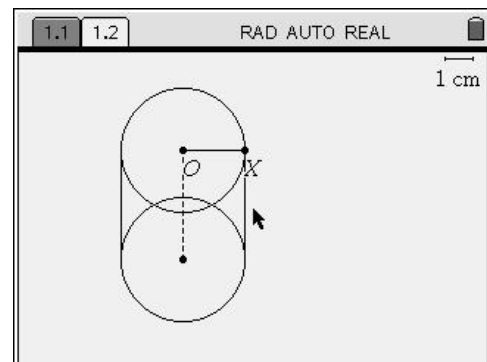


Figure 15

16. Next measure the radius and height of the cylinder. Press MENU 7 1 for Menu, 7:Measurement, 1:Length. Move the cursor until the radius is flashing and the text reads, “segment OX”. Press ENTER . The measurement first appears in grayscale. Move the measurement where you want it, and press ENTER again. Repeat the process for the height of the cylinder. (Figure 16)

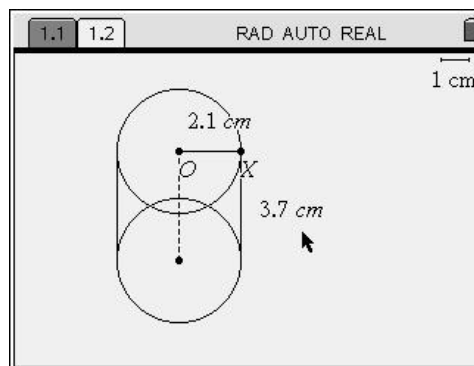


Figure 16

17. Change the unit of measurement to feet. Move the cursor to the upper right corner of the screen to the scale 1 cm., and position it over “cm” until the cursor changes to an I-beam. Press ENTER . Press CLEAR twice to delete cm, and type F T ENTER . All units should change to “ft”. (Figure 17)

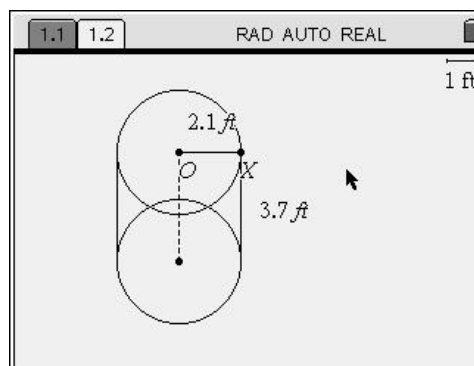


Figure 17

18. Test the cylinder to see if everything is working correctly. Move the cursor to pt. X until it becomes an open hand. Center click CLICK & hold until the hand closes. (Figure 18) Adjust the radius to be 3 ft. Press ESC to let go of the radius pt. Move to the center point of the bottom circle. Repeat the above procedure to adjust the height of the cylinder to 5 ft. (If you did not hide point Y, you will not be able to get the open hand cursor and grab the center point of the bottom circle.)

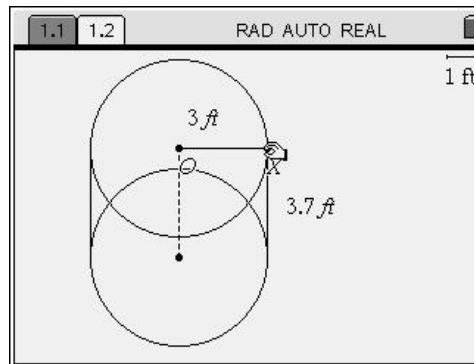


Figure 18

19. Store the radius and height as variables. Move the arrow to the radius measurement. When the hand appears, press ENTER . The measurement should appear shaded. Next press CTRL STOP VAR . Type R to overwrite var, and press ENTER . Repeat this process to store the height as **h**. The **r** and **h** will be bold to indicate that they are variables. (Figure 19)

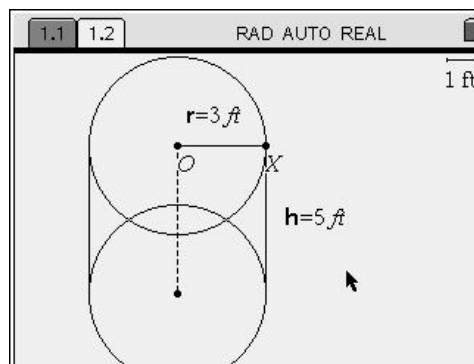


Figure 19

20. Add a text box to enter the volume formula. Press MENU 1 5 for Menu, 1:Actions, 5:Text. Move the I-beam to where you would like the formula and press ENTER . Type $\text{vol}=\pi \cdot r^2 \cdot h$ and press ENTER . (Figure 20) Press ESC to put the text box tool away.

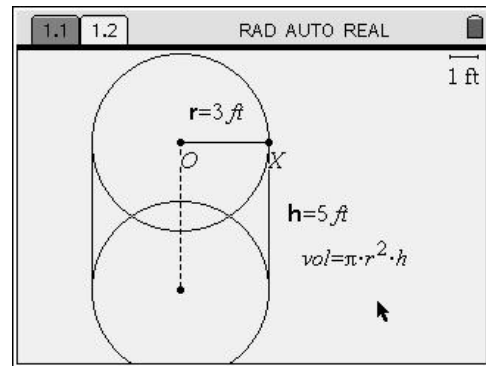


Figure 20

21. Next calculate the volume by pressing MENU 1 7 for Menu, 1:Actions, 7:Calculate. Move the cursor to the formula until it becomes a hand with a pointing finger. Press ENTER . When it says, “select h...”, move the cursor to the measurement for h until it becomes a pointing hand again. Press ENTER . Repeat for the measurement for r. Finally move the result of the volume calculation to an appropriate place on the screen, and press ENTER one last time. It takes 4 ENTER 's to complete the calculation. Press ESC to put the calculation tool away. (Figure 21)

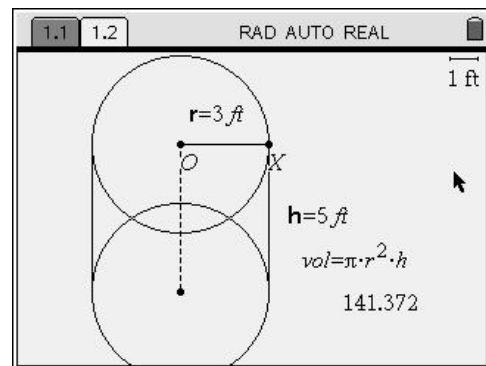


Figure 21

22. Store the volume as a variable. Move the arrow to the volume calculation. When the hand appears, press ENTER . The number should appear shaded. Next press CTRL VAR . Type V to overwrite *var*, and press ENTER . (Figure 22) Vary the radius and the height of the cylinder, and observe how the volume changes. Answer questions 6 & 7 on the answer sheet.

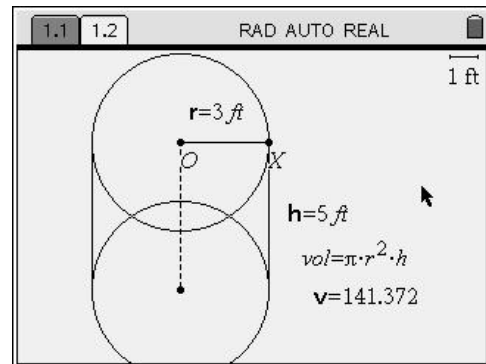


Figure 22

23. Add a text box for computing the percent of hay lost as the radius decreases by pressing MENU 1 5 for Menu, 1:Actions, 5:Text. Move the I-beam to where you would like the formula and press ENTER . Type $\text{loss}=(141.372 - v) \div 141.372 \times 100$ and press ENTER . Press ESC to put the text box tool away. (Figure 23)

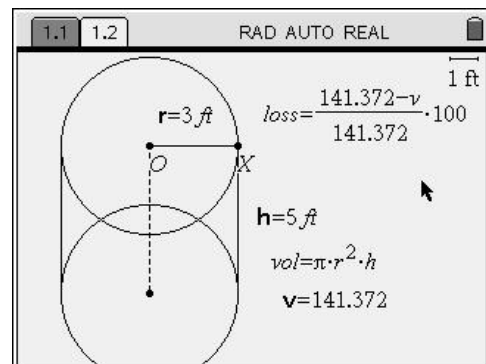


Figure 23

24. Next calculate the formula by pressing MENU 1 7 for Menu, 1:Actions, 7:Calculate. Move the cursor to the formula until it becomes a hand with a pointing finger. Press ENTER . When it says, “select v...”, move the cursor to the measurement for v until it becomes a pointing hand again. Press ENTER . Move the calculation to an appropriate place on the screen and press ENTER one last time. Press ESC to put the calculation tool away. (Figure 24)

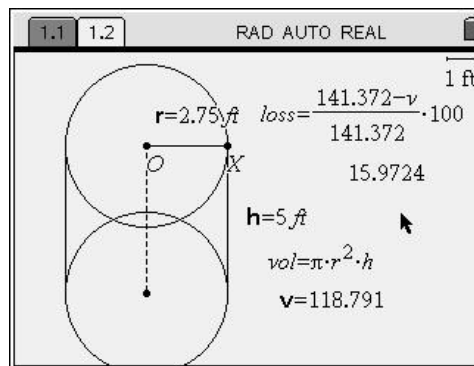


Figure 24

25. Store the percent lost as a variable. Move the arrow to the percent lost calculation. When the hand appears, press ENTER . The number should appear shaded. Next press CTRL VAR . Type L to overwrite *var*, and press ENTER . Move the cursor to the radius point X until it becomes an open hand. Center click C and hold until the hand closes. (Figure 25) Vary the radius, and observe the percent lost. Answer questions 8 – 11 on the answer sheet.

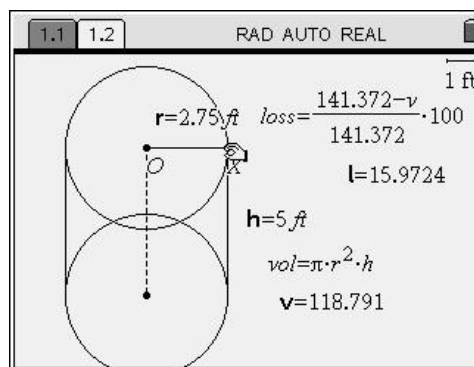


Figure 25

Extension – Collecting Data in a Spreadsheet and Displaying it in a Graph

26. Add a spreadsheet page by pressing 2ND F7 , select 3:Lists & Spreadsheets and press ENTER . Arrow to the top of the first column and type, “radius”. Press ENTER . Arrow to the top of the second column and type, “volume”. At the top of the third column type, “percentloss”. (Figure 26)

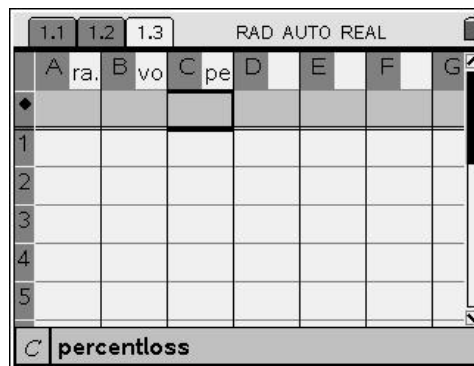


Figure 26

27. Next widen the columns so the entire column heading is visible. Move to the first column and arrow up until the entire column is shaded. Press MENU 1 2 1 for Menu, 1:Actions, 2:Resize, 1:Resize Column Width. Arrow to the right until the word, “radius” is visible. Press ENTER to fix the column width. Repeat this process for the next two columns. (Figure 27)

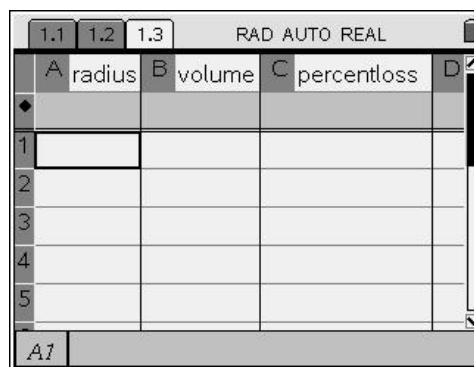


Figure 27

28. Set the spreadsheet up to manually collect data from the cylinder drawing. Position the cursor in the space below the column heading “radius”. To manually collect data press MENU $\langle 3 \rangle$ $\langle 2 \rangle$ $\langle 2 \rangle$ for Menu, 3:Data, 2:Data Capture, 2:Manual Data Capture. “var” will be shaded, and to select the variable to be captured, press STOP VAR and select “r” from the displayed list. (Figure 28) Press ENTER . (The zero indicates that the data will be captured manually.)

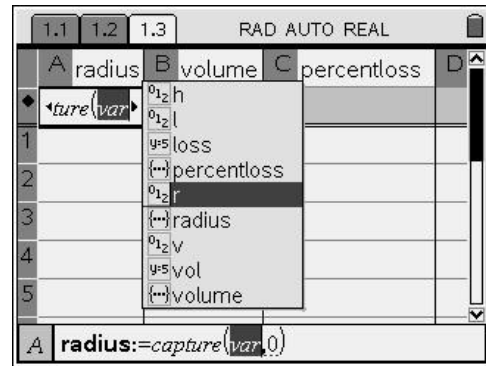


Figure 28

29. Repeat the above procedure to collect the variable, “v” in the volume column and the variable, “l” in the percentloss column. (Figure 29) (Variables must be selected from the list, and variables and lists must have different names.)

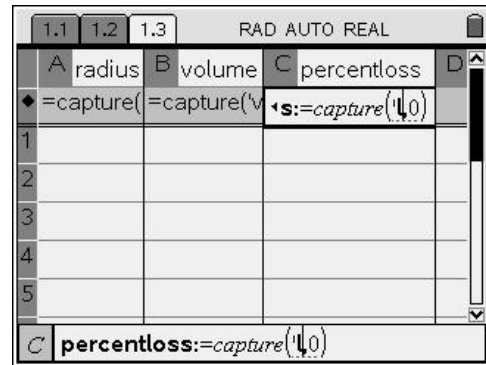


Figure 29

Graphing the collected data

30. Add a graph page by pressing 2ND F5 and selecting 2:Graphs & Geometry. Press ENTER . To graph a scatter plot, press MENU $\langle 3 \rangle$ $\langle 4 \rangle$ for Menu, 3:Graph Type, 4:Scatter Plot. The box for the x variable should be bold. Press ENTER to display the variable choices. (Figure 30) Select “radius” and press ENTER . Arrow to the right to make the box for the y variable bold. Press ENTER to display the choices and select “volume”. Press ENTER . The plot is set up & ready for collected data.

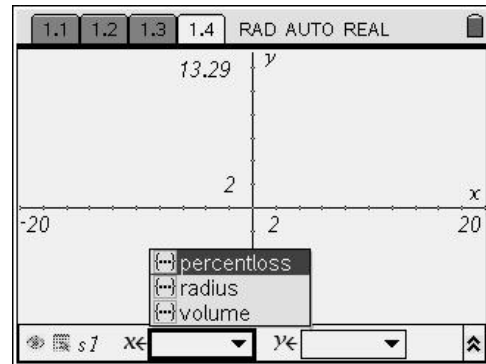


Figure 30

31. Add another graph page using the above procedure. Again select scatter plot as the graph type. This time select “radius” as the x variable and “percentloss” as the y variable. (Figure 31)

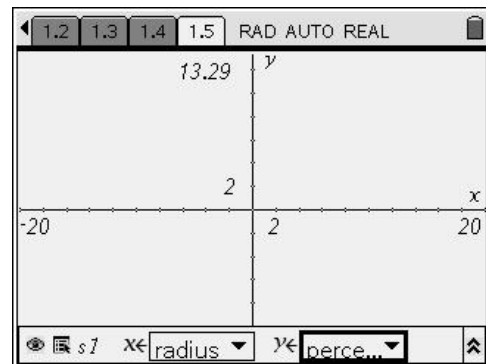


Figure 31

32. Now we are ready to collect some data from the cylinder. Press $\text{ctrl} \llcorner \llcorner \llcorner$ on the NavPad to return to page 1.2. To begin the data collection, adjust the radius of the cylinder to 3 ft. and the height to 5 ft. To collect the first data point, press $\text{ctrl} \langle \cdot \rangle$. Press $\text{ctrl} \triangleright$ to return to the spreadsheet on page 1.3 and observe the first collected data. (Figure 32)

	A radius	B volume	C percentloss	D
1	3	141.372	.000234	
2				
3				
4				
5				

A1 = 3

Figure 32

33. Return to page 1.2 and collect several data points. Try to collect a data point about every .1 ft. Observe the collected data on page 1.3. (Figure 33)

	A radius	B volume	C percentloss	D
1	3	141.372	.000234	
2	2.9	132.104	6.55577	
3	2.8	123.15	12.8891	
4	2.7	114.511	19.0002	
5	2.6	106.186	24.8891	

A1 = 3

Figure 33

34. Press $\text{ctrl} \triangleright$ to move to page 1.4. Set the appropriate window for the collected data by pressing $\text{menu} \langle 4 \rangle \langle 9 \rangle$ for Menu, 4:Window, 9:Zoom-Data. Press $\text{ctrl} \langle \text{G} \rangle$ to hide the entry line. (Figure 34) Repeat the above procedure for the graph on page 1.5. Answer questions 12 – 17 on the answer sheet.

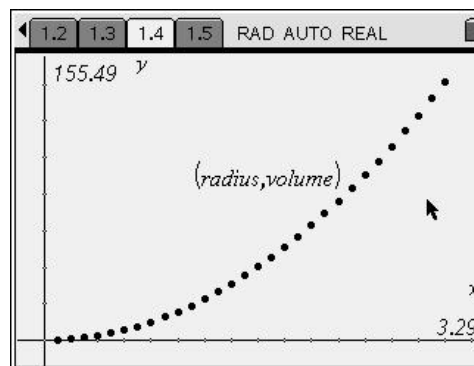


Figure 34

35. Return to page 1.4. Press $\text{menu} \langle 3 \rangle \langle 1 \rangle$ for Menu, 3:Graph Type, 1:Function. This displays a function entry line. Using the work you have done in this activity, determine a function to model this data and enter it in the function entry line. Press enter .
36. Move to page 1.5. Display the function entry line as above. Using the work you have done in this activity, determine a function to model this data and enter it in the function entry line. Press enter . Answer questions 18 – 20 on the answer sheet.