

TEACHER NOTES

About the Lesson

In this activity, students will measure the mass and volume of several collections of a coin type, enter the data into their handheld and explore for patterns, make a plot and look at the ratio of Mass vs. Volume, create a mathematical model that demonstrates the relationship between mass and volume and discover the density value embedded in the data.

As a result, students will:

• Explore the relationship between the number of coins and their mass, volume and density.

Vocabulary

- mass
- volume
- density
- percent error

Teacher Preparation and Notes

- Students should know how to input data into lists.
- Teachers may want to give more guidance to students regarding the use of the Equation Solver in the Math Menu.

Activity Materials

• Compatible TI Technologies:

TI-84 Plus* TI-84 Plus Silver Edition* TI-84 Plus C Silver Edition TI-84 Plus CE

* with the latest operating system (2.55MP) featuring MathPrint[™] functionality.



Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <u>http://education.ti.com/calculato</u> <u>rs/pd/US/Online-</u> <u>Learning/Tutorials</u>
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

Lesson Files:

- Making_Cents_Of_Data_Student .pdf
- Making_Cents_Of_Data_Student .doc



Entering the Data

- 1. Before entering data in the lists, clear any existing data from the lists.
- Before entering data in the lists, clear any existing data from the lists. Press 2nd [mem]. Highlight 4:CIrAIILists, and then press [enter].

This takes you to the Home screen, and you will see **4:CIrAIILists** with a blinking cursor following it. Press enter, and the TI-84 Plus CE displays *Done*. Your lists are now cleared.

3. Press stat. Press enter to choose **1:Edit**.Make three lists on your TI-84.

- Enter your lists COINS, VOL, and MASS. Get into alpha-lock mode by pressing 2nd[A-lock], key in the letters for the names. Press enter and then move over to the next column and repeat the process.
- 5. Measure 7, 14, 21, and 28 coins at a minimum. Move into the list for COINS and enter these numbers. If you have more than 28 coins, keep adding the sets of 7 until you are finished.

MEMO	DV.	
1:Ab	out	
2:Me	m Managemer	nt/Delete
3:01	ear Entries	5
4:C1	AllLists	
5:Ar	chive	
6:Un	Archive	
7:Re	set	
8:Gr	DUP	

NORMAL	FLOAT AL	JTO REAL	RADIAN	MP	Î
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L1=					

NORMAL FLOAT AUTO REAL RADIAN MP 👘

				-
COINS	VOL	MASS	 	э
MASS				



 Determine the volume of your coins by measuring the diameter of one of your coins. Then make a stack of 7 coins to make a cylinder. Measure its height. Now calculate the volume using the following formula:

$$V = \pi \left(\frac{d}{2}\right)^2 h$$

where d is the diameter in cm, h is the height in cm, and V is the volume in cubic centimeters.

Optional: Get the volume of the stacks of 7 coins by displacement. To do this, after you mass them, put 50 ml of water in a graduated cylinder and then drop the 7 coins in. Record the new water level and subtract to get the number of milliliters of water the coins occupy. This is the volume in cubic centimeters.

- 7. To get the volume we will go to the Solver. Press math enter to get to there. Press clear to remove the old equation. Note: Each line/variable will need a value on it if you have an old equation so you can't clear out values and then move off of the variable line. Key in the formula as shown.
- 8. We will enter our values for D (diameter of the coin) and H (height of your stack) and then we will solve for V. To solve for volume, you will need to put the cursor on the V= line. Key in a guess and then press apha enter to get the answer. Notice the bullet that indicates you have the answer. Enter this volume in your lists. You probably want to round off the answer. In this case the volume would be 4.28 cm³. Change the value for the height (H) and repeat the process. Remember that the diameter (D) stays the same. Try to guess each time.
- 9. Now place your coins on the massing device and get the mass of 7 coins. Then add 7 more coins and get the mass for 14 coins, then add 7 each time to get the mass for 21 coins and 28 coins. If you have additional sets of 7 coins, collect those masses as well. Record the mass in grams.



COINS	VOL	MASS	
0	0	0	
7	4.28	14.7	
14	8.55	29.4	
21	12.83	44.1	
28	17.11	58.8	



10. Do you see a relationship between the numbers? A pattern? What do you think the mass of one coin is? The volume of one coin? How about 1 dollar?

NORMAL FLOAT AUT Select variable; P	O REAL A Press sol	ADIAN N .VE	¹⁹ (
π(D∕2) ² H−V=	0		
D=0			1
H=0			
v=0 bound={-1	E99,1	E99}	
			SOLVE
NORMAL FLOAT AUT Solution is Marke	D REAL R D -	ADIAN M	¹⁹ (
π(D/2) ² H-V=	ø		
D=1.1 H=4 5			
• V=4.27649 bound={-1 • E1-E2=0	29996 E99,1	991 E99}	

- 11. To help determine the pattern in another way we will need to set up a plot. Press [2nd] [stat plot] [enter] and set up the plot as shown. Recall that you can access the list names by pressing [2nd] [list].
- 12. Now check to see if you have any equations or plots on. Press y= and turn off or clear your equations and see you only have **Plot1** on.
- 13. Set the Window with **ZoomStat**. Press zoom 9 and explore the graph with trace ().



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14. We want to guess the equation that fits the data. Press y= and start with Y1=1*X. Move to the left of the Y1 and press enter until you get it. Press graph and see how close you are. If you didn't hit it, keep trying. Recall that 2nd [ins] to insert rather than overstrike.

- 15. This number, the one in front of the X, is the slope. The slope is the ratio of the change in Y and the change in X. In this situation that is the change in mass divided by the change in volume, or grams per cubic centimeters. This is the Density!
- 16. Check on the Internet or with your teacher to get the true density for your coin. The U.S. Mint would be a good place to look. To compare your answer with the actual density we can do a percent error. To get a better value for the density of your coin we can have the computer do the calculation. Return to the List Editor and make a new list named DENSE. Use the techniques used earlier. Press stat 1 to get to the lists.
- 17. In the header of this new list we will divide the mass by the volume. The zeros must be removed. To do this move to the place where the zero is and press del then move to the next one until you have removed all the zeros.
- Now go to the header of the DENSE list and we will enter the formula MASS/VOL. Get the list names from the list of lists –2nd [list]. Once you have the formula in press enter.

In this case, the solution is $x \le -4$ or $x \ge 12$.

19. These numbers should vary so we want to get the average. Do you see that these densities are close to the value you used in the Y= area?



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- 20. To get the mean of a list go to the Home Screen and clean up. Press [2nd] [quit] [clear].
- 21. To get the command for mean press 2nd [list] 3.

Making Cents of Density

22. Now we are ready to do a percent error. The formula is: $PercentError = \frac{Truth - Observed}{Truth} \times 100\%$

Key this in at the Home Screen using the value you picked for Y= as the Observed and the Truth will be what they report is the density of your type of coin. This should be less than 10%. In the sample it is 1.74%!

NORMAL FLOAT AUTO REAL RADIAN MP
NAMES OPS MATT
1:min(
2:max(
3:mean(
4:median(
5:sum(
6:prod(
7:stdDev(
8:variance(
NORMAL FLOAT AUTO REAL RADIAN MP
mean(LDENSE)
3,436754788
((3.5-3.44)/3.45)*100
1./37130435

