EXPLORATIONS

Activity 5

Give Me a Hand or Leaf Me Alone

Objectives

- To find the surface area of an irregularly shaped object by relating area to mass
- To find the *y* value of a function, given the *x* value
- To use technology to find a best fit line
- To use technology to plot a set of ordered pairs

Materials

- TI-73 graphing device
- Card stock paper (poster board, manila folders, or any heavy weight paper can be used)
- Scissors, one pair per student
- Scale or balance that measures in grams
- Ruler that measures in centimeters or inches, one per student
- Leaves of various sizes (at least one leaf per student)

Introduction

The idea of surface area is one of the most important concepts to understand in the biomedical sciences. Consider these examples. When you breathe, you must be able to absorb enough oxygen into your blood. Your highly compartmentalized lungs provide 70 square meters of surface area for oxygen absorption. That is about the size of the floor in your classroom. The surface area of the lining of your small intestines is 300 square meters, which is about the size of a tennis court. That allows you to efficiently absorb the nutrients from the food that you digest.

Surface area adaptations are found throughout the living world. Root hairs provide a tremendous surface area for water and mineral absorption, and the large surface area of leaves allows them to efficiently absorb sunlight.

Measuring the surface area of these irregularly shaped objects provides quite a challenge, one that is important enough to mathematically overcome.

Problem

There are formulas for finding the surface area of geometric figures such as a square, a rectangle, a triangle, or a circle. However, there are no such formulas for finding the surface area of an irregularly shaped object such as a hand or a leaf. How can you find the surface area of your hand or a leaf?

Collecting the data

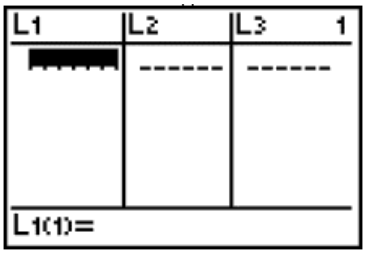
1. Your teacher will assign you a specific length, between 1 and 18 centimeters, to use as the length for the side of a square. Cut a square of this side length from a piece of card stock paper.
2. Calculate the area of your square using the formula: $A = s^2$. Record the length of each side and the area of your square. Record the area on the square.
3. Use the scale to find the mass of your square in grams. Record the mass on the square.
4. Record the area and mass of your square on the **Data Collection and Analysis** page. Record all of the data for the class in the table on the **Data Collection and Analysis** page.

Setting up the TI-73

Before starting your data collection, make sure that the TI-73 has the STAT PLOTS turned OFF, Y= functions turned OFF or cleared, the MODE and FORMAT set to their defaults, and the lists cleared. See the Appendix for a detailed description of the general setup steps.

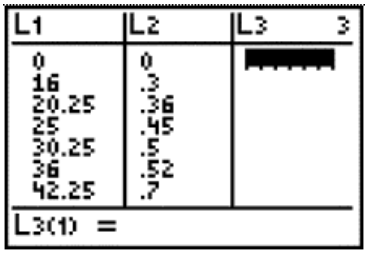
Entering the data in the TI-73

1. Press [LIST].



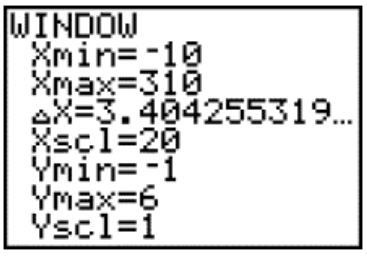
2. Enter the area of each square in **L1**.
3. Enter the mass of each square in **L2**.

Note: Be sure to enter zero in both **L1** *and* **L2** *as your first entries.*



Setting up the window

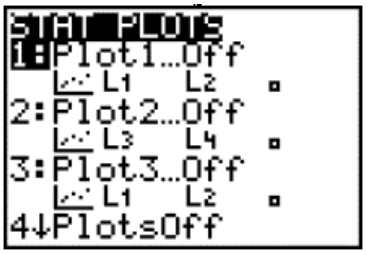
1. Press [WINDOW] to set up the proper scale for the axes.
2. Set the **Xmin** value by identifying the minimum value in **L1**. Choose a number that is less than the minimum.



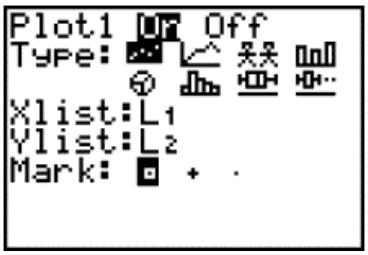
3. Set the **Xmax** value by identifying the maximum value in each list. Choose a number that is greater than the maximum. **Do Not Change the ΔX Value.** Set the **Xscl** to **20**.
4. Set the **Ymin** value by identifying the minimum value in **L2**. Choose a number that is less than the minimum.
5. Set the **Ymax** value by identifying the maximum value in **L2**. Choose a number that is greater than the maximum. Set the **Yscl** to **1**.

Graphing the data: Setting up a scatter plot

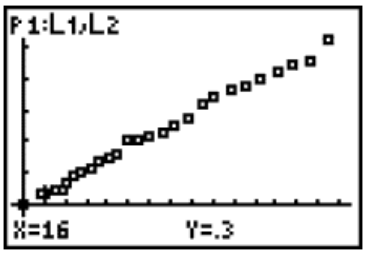
1. Press [2nd] [PLOT]. Select **1:Plot1** by pressing **1** or [ENTER].



2. Set up the plot as shown by pressing [ENTER] [▼] [ENTER] [▼] [2nd] [STAT] **1:L1** [▼] [2nd] [STAT] **2:L2** [▼] [ENTER].



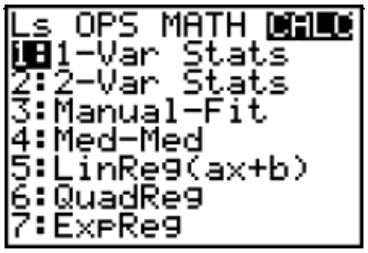
3. Press [TRACE]. Use [◄] and [►] to move between the points.



Analyzing the data

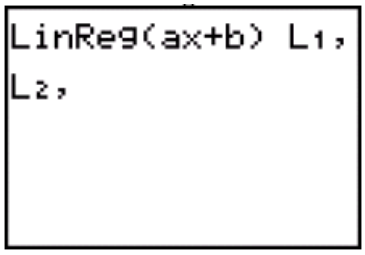
Finding a best fit line

1. Find a linear regression equation for the data. Press [2nd] [STAT] [◄] to move the cursor to the **CALC** menu.



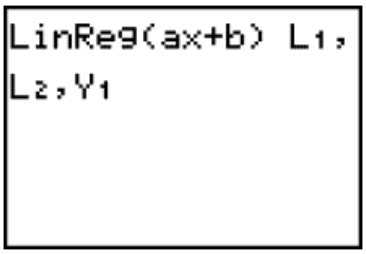
2. Select **5:LinReg(ax + b)** by pressing **5.**

3. Press 2nd [STAT] **1:L1** , 2nd [STAT] **2:L2** ,.

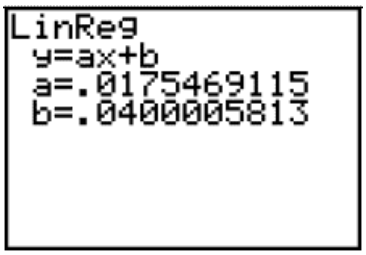


4. Press 2nd [VARS]. Select **2:Y-Vars** by pressing **2**.

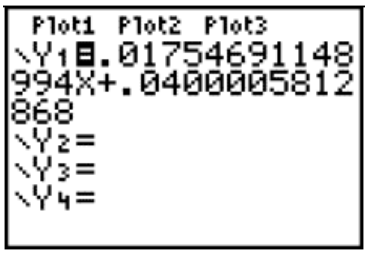
5. Select **1:Y1** by pressing **1** or ENTER.



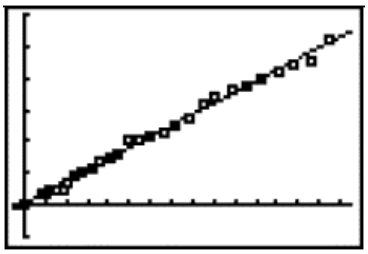
6. Press ENTER to calculate the linear regression. The function is pasted in **Y1**.



7. Press Y= to see the function.



8. Press GRAPH to see the graph of the best fit line.

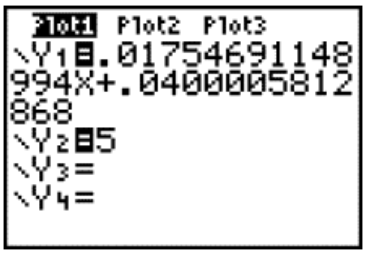


Answer questions 1 through 4 on the **Data Collection and Analysis** page.

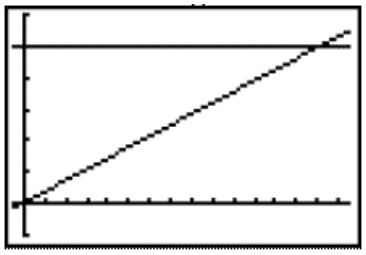
Finding the area of your hand and a leaf

1. Trace your hand and a leaf on a sheet of card stock paper. Cut out each of the tracings. Find the mass in grams of your cut out hand and your cut out leaf.

2. Find the surface area of your hand. Press Y= and ▼ until the cursor is on **Y2**. Enter the mass of your cut out hand in **Y2**.



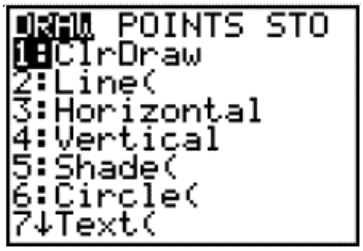
3. Turn **Plot1** off. Press ▲ until the cursor is on **Plot1**. Press ENTER to turn it off. Press ▼ and notice that **Plot1** is no longer highlighted. Press GRAPH to see the intersection of the two lines.



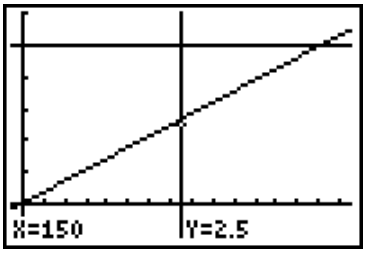
Note: *You may have to change the window to see the intersection of the lines.*

Find the coordinates of the point of intersection of the two lines. Draw a vertical line that passes through the point of intersection.

4. Press DRAW.

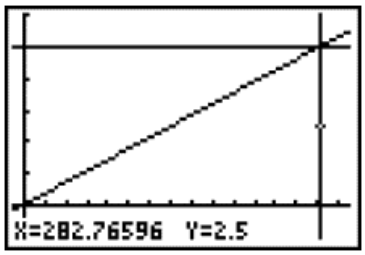


5. Select **4:Vertical** by pressing **4**.



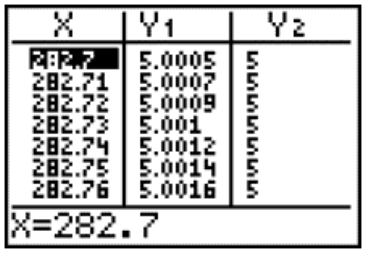
6. Press ▶ to move the vertical line until you reach the point of intersection.

***Note**: The x value is the approximate area.*

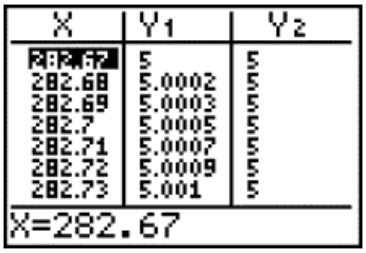


7. Use the **TABLE** to confirm the area. Press 2nd [TBLSET] and set up the **TABLE** like the one shown to the right. Use a value close to the *x* value that you found above as your **TblStart**.

8. Press 2nd [TABLE] to view the **TABLE**.



9. If necessary, use ▲ and ▼ to scroll the table to find the x value that corresponds to the mass of your cut out hand. Record the point of intersection found in Step 5 on the **Data Collection and Analysis** page.



Answer questions 6 through 9 on the **Data Collection and Analysis** page.

Follow steps 2 through 9 above to find the surface area of the leaf. Answer questions 10 through 13 on the **Data Collection and Analysis** page.

Data Collection and Analysis

Name _____

Date _____

Activity 5: Give Me a Hand or Leaf Me Alone

Collecting the data

Record your data in the table below.

Student No.	Length of side of square (cm)	Area of square (cm^2)	Mass of square (grams)
1	0		
2	4		
3	4.5		
4	5		
5	5.5		
6	6		
7	6.5		
8	7		
9	7.5		
10	8		
11	8.5		
12	9		
13	9.5		
14	10		
15	10.5		
16	11		
17	11.5		
18	12		
19	12.5		
20	13		
21	13.5		
22	14		
23	14.5		
24	15		

Analyzing the data

1. The *slope* of the linear regression line is _____ .
2. Explain what the *slope* represents.

   _____

   _____
3. The *y*-intercept of the line is _____ .
4. Explain what the *y*-intercept represents.

   _____

   _____
5. Record the coordinates of the point of intersection of your two lines for the hand data.

   _____
6. What does the *x* value represent?

   _____

   _____
7. What does the *y* value represent?

   _____

   _____
8. To find the approximate surface area of your hand, double the value that represents the surface area in number 7. You are doubling the surface area of your hand to approximate adding the top and bottom (neglecting the sides) of your hand. The total surface area of your hand is:

   _____
9. What is the surface area of both of your hands?

   _____
10. Record the coordinates of the point of intersection of your two lines for the leaf data.

    _____
11. What does the *x* value represent?

    _____
12. What does the *y* value represent?

    _____

13. To find the approximate surface area of the leaf, double the value that represents the surface area. The total surface area of the leaf is:

_____

Extension

Doctors sometimes use body surface area to determine the dosage of medicine to prescribe to their patients. There are several formulas for calculating the Body Surface Area (BSA). Boyd and Mosteller developed this formula:

$$BSA = \frac{\sqrt{\text{Height (cm)} \bullet \text{Weight (kg)}}}{3600}$$

Use the formula to calculate your body surface area.

Teacher Notes

Activity 5

Give Me a Hand or Leaf Me Alone

Objectives

- To find the surface area of an irregularly shaped object by relating area to mass
- To find the *y* value of a function, given the *x* value
- To use technology to find a best fit line
- To use technology to plot a set of ordered pairs

Materials

- TI-73 graphing device
- Card stock paper (poster board, manila folders, or any heavy weight paper can be used)
- Scissors, one pair per student
- Scale or balance that measures in grams
- Ruler that measures in centimeters or inches, one per student
- Leaves of various sizes (at least one leaf per student)

Preparation

- The paper used for cutting the hand and leaf tracings can be tag board, chart paper, folders, or any heavy paper.
- Collect all of the squares with the area and mass recorded on them. Before proceeding to the **Finding the area of your hand and a leaf** section, use the squares to estimate the area of the cut out hand and leaves. Allow the students to place their cut out hand or leaf on the square that is closest in area to their cut out. Estimate the area of their cut out hand or leaf.
- Make sure you adjust the window when finding the intersection of the two lines.

Answers to Data Collection and Analysis questions

Collecting the data

Sample data for a leaf:

Area of square (cm^2)	Mass of square (grams)
0	0
16	.3
20.25	.36
25	.45
30.25	.5
36	.52
42.25	.7
49	.97
56.25	1
64	1.2
72.25	1.33
81	1.5
90.25	1.56
100	2.05
110.25	2.1
121	2.18
132.25	2.25
144	2.53
156.25	2.78
169	3.2
182.25	3.42
196	3.61
210.25	3.75
225	3.95
240.25	4.17
256	4.41
272.25	4.55
289	5.2

Analyzing the data

1. The *slope* of the linear regression line is _____ .

Answers may vary.
The slope of the linear regression line is 0.0175.

2. Explain what the *slope* represents.

The slope represents the number of grams per square centimeter of area. For the data presented, for every square centimeter increase in area the mass increases by about 0.0175g.

3. The *y*-intercept of the line is _____ .

The y-intercept is 0.0400.

4. Explain what the *y*-intercept represents.

The y-intercept indicates that a cut out with an area of zero has a mass of 0.0400g. Of course, this is not the case. Point out to students that this is a model and the y-intercept is close to zero.

5. Record the coordinates of the point of intersection of your two lines for the hand data.

Answers may vary.

6. What does the *x* value represent?

The coordinate x represents the area of the cut out hand.

7. What does the *y* value represent?

The coordinate y represents the mass of the cut out hand.

8. To find the approximate surface area of your hand, double the value that represents the surface area in number 7. You are doubling the surface area of your hand to approximate adding the top and bottom (neglecting the sides) of your hand. The total surface area of your hand is: _____ .

Answers may vary.

9. What is the surface area of both of your hands?

Answers may vary.

10. Record the coordinates of the point of intersection of the two lines for the leaf data.

Answers may vary.

11. What does the *x* value represent?

The coordinate x represents the area of the cut out leaf.

12. What does the *y* value represent?

The coordinate y represents the mass of the cut out leaf.

13. To find the approximate surface area of the leaf, double the value that represents the surface area. The total surface area of the leaf is: _____ .

Answers may vary.