

NAME _____

SECTION _____

PARTNERS _____

DATE _____

AN EXPLORATION OF SURFACE AREA, VOLUME, AND GRAPHING

This activity is designed to explore relationships between surface area and volume. It will also allow you to review your manual graphing skills.

PROCEDURE

Assemble into 3 or 4-person groups. One person in each group needs to obtain a bag of plastic cubes and a ruler. You also need a sheet of graph per person.

PART I: Deriving Formulas and Generating Data

1. The cubes (□) used in this activity are 10 mm (1 cm) on an edge (e). As you may recall from your study of algebra or geometry, the *area* of a parallelogram, such as the face of your cube, is calculated by multiplying the length by the height. Since in a cube, the length and height are the same and can be measured at the edges:

$$A = \text{edge} \times \text{edge} \qquad \text{or} \qquad A = e^2$$

- a. How many flat surfaces (faces) does a cube have? _____
- b. What would the formula be to find the total surface area (SA) of the entire cube?

Enter the surface area of this 10 mm edge cube in Data Table #1. Be sure to include the proper units. (Remember $\text{mm} \times \text{mm} = \text{mm}^2$)

2. The *volume* (V) of a cube, or the amount of space it takes up, is a three dimensional property. It is calculated by multiplying length \times height \times width or e^3

$$V = e^3$$

Enter the volume of this 10 mm cube in the data sheet.
(Remember $\text{mm} \times \text{mm} \times \text{mm} = \text{mm}^3$)

3. Divide the surface area (SA) by the volume (V) and record the ratio of the Surface Area to Volume **in decimal form** on the data sheet.

4. Using some of other cubes in the set, double the size of all of the edges of your cube to form a new cube. Count the total number of individual 10 mm cubes that were required to make this larger cube and record it in the table. Perform the calculations for surface area, volume, and SA/V and enter the data on the sheet.

5. Construct a cube that is 30 mm on each edge. Perform the same calculations as in step 4.

6. Complete the rest of the data table without constructing the actual cubes. Describe in words how you figured out how many little cubes would make up the larger cubes.

7. How does the ratio of surface area to volume change as the length of the edge increases?

8. If you needed to have the largest surface area to volume ratio, which cubes would you select, the smallest one or the largest one? Explain.

Data Table #1

Length of Edge	Number of 10 mm cubes	Surface Area (SA)	Volume (V)	Surface Area/Volume (SA/V)
10 mm	1			
20 mm				
30 mm				
40 mm				
50 mm				
60 mm				

PART III: Graphing

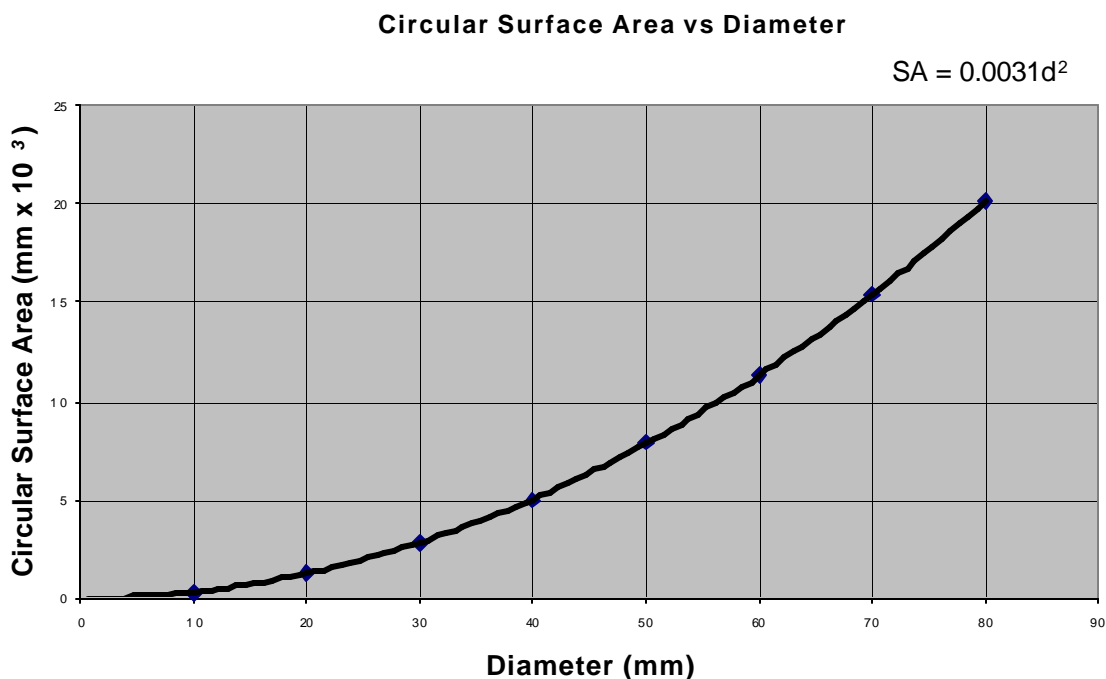
1. Using the data generated from the above activities, you will construct four graphs. Each individual in the group must do their own set of graphs for practice. Take one sheet of graph paper (printed on both sides) and fold it in half. You will place one graph in each of the four sections. Before you begin, review the information about graph construction below.

CHECK WITH YOUR INSTRUCTOR ABOUT DOING PART III ALONG WITH PART II.

Some Reminders about Constructing a Graph (in Science)

- The independent variable is placed on the x-axis (horizontal axis) no matter how the paper oriented. The independent variable is the one that you manipulate or vary. The dependent variable is placed on the y-axis and is the variable that measures response to or outcome of changes in the independent variable. Axes must be drawn with a straight edge, not freehand.
- Axes must be labeled with the name of the variable and the units (usually in parentheses). The graph must have a title. In science, we use the format “Dependent vs Independent” since y is considered to be a function of x.
- Scaling on an axis must be uniform (i.e. all intervals or distances have the same value). The scaling can be different on the x-axis compared to the y-axis. Make the intervals on the scale easy to interpret (i.e. 1, 10, 0.5 not 3.75 or 0.75). If numbers are very large you can rewrite them in scientific notation graphing the value and adding the exponential part to the unit in the title.
- The intersection of the x and y axes should be 0, 0.
- Draw a smooth curve or straight line that describes the pattern of the data points. **DO NOT CONNECT THE DOTS!** Remember that real data has error and every point might not fall on the curve that represents the data. If the curve is a straight line, use a ruler!

A sample graph is shown below.



2. **Graph 1.** Show the relationship between the independent variable of length of edge of cube versus the dependent or outcome variable of surface area.

Graph 2. Plot the independent variable of length of edge of cube versus the dependent variable of volume of cube.

Graph 3. Plot the independent variable of length of edge of cube versus the dependent variable of ratio of Surface Area/Volume.

Graph 4. Plot the independent variable of number of 1 cm cubes in the larger cube vs the dependent variable of volume.
3. In the upper right corner of each graph write the equation used to calculate the dependent variable written in terms of the variables (not x, y)
4. Can you express any relationship between the shape of the curves and the equations used to generate them?

Will the curves of any of the above graphs go through the origin (0, 0)? Explain. If 0, 0 is a probable data point your relationship it should be included as a data point and the curve should be extended through the origin.

5. Use your graph to estimate the ratio of SA to Volume if:

e = 5.0 mm _____ 100 mm _____
6. It is known that warm blooded animals lose a lot of heat through their skin. It has also been observed that there is a difference in the body shapes (round and full vs lean) and ear lengths (short and stubby vs long) of rabbits that live in cold and warm climates. Discuss how you can tell which of two rabbits lives in which environment.

PART III: Calculating and Displaying Data Using the Graphing Calculator

1. Enter your data into lists in your graphing calculator. As you generate each graph, plot the same data sets on the calculator and compare the data patterns.
2. Generate the regression equation for each data set as you proceed. How does the regression equation compare to the equation you used to obtain the dependent variable?

POST-LAB QUESTIONS

1. Complete the following data table (including units) for spheres of different diameters. The formulas for spheres are:

$$\text{Surface Area} = \pi d^2 \qquad \text{Volume} = (4/3) \pi (d/2)^3 \qquad d = \text{diameter}$$

Diameter	Surface Area	Volume	Surface Area/Volume
mm			
10			
20			
30			
40			
50			
60			

2. You can fit a sphere with a 10 mm diameter in a cube with a 10 mm edge length. Obviously, the cube will have a greater volume than the sphere that fits in it. However, we can compare how the surface area to volume ratio of these two solid objects changes as their edge or diameter changes.
- On Graph 3, plot the diameter and surface area/volume ratio for the spheres of varying diameters.
 - How does the shape of the curve for the sphere compare to that of the cube?
 - What happens to the differences in the SA/V ratio comparing the sphere to the cube as the diameters and edge sizes increase?
 - If you need to have the smallest surface area to volume ratio would you want a larger sphere or a smaller sphere?
 - If you wanted the smallest surface area per unit volume would you select a sphere or cube?

