Includes
Teacher's Notes
and
Typical
Experiment Results

Instruction Manual and Experiment Guide for the PASCO scientific Model SE-9719

012-07192A

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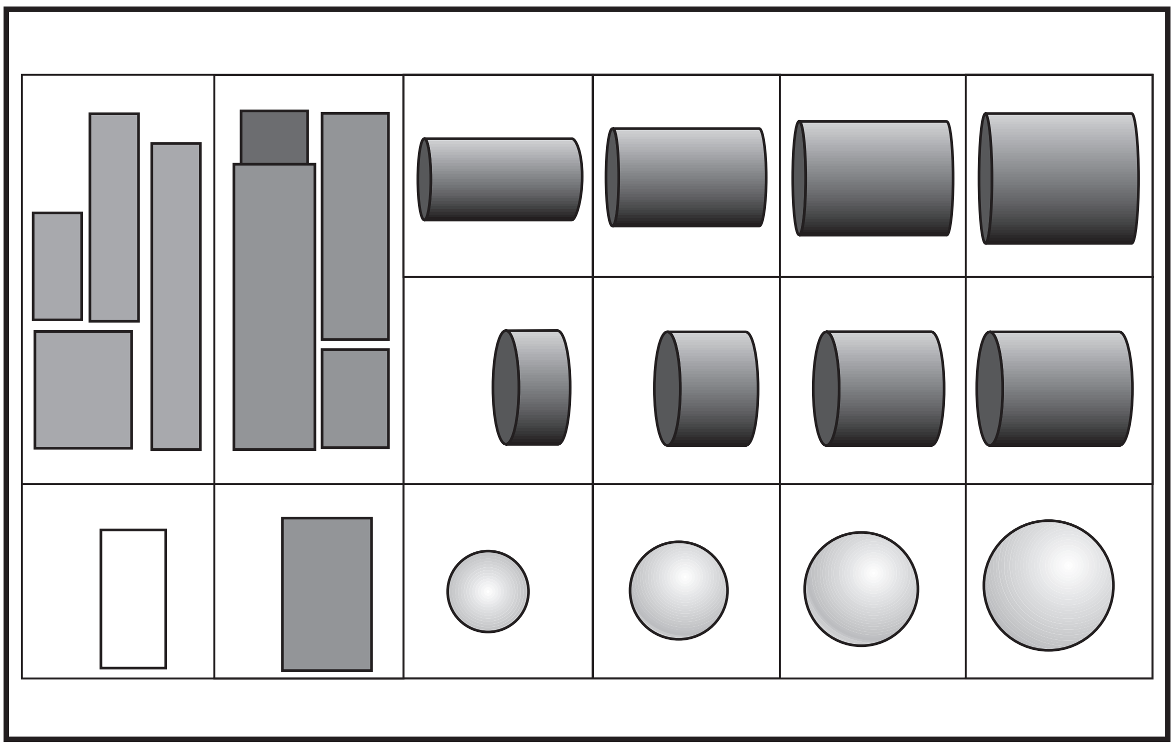
DISCOVER DENSITY SET



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Author: Jim Housley
Editor: Sunny Bishop

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Introduction

The PASCO SE-9719 Discover Density Set provides materials and activities to guide students through some basic graphical analysis techniques.

In each case, an example is worked out, with explanations, and then the student is asked to perform a similar analysis based on the materials in the set.

In the first analysis, students discover the concept as a mathematical constant relating measurements of a particular substance.

Then they are asked to discover experimentally an equation that predicts the mass of spheres of unknown, but constant, composition, based on their diameter.

Finally, they are lead to develop an equation in three variables that predicts the mass of cylinders of unknown, but constant, composition, based on measurements of their diameter and length.

The only mathematical formula students are expected to know is that for slope. If they recall special volume formulas for spheres and cylinders, they are asked not to use this information in the development of their equations. After graphical analysis yields the desired equations, students can use volume formulas and tabulated density data to verify the correctness of the equations they have discovered experimentally.

Other Uses

Because the items in the set are machined to close tolerances, and dimensions and masses are given in the teacher's guide, the set may be used for other purposes, such as a traditional density set, or as items to test students' ability to make accurate measurements, etc.

Equipment

Included:

- PASCO SE-9719 Discover Density Set

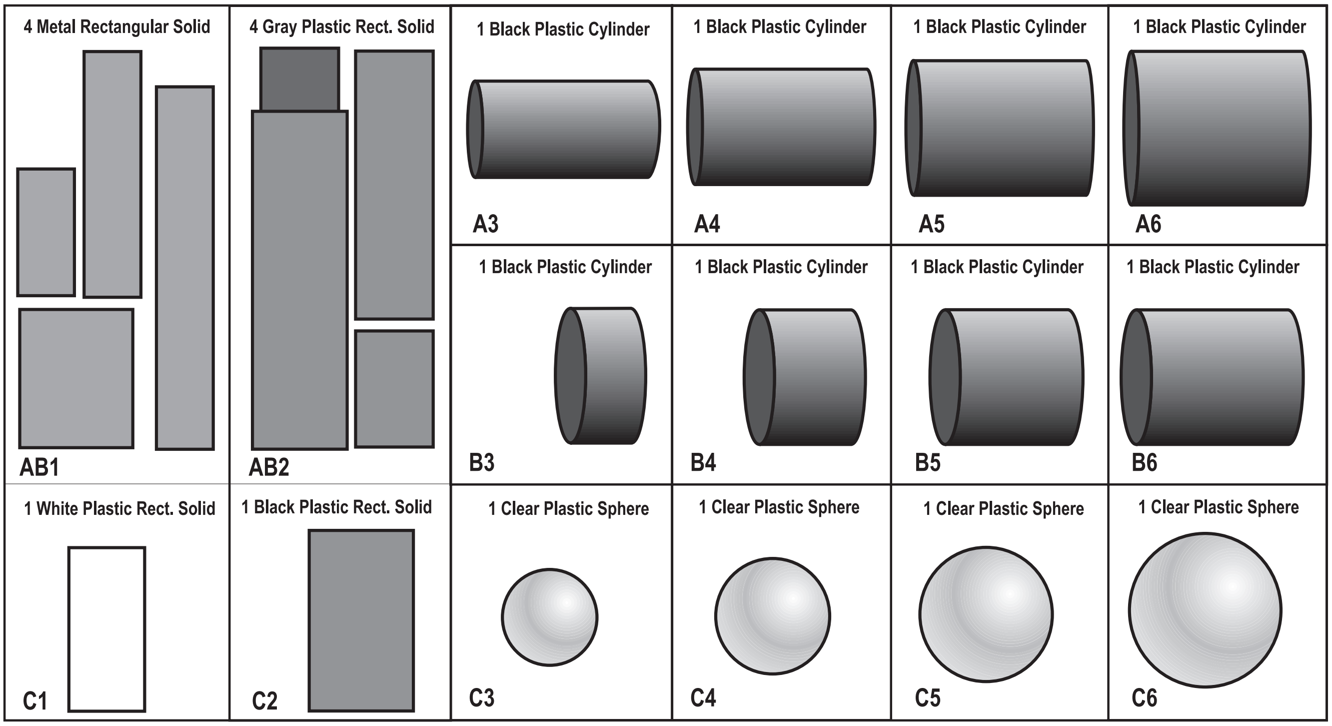

Figure 1
Contents of the SE-9719 Discover Density Set

Activities

The Speed of Sound (pre-lab)

Introduction

This sample problem presents you with experimental data, and then leads you through a process to obtain an equation that relates the data. A similar problem based on the materials in this set is left for you to do, based on the same process. The method is then extended to more complex situations.

A lightning bolt struck the earth, and upon seeing it, a number of observers started timing, using stopwatches. The observers each stopped their watches when they heard the thunder. The times recorded, and the distances of the observers from the point the lightning struck are recorded in the table. The variables have arbitrarily been labeled *x* and *y*:

x time (s)	*y* distance (km)
3.7	1.2
5.2	1.8
8.3	2.8
12.1	4.1
14.9	5.1

When this data is graphed, a straight line can be drawn that closely approximates the pattern of the data. We may assume that there are errors in the data caused by factors such as random differences in human reaction time in actuating the stopwatches, and inaccuracies of an unpredictable nature in measuring the distances. Such errors may be the reason that the points do not all fall exactly on the line.

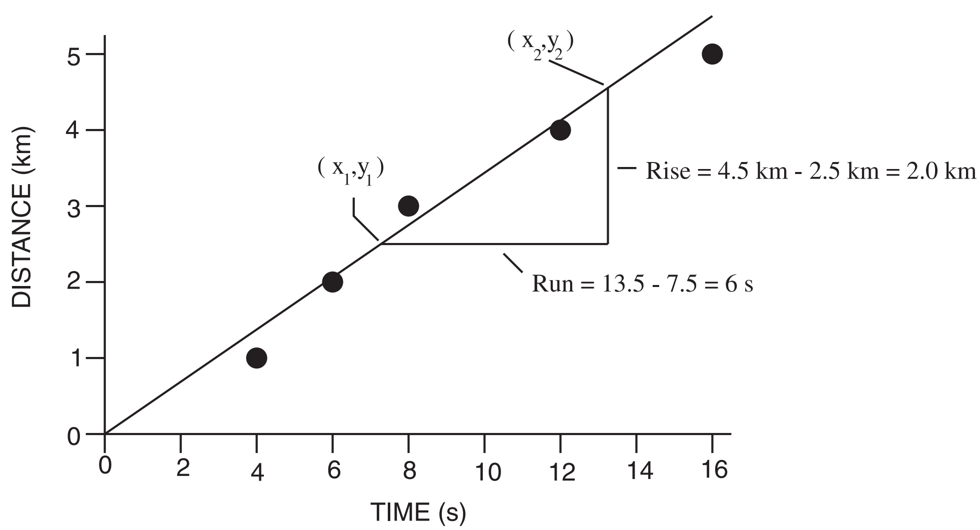

Figure 2
Graph of Speed of Sound data

In algebra, the formula for a graph such as above is often given by:

y = m x + b,

where y is the variable on the vertical axis,
x is the variable on the horizontal axis,
b is the point on the vertical axis where the line intersects, and
m is the slope of the line.

The slope is found by marking two points on the line, and dividing the difference in y-coordinates (called the rise) by the difference in x-coordinates (the run).

Since all parts of a straight line have the same slope, the slope is a constant for this experiment.

For this data, b is zero, and m is 2.0 km / 6.0 s = 0.33 km/s

Notice that dimensional units are part of the rise and of the run. The slope is found in this case by dividing a distance by a time. You should recognize this as the formula for speed.

The algebra equation y = m x + b may be translated into an equation appropriate to this situation by replacing the algebra symbols with the variables in the problem.

Thus, **distance = speed * time**, a very familiar equation!

The speed in this case is the speed of sound, and is in agreement with published data, considering uncertainty.

This example is intended as a simple illustration of how numerical data from an experiment is transformed from a table to a graph to a meaningful equation.

Finding an Equation Relating Mass and Volume

Introduction

In this activity you are given four rectangular solid metal pieces, and four similar plastic pieces. You are asked to take data, organize it, graph it, and create equations relating the mass and volume of each of the two kinds of material. A minimum of instructions are given. You should study and follow the example titled "The Speed of Sound" which preceded this task.

Materials required

The materials needed are in compartments AB1, AB2, C1, and C2.

Procedure

1. Create a table to record the length, width, and height, volume, and mass of the four metal pieces from compartment AB1, and a similar table for the four gray plastic pieces from compartment AB2.
2. Record the length, width, and height in centimeters. If you are using a metric ruler, estimate to the nearest 0.01 cm when finding these dimensions. Use the rules regarding significant figures or other appropriate methods of expressing uncertainty.
3. Consider the volume to be the independent variable, and the mass to be the dependent variable when graphing the data. Prepare a graph that shows the data for all eight objects, labeling your data points for the metal pieces with circles, and the data points for the gray plastic pieces with squares.
4. Draw a best-fit line for the data from the metal pieces, and another for the data from the grey plastic pieces. If straight lines passing through the origin do not represent the data well, recheck your measurements and calculations for any data points that do not fit the pattern.
5. Calculate the slope of each line, and include dimensional units as part of your calculations. Show your calculations, and use significant figures or another appropriate expression of uncertainty.
6. Although each item had its own mass and volume, the slope of the line for the metal pieces is constant. The metal pieces are all aluminum, and the slope is termed the *density of aluminum*. Find a published value for the density of aluminum, and compare to your value. Does your value agree within the limits of uncertainty?
7. The gray plastic is polyvinyl chloride, or PVC. Its published density is 1.36 to 1.40 g/cm^3. Does your value agree within the limits of uncertainty?

8. Write equations for each of the two lines obtained. Use meaningful symbols, such as “m” and “v”. Include dimensional units in the constant.

9. Find the mass, volume, and density of the transparent rectangular solid and the black rectangular solid from compartments C1 and C2. Plot them on the same graph as the aluminum and PVC. Ignoring the color, can you say with confidence that they are or are not the same type of plastic as PVC, or as each other?

The Mass of Fluorite Octahedra (Pre-lab)

Introduction

Developing a mathematical equation from a set of experimental data is an extremely useful skill. The examples that follow show a method that will work for a great many physics phenomena. Then you will be asked to apply the method to data in a lab situation.

The mineral fluorite is often found in geometric shapes having eight faces which are equilateral triangles. This example addresses the problem of finding an equation that allows one to calculate the mass of such a fluorite specimen from a measurement of one of the edges.

Experimental Data

Some data were obtained from direct measurement of five fluorite specimens:

x edge (cm)	*y* mass (g)
0.8	0.8
1.3	3.3
2.0	12.0
2.7	29.5
3.7	75.9

Graphing this data in the ordinary manner is a good first step. The results suggest an equation such as $y = x^2$, or $y = x^3$. Of course, a constant multiplier would likely be present, resulting in an equation such as $y = 0.57x^2$, or $y = 3.9x^2$. Finally, if the exponent were a number such as (3/2) or 2.716, the same basic shape of graph would still result. Quite often in physics, and particularly in simple situations such as this, the exponent will be either a small integer, or a ratio of two small integers.

Data Analysis

All of the equations above are of the form $y = c\, x^k$, where c and k are two different constants. Many equations in physics, although certainly not all, are of this form.

If an initial graph or other reasoning make it reasonable to assume an equation of the form of the form $y = c\, x^k$, the next task is to determine the values of c and k. Several methods exist for doing this. The first might be called “guess and test.”

We might guess, for the fluorite example, that the exponent is 2, so $y = c\ x^2$. This could be expressed in words as "y is proportional to x^2." Making a new table results in the following: (A computer spreadsheet program is an efficient way of creating such tables.)

x^2 edge^2 (cm^2)	y mass (g)
0.6	0.8
1.7	3.3
4.0	12.0
7.3	29.5
13.7	75.9

A graph of the above data does not result in a straight-line, as would have been the case if y had been proportional to x^2. See Figure 3.

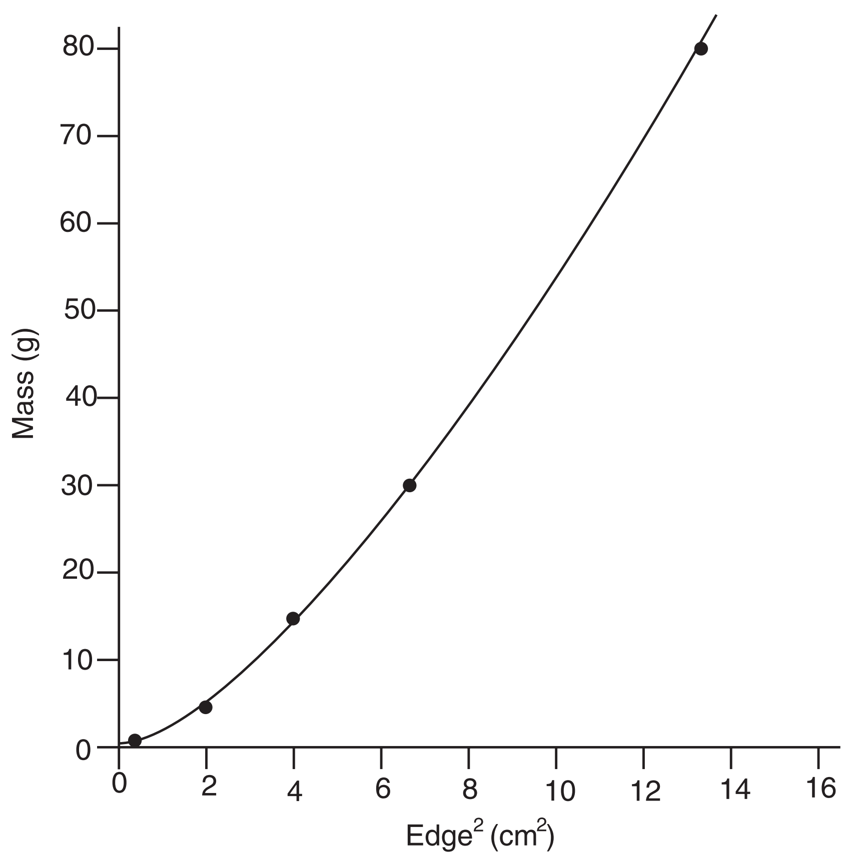

Figure 3
Graph of x^2 vs mass

The corresponding graph from table of x^3 and *y* values *is* straight, and thus shows that *y is* proportional to x^3. See Figure 4.

x^3 edge^3 (cm^3)	*y* mass (g)
0.5	0.8
2.2	3.3
8.0	12.0
19.7	29.5
50.7	75.9

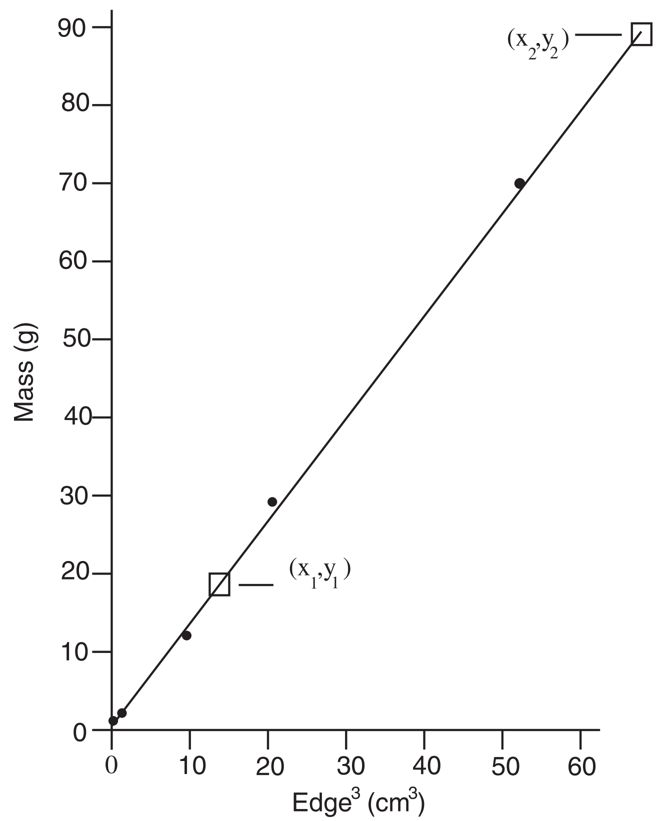

Figure 4
Graph of x^3 vs mass

The analysis has established that $y = c\,x^3$. The constant of proportionality, c, is simply the slope of the graph. Picking two points (x_1, y_1) and (x_2,y_2) on the graph and using the formula for slope

$(y_2 - y_1) / (x_2 - x_1)$ gives

$c = (90\text{ g} - 20\text{ g}) / (60\text{ cm}^3 - 12.5\text{ cm}^3) = 1.47\text{ g/cm}^3$

Notice that the value for c has dimensional units as part of its value; this will often be the case in science.

The final equation is thus:

$$y = 1.47 \text{ g/cm}^3 \; x^3,$$

and replacing the symbols x and y with more meaningful symbols (e for edge, m for mass), the final result is:

$$m = 1.47 \text{ g/cm}^3 \; e^3.$$

Although this is sometimes a tedious way to discover an equation representing data, a graph such as that in Figure 4 is a common and effective way to visually show the relationship. For this reason it is valuable to understand the method, even when the existence of technology (such as Data Studio) provides other methods that are easier to use.

Another method for data analysis

A second method is useful when a relationship such as $y = c\,x^k$ is suspected, but there is no clue what the exponent might be. This method is suggested by taking the logarithm of both sides of the equation:

$\log(y) = \log(c\,x^k)$, and then simplifying,

$$\log(y) = \log(c) + k\,\log(x)$$

If we regard $\log(y)$ and $\log(x)$ simply as two new variables, and if we understand that log(c) is merely another constant, we can see that this equation could be interpreted as just another linear equation. In this case, k is the slope, and log(c) is the vertical intercept. Creating a table of the logarithms of the original data and graphing shows this: (Again, a spreadsheet would be helpful.)

log(*x*) **log(edge)**	**log(*y*)** **log(mass)**
-0.1	- 0.1
0.11	+ 0.52
0.30	1.08
0.43	1.47
0.57	1.88

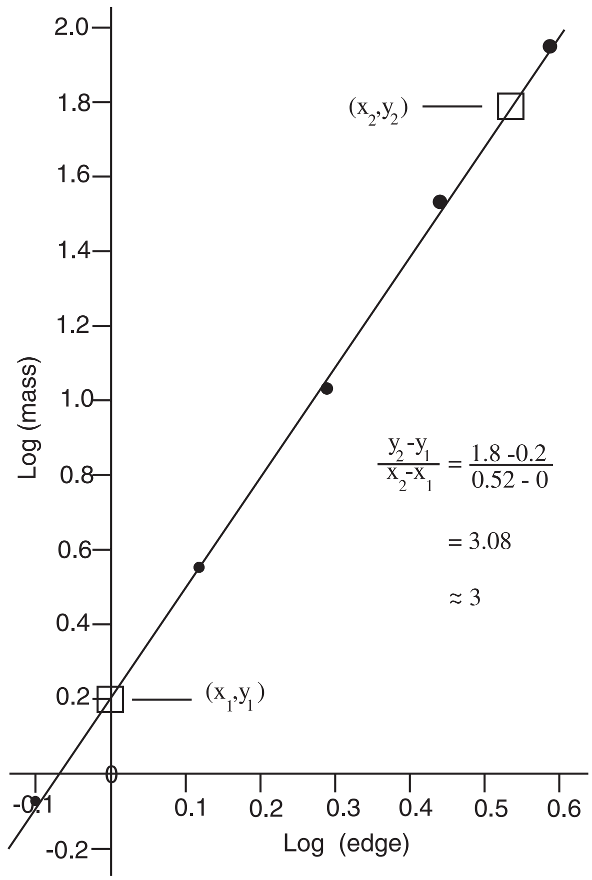

Figure 5
Graph of the log transformation of the experimental data

The straight-line graph (Figure 5) is confirmation that $y = c\,x^k$ was indeed the form of the equation. The slope of this graph is 3, showing that the exponent k is 3.

The constant c may be evaluated by various methods. Perhaps the best is by solving the equation for c, and substituting data from the original table.

Given that $y = c\,x^3$,

$c = y / x^3$, and substituting

$x = 2.7$ cm, $y = 29.5$ g (from the next-to-last data pair; any data pair could have been used)

$c = (29.5\text{ g}) / (2.7\text{ cm})^3$,

$c = 1.50\ \text{g/cm}^3$ Substituting this value, and the symbols e and m (for edge and mass), the final equation is

$m = (1.50\ \text{g/cm}^3)\ e^3$.

As an alternative to calculating the logarithms of all of the data, the data may be plotted on log-log graph paper, also called full logarithmic paper. The spacing between the lines on this paper is adjusted so that the appearance is the same as plotting the logarithms of the data on ordinary paper. The result is a straight line with a slope of 3. (Since the numbers on the paper are the same as the original data, calculating the slope requires first calculating the logarithms of the coordinates of two points.)

Note: As remarked before, while computer programs such as DataStudio provide rapid methods of data analysis, logarithmic graphs such as that above are a common and effective way to visually show this type of relationship. For this reason it is valuable to understand the method and gain familiarity with logarithmic graphs.

Analysis Verification

Often, data analysis of this sort is done in the hope of confirming some hypothesis that has been proposed. In any case, some sort of check or comparison is in order. Frequently, this check first involves algebraic manipulation of either the equation developed, or the hypothesized equation, to put them in the same terms.

In this example, we know that

mass = (density)(volume),

a math reference gives, for the octahedron,

volume = $(1/3)\ a^3\ (2^{\ 0.5})$, where a is the length of an edge,

and another reference gives

density of fluorite = 3.18 g/cm^3.

Combining these equations, we get

mass = $(3.18\ \text{g/cm}^3)(1/3)a^3\ (2^{\ 0.5})$,

and simplifying results in

mass = $1.499\ \text{g/cm}^3\ a^3$.

This result is in agreement with the results obtained by analysis of the experimental data.

Finding an Equation Relating Mass and Diameter of Transparent Plastic Spheres

Introduction

In this activity you are given four transparent plastic spheres of different diameters. You are asked to take data, organize it, graph it, and create an equation relating the mass and diameter of the spheres. A minimum of instructions are given. You should study and follow the example titled “The Mass of Fluorite Octahedra,” which preceded this task.

Materials

The materials needed are in compartments C3, C4, C5, and C6.

Procedure

1. Create a table to record the diameter and mass of the four spheres. Record the diameter in centimeters. If you are using a metric ruler, estimate to the nearest 0.01 cm when finding these dimensions. You should use two rectangular objects with the ruler to increase your accuracy. (See Figure 6.) Use the rules regarding significant figures or other appropriate methods of expressing uncertainty.

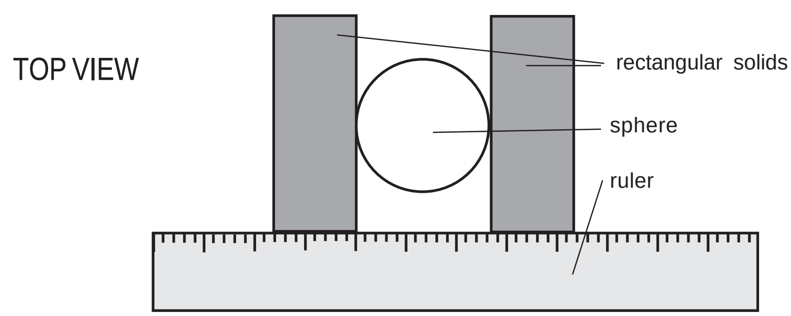

Figure 6
Using the rectangular solids to increase the accuracy of the measurement of the diameter of a cylinder

2. Consider the diameter to be the independent variable, and the mass to be the dependent variable when graphing the data. Prepare a graph that shows the data for all four spheres.
3. Draw a best-fit line for the data, which may be a smooth curve. If it is not possible to represent the data well with a smooth curve, recheck your measurements for any data points that do not fit the pattern.
4. State a hypothesis regarding the form of equation that is likely to best describe the data.
5. Determine an equation that represents the data. Use one or more of the methods outlined in the example, “The mass of fluorite octahedra.”

Your instructor may tell you which method(s) to use.

6. Check the accuracy of the equation by using the following data from published sources:

   volume of a sphere = $(4/3)\pi r^3$
   radius = diameter / 2
   density of the sphere material = 1.18 g/cm^3
   density = mass / volume

7. Algebraically combine this information to produce an equation giving the mass of these spheres in terms of their diameter.

8. Compare this result with the equation you determined experimentally. Are they in agreement, taking into account uncertainty?

Discovering a Mathematical Equation That Describes Experimental Data (Pre-lab)

Introduction

Mathematical equations of several variables are common in physics. Some examples are;

$F = m\,a$, Newton's Second Law of Motion,
$F = G\,(m_1\, m_2) / d^2$, The gravitational force between two point objects,
$a = v^2 / r$, a formula for centripetal acceleration, and
$T^2 = (4\,\pi / G)\, r^3 / M$, an equation relating orbital time of a satellite to the radius of its path and the mass of the body it orbits.

These equations and others may be discovered by organizing and analyzing experimental data. The example that follows leads you through the process of discovering a mathematical equation that describes experimental data. You will follow the same process in a lab activity that follows.

Pre-Lab Exercise: The Mass of Cones

Suppose you are given a variety of solid cones made of a certain type of metal. You are then asked to discover a formula that will allow you to calculate the mass of any cone of this metal, from measurements of the diameter of the base and the height. You are free to make measure the mass and other dimensions of the cones you have been given. You should assume that you do not know any special mathematical formulas regarding cones.

First, you recognize that there are three variables involved: mass, diameter, and height. Since it is difficult to analyze data from experiments in which more than two variables, you group the cones into two groups. One group all have the same height, and the other group all have the same diameter. Two others did not fit in either group. Measuring the cones gives the following results:

Group One are all 2.0 cm in diameter

Height	**Mass**
3.0 cm	5.56 g
4.0 cm	7.41 g
5.0 cm	9.27 g
6.0 cm	11.12 g

Group Two are all 2.0 cm tall

Diameter	**Mass**
2.0 cm	3.71 g
3.0 cm	8.34 g
4.0 cm	14.83 g
5.0 cm	23.17 g

Cones not in either group above

Diameter	**Height**	**Mass**
“A”: 1.0 cm	4.0 cm	1.85 g
“B”: 1.0 cm	6.0 cm	2.78 g

Group 1 and 2 each relate mass, which may be thought of as the dependent variable, to another variable that influences the mass.

Graphing the data from group 1, placing mass on the vertical axis, and height on the horizontal axis, we obtain a straight line that passes through the origin.

This form of graph shows that $y = \mathrm{m}\, x$, where y is the variable plotted on the vertical axis, and x is the variable plotted on the horizontal axis. “m” is the slope, which is constant. The value of “m” could be determined, to complete the equation. In this case, we do not need this much information. It is enough for us to see that y is proportional to x, or, in this case, that

mass is proportional to height.

Graphing the data of group 2 does not generate a straight line. The shape of the graph suggests an equation of the form $y = \mathrm{c}\, x^{\mathrm{k}}$, where and k are constants. This hypothesis may be tested, and the constants evaluated using any of the three methods described previously in the fluorite example.

The result of such an analysis is the discovery that y is proportional to x^2. In other words,

mass is proportional to diameter^2.

Evaluating the constant c is not needed.

An Important Theorem:

If a quantity is proportional to a second quantity, and the first quantity is also proportional to a third quantity, then the first quantity is proportional to the product of the second and third quantities.

Applying this theorem to the example at hand makes this concept more clear.

mass is proportional to height, and
mass is proportional to diameter^2 so

mass is proportional to height times diameter^2

In symbols:

$$M = CHD^2$$

where C is a constant of proportionality to be determined.

Solving for C gives

$$C = M / (HD^2).$$

Substituting any correlated set of data from the original data set, such as D = 2.0 cm, H = 6.0 cm, M = 11.12 g (corresponding to the last cone in group 1) gives

$$C = 11.12\ \text{g} \ / \ ((6.0\ \text{cm})(2.0\ \text{cm})^2)$$
$$= 0.46\ (\text{g/cm}^3)$$

The final equation, relating the mass, diameter, and height of all cones made of this particular alloy, is

$$M = 0.46\ (\text{g/cm}^3)\ HD^2$$

Finding an Equation Relating Mass to Length and Diameter of Black Plastic Cylinders

Introduction

In this activity you are given eight black plastic cylinders of different diameters. You are asked to group the cylinders, take data, organize it, graph it, and create an equation relating the mass to the length and diameter of the spheres. A minimum of instructions are given. You should study and follow the examples titled "the speed of sound," "The mass of fluorite octahedra," and "The mass of cones", which preceded this task.

Materials

The materials needed are in compartments A3 through A6, and B3 through B6. Place the cylinders into two groups. In each group, mass and only one other variable should vary.

Procedure (Group 1)

1. For one group of cylinders, create a table to record the diameter and mass of each. The length of each cylinder in this group should be the same. Record the diameter in centimeters. If you are using a metric ruler, estimate to the nearest 0.01 cm when finding these dimensions. You should use two rectangular objects with the ruler to increase your accuracy (Figure 7). Use the rules regarding significant figures or other appropriate methods of expressing uncertainty.

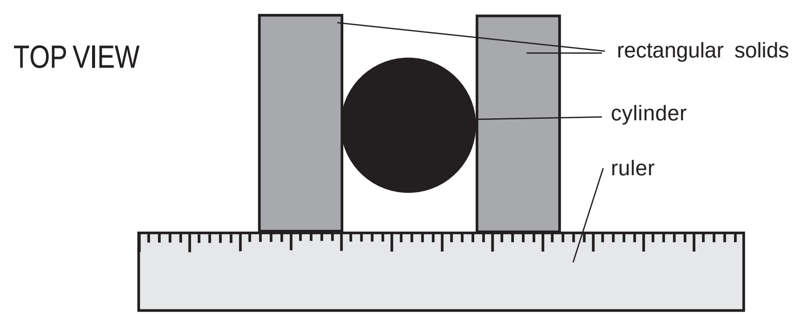

Figure 7
Using the rectangular solids to increase the accuracy of the measurement of the diameter of a cylinder

2. Consider the diameter to be the independent variable, and the mass to be the dependent variable when graphing the data. Prepare a graph that shows the data for all four cylinders.
3. Draw a best-fit line for the data, which may be a smooth curve. If it is not possible to represent the data well with a smooth curve, recheck your measurements for any data points that do not fit the pattern.
4. State a hypothesis regarding the form of equation that is likely to best describe the data.

5. Determine an equation that represents the data. Use one or more of the methods outlined in the previous examples. Your instructor may tell you which method(s) to use. It is not necessary to evaluate the constant in the equation at this time.

Procedure (Group 2)

1. For the other group of cylinders, create a table to record the length and mass of each. The diameter of each cylinder in this group should be the same. Record the length in centimeters. If you are using a metric ruler, estimate to the nearest 0.01 cm when finding these dimensions. Use the rules regarding significant figures or other appropriate methods of expressing uncertainty.

2. Consider the length to be the independent variable, and the mass to be the dependent variable when graphing the data. Prepare a graph that shows the data for all four cylinders.

3. Draw a best-fit line for the data. If it is not possible to represent the data well with a smooth line, recheck your measurements for any data points that do not fit the pattern.

4. State a hypothesis regarding the form of equation that is likely to best describe the data.

5. Determine an equation that represents the data. Use one or more of the methods outlined in the previous examples. Your instructor may tell you which method(s) to use. It is not necessary to evaluate the constant in the equation at this time.

6. Now combine the equations that you have developed for the two groups of cylinders. You may follow the example entitled "The mass of cones." At this time you should evaluate the constant in the equation, including dimensional units.

Analysis Verification

Check the accuracy of the equation you have developed by using the following data from published sources:

volume of a cylinder = $\pi r^2 h$
radius = diameter/2
density of the cylinder material = 1.42 g/cm^3
density = mass/volume

Algebraically combine this information to produce an equation giving the mass of these cylinders in terms of their diameter.

Compare this result with the equation you determined experimentally. Are they in agreement, taking into account uncertainty?

Specifications for the Parts

AB1	(a) 5.02 g; 0.95 cm * 0.95 cm * 2.08 cm = 1.88 cm^3 (b) 9.83 g; 0.95 cm * 0.95 cm * 4.05 cm = 3.66 cm^3 (c) 14.73 g; 0.95 cm * 0.95 cm * 6.08 cm = 5.49 cm^3 (d) 20.92 g; 1.90 cm * 1.90 cm * 2.18 cm = 7.89 cm^3
AB2	(a) 4.47 g; 1.31 cm * 1.31 cm * 1.93 cm = 3.31 cm^3 (b) 10.29 g; 1.31 cm * 1.31 cm * 4.45 cm = 7.62 cm^3 (b) 14.81 g; 1.31 cm * 1.31 cm * 6.38 cm = 10.94 cm^3 (b) 19.62 g; 1.31 cm * 1.31 cm * 5.59 cm = 14.7 cm^3
A3	8.04 g diameter = 1.59 cm; length = 2.86 cm
A4	11.38 g diameter = 1.91 cm; length = 2.86 cm
A5	15.52 g diameter = 2.22 cm; length = 2.86 cm
A6	20.57 g diameter = 2.54 cm; length = 2.86 cm
B3	5.51 g diameter = 2.22 cm; length = 1.02 cm
B4	8.25 g diameter = 2.22 cm; length = 1.53 cm
B5	11.10 g diameter = 2.22 cm; length = 2.04 cm
B6	13.81g diameter = 2.22 cm; length = 2.54 cm
C1	4.92 g 1.29 cm * 1.29 cm * 2.69 cm = 4.48 cm^3 Calculated density: 1.10 g/cm^3
C2	6.93 g 1.33 cm * 1.60 cm * 2.83 cm = 6.02 cm^3 Calculated density: 1.15 g/cm^3
C3	2.48 g diameter = 1.59 cm
C4	4.32 g diameter = 1.91 cm
C5	6.81g diameter = 2.22 cm
C6	10.15 g diameter = 2.54 cm

Teacher's Notes

Spheres

Finding the equation that describes the experimental data (spheres)

From the experimental data, the following relationships are shown to exist:

mass is proportional the diameter cubed

therefore:

mass = C * diameter^3

where "C" is some constant

Solving for "C":

C = mass / diameter^3

Substituting values for smallest sphere:

C = 2.48 g / (1.59 cm)^3 = **0.617 g/cm^3**

Rechecking with values from the next to largest sphere:

C = 4.81 g / (2.22 cm)^3 = **0.622 g/cm^3**

Calculating the theoretical value using known equations (spheres)

mass = density * volume; volume = 4/3 πr^2

density of acrylic = 1.18 g/cm^3; radius = diameter/2

then, mass = 1.18 g/cm^3 * 4/3 * π * (diameter^3)/8

mass = **0.618 g/cm^3** * diameter^3

This result is in agreement with the experimentally determined equations, considering uncertainty.

Cylinders

Finding the equation that describes the experimental data

From the experimental data, the following relationships are shown to exist:

mass is proportional to the diameter squared
mass is proportional to the length

therefore:

mass is proportional to the (diameter squared * length)

this means:

mass = C * diameter squared * length
where "C" is some constant

Example:

Calculating "C" for the item in A4:

C = mass / (diameter squared * length) = 11.38 g/ (19.1 cm^2 * 2.86 cm)
= 1.09 g/cm^3

Example:

Calculating "C" for the item in B6

C = 13.81 g / 2.22 cm^2 * 2.54) = 1.10 g/cm^3

Final Equation for the cylinders:

mass = **1.095 g/cm^3** * $diameter^2$ * length (l)

Calculating the theoretical value using known equations

mass = density * volume

substituting the formula for volume of a cylinder (volume = $\pi r^2 * l$):

mass = density * $\pi r^2 * l$

substituting an equation that relates radius and diameter (r = d / 2):

mass = density * π * (diameter / 2)^2 * l

Substitute the value for the density of the plastic, and gathering numerical factors:

mass = 1.42 g/cm^3 * π * 0.25 * $diameter^2$ * l

mass = **1.12 g/cm^3** * $diameter^2$ * l

This result is essentially the same as the experimentally determined value, except for the slight difference in the constant, due to measurement error.

Technical Support

Feedback

If you have any comments about the product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, please tell us. PASCO appreciates any customer feedback. Your input helps us evaluate and improve our product.

To Reach PASCO

For technical support, call us at 1-800-772-8700 (toll-free within the U.S.) or (916) 786-3800.

fax: (916) 786-3292

e-mail: techsupp@pasco.com

web: www.pasco.com

Contacting Technical Support

Before you call the PASCO Technical Support staff, it would be helpful to prepare the following information:

➤ If your problem is with the PASCO apparatus, note:

- Title and model number (usually listed on the label);
- Approximate age of apparatus;
- A detailed description of the problem/sequence of events (in case you can't call PASCO right away, you won't lose valuable data);
- If possible, have the apparatus within reach when calling to facilitate description of individual parts.

➤ If your problem relates to the instruction manual, note:

- Part number and revision (listed by month and year on the front cover);
- Have the manual at hand to discuss your questions.