1978

The Planet Puzzle (Lesson #2)

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The Planet Puzzle ADAPT Physics

Purpose and Introduction

Students were asked to categorize 13 previously collected samples into 4 groups. Ideas on what properties should be used to categorize the samples were left open to the students. It was found that properties dependent upon the method of collection would make more than 4 groups, therefore properties dependent only upon the material were used in the categorization.

Discussion

All samples were coated in red paint and shaped as parallelepipeds. Volume (size) was determined by water displacement upon immersion in a graduated cylinder (knowing that 1ml = $1cm^3$) or by measuring the length of sides with a ruler (knowing that vol. = len. side 1 * len. side 2 * len. side 3). Mass was determined by using a pan balance and standard masses. However, these properties were reasoned to be extrinsic as they depended upon collection methods.

Possible intrinsic properties were examined next. By using a compass, it was found that none of the samples were magnetic. 4 samples were found to float. This led to density as an intrinsic property. As found in lab, density is mass divided by volume (d = m / v). This is a measure of how much mass is 'packed' into a unit volume and is dependent upon the type of material, not how it is collected.

Explanation

Density was used to group the 13 samples (see data sheet 1). The four groups were matched to Earth materials as follows:

Alpha	Oak
Beta	Aluminum
Gamma	Brass
Delta	Lead

the 4 odd shaped objects were determined to be:

Clothes Pin	Pine
Stopper	Lucite
Screw	Zinc
Cylinder	Copper

Most of the error between the measured and the known densities occurred in measuring the volume. The graduated cylinder could be read only to the nearest .5 ml and any error in using a ruler was increased upon finding the volume. A smaller error was attributed to measuring the mass.

Conclusions

As stated before, density is an intrinsic property; a property depending upon only the material. It is useful as it may be used to determine the material of an unknown sample if given a reference of known densities.

The density of water is $1gm/cm^3$ (see data sheet 2). If an object is less dense than water it will float; more dense it will sink.

Density is used outside physics and chemistry in a variety of ways. The population density of a city is greater than that of a rural area. A forest is dense with trees where a field is not. A person may be considered dense if she/he is slow witted. The first two uses are closely related to that in physics and chemistry since they describe how much 'something' is in a certain area or volume.

Through exploration, the lab showed the importance of intrinsic properties. Density was found and applied to various objects to determine their material composition. The Planet Puzzle lab stressed problem solving through ideas and used concept applications to solidify the notion of density.

Instructor's Sheet for the Planet Puzzle

The central idea of this activity is to confront the student with the requirement to quantify his concrete experience with materials of different densities. Density, since it involves ratios, requires formal operations. This experiment begins with a task that will hopefully induce some disequilibration, followed by the opportunity for self-regulation.

EXPLORATION The samples which we prepared were chosen so as to provide a moderate amount of disequilibration, even for the better students. Since we used standard square bar stock the sizes are given in inches. All the samples were painted with the same color of paint.

Sample	Size	Mass(grams)
Four of equal volume		
Lead (sp. gr. = 11. 3)	1/2" x 1/2" x 1/2"	23.0
Yellow brass (sp. gr. = 8.56)	1/2" x 1/2" x 1/2"	17.6
Aluminum 606l (sp. gr. = 2.71)	1/2" x 1/2" x 1/2"	5.6
Oak (sp. gr. = 0.635)	1/2" x 1/2" x 1/2"	2.6
Four of equal mass		
Lead	1/2" x 1/2" x 0.86"	40.0
Brass	1/2" x 1/2" x 1.44"	40.0
Al 6061	1/2" x 1/2" x 3.60"	40.0
Oak	3/4" x 3/4" x 6.825"	40.0
0dd one		
Lead	1/2" x 1/2" x 1.14"	52.8
Two of equal volume		
Brass	1/2" x 1/2" x 1.825"	65.8
Al 6061	1/2" x 1/2" x 1.825"	20.9
Same mass as small Al cube		
Oak	1/2" x 1/2" x 2.16"	5.6
Same length as Al bar		
Oak	3/4" x 3/4" x 3.60"	21.1

Note that two of the samples are too big to fit down into the 100 ml graduated cylinder.

INVENTION

Please make certain that all of the students are aware of the process by which the volume of an odd shaped object can be measured by using its displacement of water.

APPLICATION

Include one odd shaped object that is less dense than water as a challenge to the students.

The densities given in the table may be corrected so that the oak, aluminum, brass, and lead densities match those of the samples that are used in the exploration.

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Exploration Activity

The starship Enterprise visited the planetary system that surrounds the star Nerf. The ship and crew visited four planets in the system and collected representative samples of material of each planet. Upon their return to the Enterprise, the samples were cut into rectangular parallelepipeds, and covered with a heavy coat of space paint to protect the samples from our oxygen rich atmosphere. Unfortunately, the lab assistants forgot to put proper code numbers on the various samples.

You are given a sack containing 13 samples that were collected by the Enterprise crew. Without damaging the space paint coat, separate these samples into four classes which you think represent the material of each of the planets they visited.

What are the properties of these materials that you can use to classify them?

Write a brief characterization of the material from each of the planets, say...

Alpha:

Beta:

Gamma:

Delta:

To assist you in this task you will find the following items on your lab table:
a piece of string, tub of water, meter stick, a pan balance, magnetic compass, 100 ml graduated cylinder, and some standard masses.

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Concept Invention

What is the amount of space occupied by each of the 13 samples?

Explain how you determine this for the samples. How could you determine it for an odd shaped object?

What is the mass of each sample?

Explain how you determine this for the samples.

DENSITY = _____

Measure the density of water.

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Concept Application

Density of Materials
(as found here on Earth)

Material	Density (gm/cm^3)
Mahogany	0.54
Pine	0.59
Oak	0.64
Bakelite	1.07
Lucite	1.18
Magnesium	1.74
Aluminum	2.70
Vanadium	5.96
Zinc	7.14
Brass	8.56
Copper	8.92
Silver	10.5
Lead	11.3
Tantalum	16.6
Uranium	18.7
Gold	19.3
Platinum	21.5

What four earth materials are most like the composition of the four planets?

Given four odd shaped objects, from their densities alone, determine of what materials they are most likely composed.

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Write-up: Due at the beginning of the next lab period

The Planet Puzzle Report

Write your own individual report on the Planet Puzzle. All members of your group should have the same data and results. Your individuality should show in specified parts:

Your PURPOSE AND INTRODUCTION
Your DISCUSSION of data collection process
a) Why did you select density as an important property of the samples?
Your EXPLANATION of the data analysis
Group DATA AND REASONING
Your CONCLUSIONS
a) What kind of property is density?
b) How is density a useful concept?
c) How can density be used in deciding if objects will float or sink in water?
d) List three ways the word density is used outside physics or chemistry. How do these uses compare with the word as used in physics?
Your ASSESSMENT of the contribution of each member of the group made to your group work. Did some people do much more that others? Some much less than others? Assign a percentage of the total work to each person.