Earth Science Name:
Date:

Introduction to Observation and Measurement

Introduction

Your skills in observing, measuring, and describing your world are, and always will be, very important to you. The activities you'll do in these investigations help you improve your abilities, and introduce you to ways in which scientists measure our planet and its place in the solar system.

You can observe the world using your five **senses**: **sight, hearing, touch, smell,** and **taste**. Sometimes you need to know more than you can learn only through your senses, so that's where measuring becomes important. You're making a measurement when you decide what size clothing to buy, or even how old you are.

We use **instruments** to extend our senses and make more accurate measurements. In the blank spaces, write the names of some instruments that you might use to measure each variable.

Length:

Mass (weight):

Liquid volume:

Temperature (heat energy):

Time:

All of these measurements are **direct—**this means that you find the value by comparing it with a know amount, such as the distance between lines on the ruler. Examples of variables you often measure directly are your height and weight (mass.)

Other measurements are **indirect**—they are found by measuring something which is related, then using a mathematical equation to calculate what you want. For example, to find the area of a flat surface, you'd measure the length and width, and then multiply them to find the area. To find the volume of a rectangular solid, such as a block, you'd multiply the length times the width times the thickness.

One of the most important variables you will study this year is **density.** This describes the amount of a substance in a certain volume. For example, if you had the same volume of a solid, such as a rock, and a gas, such as air, the solid would have a greater mass, so we say it is "more dense" or "denser." After you measure the volume and use a **balance scale** to find the mass, you can determine the density using the relationship:

density = (mass) / (volume)

That is, you divide the mass by the volume. If you know any two of these three variables, you could find the other through their relationships:

mass = (density) x (volume) volume = (mass) / (density)

Some examples of how density is important in our world are that weather, volcanic eruptions, and even the slow movements inside the Earth that move continents over vast periods of time are driven by differences in density.

Finally, you need to consider the **accuracy** of your measurements. All instruments have slight errors—the bathroom scale you use is not precise, nor is any ruler completely accurate. So we commonly use two mathematical techniques to help understand more about accuracy. One is **finding the average**, which you probably already know. The other is finding the **percent deviation from the accepted value**, which you will learn more about later in this activity.

Activity 1 –Making Measurements of Length, Area, and Volume (12 pt.)

1. **Length**

Let's start with something both simple and important to you—your own height and the circumference of your head. Work with a partner to measure and record these, to the nearest 0.1 cm.

Your height: Circumference of your head:

Measure the objects given to the **nearest 0.1 cm** and record your answers.

Block	Length (longest side)	Width (middle side)	Thickness (shortest side)
Code			
Cylinder	Length (longest side)	Diameter (across the top)	Circumference (around the middle)
Code			

Ball	Diameter (across the top)	Circumference (around the middle)
Code		

2. **Area**

The area means how much space an object covers on a surface.

Area of a rectangle

The side of a block is rectangular, so we can find its area using the relationship: **Area = length x width (or thickness, or width x thickness)**

Complete the table below of **areas for the sides of your block**. You need to record your answers to the **nearest 0.1 cm^2** (that is, **rounded to one decimal place**.)

Largest side	Medium side	Smallest side

<u>Area of a circle</u>

The area of a circle is found using the relationship: **Area = πr^2**

The symbol **"π"** is pronounced "pie" and spelled out "pi." It comes from the number one always gets by dividing the circumference of a circle by its diameter. It is approximately equal to 3.14.

Calculate and record the **area of the top of the cylinder**, rounded to the nearest 0.1 **cm^2**:

<u>Area of a sphere</u>

The area of a sphere, such as the ball, is found using the relationship:

$$\textbf{Area} = 4 \pi r^2$$

Calculate and record the **area of the ball**, rounded to the nearest 0.1 **cm^2**:

3. **Volume**

The volume of an object means how much space it occupies (takes up.)

<u>Volume of a rectangular solid</u>

The volume of a rectangular solid is found using the relationship:

Volume = (length) x (width) x (thickness)

Calculate and record the **volume of the block**, rounded to the nearest **0.1 cm^3**:

<u>Volume of a cylinder</u>

The volume of a cylinder is fond by the relationship:

Volume = (area) x (length)

Calculate and record the **volume of the cylinder**, rounded to the nearest **0.1 cm^3**:

<u>Volume of a sphere</u>

The volume of a sphere is found using the relationship:

$$\textbf{Volume} = (4/3) \pi r^3$$

Calculate and record the **volume of the ball**, rounded to the nearest **0.1 cm^3**:

4. Measuring Earth and Beyond

Directions: Use print and online resources to answer the following questions. **Cite your sources.**

A. What is the **circumference of Earth around the equator?**

B. What is the **circumference of Earth around the poles?**

C. What explains the difference?

D. What is the **average distance between the Earth and the Sun?**
What are the **maximum and minimum distances between the Earth and the Sun?**

E. What is the **average distance between the Earth and the Moon?**
What are the **maximum and minimum distances between the Earth and the Moon?**

F. Compare the distances between the Earth and Mars, and Earth and Venus. Give measurements to support your comparison.

G. What and where is the highest elevation in New Jersey? How does this compare with the highest elevation in New York? Florida? Colorado? Alaska?

Activity 2 – Measuring Mass and Density (8 pt.)

1. **Mass**

Use both **triple-beam** and **digital balance scale**s to find the mass of the objects you measured in Activity 1, to the **nearest 0. 1 g**.

Block (code:)	Cylinder (code:)	Ball (code:)
(Triple-beam)		
(Digital)		

What might explain any differences? How would you decide what value to use?

2. **Irregularly-shaped Objects**

What you have used so far were objects with "regular" shapes that can be described using mathematical equations. But how would you measure "irregularly-shaped" objects, such as minerals and rocks?

You can still use a balance scale to determine the mass. Let's begin with two common minerals—quartz (SiO_2) and galena (PbS)—and two common rocks—**granite** (lighter-colored) and **basalt** (darker-colored).

Record the masses of your samples to the nearest 0.1 g.

Quartz	Galena
Granite	Basalt

Now you have the problem of finding the volume of the irregularly-shaped object. Many centuries ago, a Greek scientist discovered how to do this using the **water displacement method**. He realized that the volume of the object is equal to the volume of water it displaces (moves up) in a container.

You will use a **graduated cylinder** or **beaker**. First, pour in water to a chosen line (the "original" level). It should be exact, but can be less than the volume of the object. Then carefully put in the object. Now use the **pipette** to add more water **carefully and precisely** until you have **just covered the object**. Record the "final" level. When you subtract the original level from the final level, the **difference** is the volume of the object.

Liquids are measured in milliliters (mL), but one mL exactly equals 1 cm^3, so record your answer to the nearest 0.1 cm^3.

Quartz	Original level	Final level	volume
Galena	Original level	Final level	Volume
Granite	Original level	Final level	Volume
Basalt	Original level	Final level	Volume

3. Determining Density

In the Introduction, you read that density is one of the most important **properties** or **characteristics** of many objects making up our world. Many Earth processes result from differences in density. Weather is a good example.

Once again,

density = (mass) / (volume)

The unit used to record density is **"grams per cubic centimeter" (g/ cm^3)**, or for liquid, **"grams per milliliters" (g/mL)**.

First, calculate the density of the objects using your measurements and record them in the table below. Then, we will compare the results of all the groups and find the "class average." This will help find out how accurate are our results.

Object	Your group's results	Class average
block		
cylinder		
ball		
quartz		
galena		
granite		
basalt		

Give two or three reasons why your group's results may differ from the class averages:

Activity 3—Finding the "percent deviation from the accepted value." (8 pt.)

The Introduction also reminded you that all instruments contain some error because they are not perfect. Often in scientific investigations, we use a technique called finding the **"percent deviation from the accepted value."** The "accepted value" is the real value, and may be given to you in a problem or found in a reference table.

The equation to find "percent deviation from the accepted value" is:

Deviation (%) = [(difference from the accepted value)/(accepted value)] x 100%

This means that you:

1. subtract the measured value from the accepted value
2. divide this difference by the accepted value
3. multiply this quotient by 100%

In most cases, it does not matter if the subtraction produces a positive or negative number—all we are interested in is by what percent the answers differ, not if it is more or less.

To learn more about this important equation, we will use the values you obtained in Activity 2 for the density of the minerals and rocks. From standard reference sources, we know that

Density of quartz = 2.7 g/cm^3
Density of galena = 7.6 g/cm^3
Density of granite = 2.7 g/cm^3
Density of basalt = 3.0 g/cm^3

In the spaces below, calculate percent deviation for your group and class results. Show your work—**remember to include the proper units**.

1. Deviation from your group's results for quartz =

2. Deviation from class average for quartz:

3. Deviation from your group's results for galena:

4. Deviation from class average for galena:

5. Deviation from your group’s results for granite =

6. Deviation from your class’s results for granite =

7. Deviation from your group’s results for basalt =

8.Deviation from your class’s results for basalt =

Question 1: Which measurements were most accurate? least accurate?
What might explain the differences?

Question 2: What are three examples of measurements that people make everyday which must have very small percent deviations (be very accurate)? What are three examples that can be less accurate (have a wider percent deviation)?

Question 3: How do airplanes make sure there is great accuracy (little deviation) in measuring their altitude (height above the ground)?

Activity 4 – Measuring Temperatures (8 pt.)

Each day, one of the first things you want to know is, "What's the temperature going to be?" This weather variable gives you important information needed to choose your dress or plan for activities. After doing the measurements in this part, find answers to these three questions:

1) How does the National Weather Service measure current air temperature?

2) When are the usual highest and lowest temperatures each day?

3) How does the NWS measure temperatures above the surface?

First, though, measure and record the temperature of the three water samples:

Ice-water mixture	Room temperature water	Boiling water

The ice-water mixture should be at 0 ^{o} C and the boiling water should be at 100 ^{o} C. Calculate the percent deviation for these. (Show work and include units.)

Now find answers to the questions above.

Final Thoughts (5 pt.)

On paper attached to this packet, write about:

- Five important things you have learned while doing these activities
- What you liked best
- What you found most difficult and why

Extra Credit 1 – The “Big Challenge” – Finding the Height of a Flagpole (5 pt.)

Everything we have done so far involves important skills, but the problems really were not too challenging. So now I give you this: How can you measure the height of something too big to measure directly, the flagpole in front of the school?

You and your group should start by discussing ways to solve the problem. Make notes of what you do as you make your measurements, and present your results. Use simple drawings to help explain things.

In a report attached to this packet, include your:

Statement of the Problem
Procedures (methods you used)
Results (including proper units)

Extra Credit 2 – Determining the Thickness of Aluminum Foil (5 pt.)

You can use the measurements and relationships among length, width, thickness, mass, and density to determine the thickness of a piece of aluminum foil. If you wish to do this, see Dr. Passow for the problem sheet.

Extra Credit 3 – Determining the Density of Air (5 pt.)

Determine a strategy to use a balloon to measure the density of air, Carry out your strategy and write a report of the procedure and results.

Compare your results with the acceptable value for the density of air. Calculate percent deviation, and give an explanation for any difference.