Chapter 1

INTRODUCTION TO EARTH SCIENCE

Chapter Checkin

- ❑ Knowing the basic ways to make a measurement
- ❑ Understanding the different ways to graph data
- ❑ Calculating the percent error of a measurement

The Earth is the only planet in our solar system that has an atmosphere that can support life. Water can be found in all three states of matter (liquid, solid, and gas) and Earth also has a dynamic crust. Forces are constantly at work changing the landscape on the Earth's surface. Earth Science can be divided into four branches. Geology is the study of rocks, minerals, and forces that wear down the surface and build mountains. Meteorology covers weather, climate, and the atmosphere. Astronomy investigates planets, stars, and other features outside of the atmosphere. The study of the oceans is called oceanography.

Observations and Measurement Methods

An **observation** is made when you collect data through your senses. **Instruments** such as telescopes, microscopes, meter sticks, and stopwatches are used to extend your senses. An **inference** is an educated guess based on data that is collected and interpreted.

Basic Units of Measurement

You can make measurements in five basic ways. A measurement consists of a number and a unit. The five basic measurements, units, and instruments used to make these measurements are in Table 1-1.

Table 1-1 Units of Measurement

Measurement	*Basic Unit*	*Instrument Used*
Length	Meter	Meter stick
Mass	Gram	Triple beam balance, electronic balance
Volume	Liter	Graduated cylinder, overflow canister
Time	Second	Stopwatch
Temperature	Degrees Celsius	Thermometer

Derived Units

From these basic units, **derived units** can be formed. Density is an example of a derived unit that is used in Earth Science. Density = mass/volume and the units are grams/cm^3 or grams/ml.

Scientific Notation

Scientific notation is used to show very small or very large numbers in a convenient way. This consists of a base number that can range from 1.0 to $9.\overline{999}$. This base number is multiplied by 10^x. If the value of *x* is negative, then the original number is less than 1.0, and the decimal place is moved to the left. A positive number in the exponent place means that a large number is converted to scientific notation, and the decimal place is moved to the right. Examples of the use of scientific notation are as follows:

43,000,000,000,000,000 mi becomes 4.3×10^{16} mi.

.00152 cm becomes 1.52×10^{-3} cm.

Prefixes can be added to the base units to subdivide a measurement. Table 1-2 shows prefixes, their abbreviations, and their multiplying factors.

Table 1-2 Scientific Notation Prefixes, Symbols, Multiplying Factors

deci	d	1/10	deka	da	10
centi	c	1/100	hecto	h	100
milli	m	1/1,000	kilo	k	1,000
micro	μ	1/1,000,000	mega	M	1,000,000
nano	n	1/1,000,000,000	giga	G	1,000,000,000

Percent Error

You can determine the inaccuracy of a measurement when compared to the actual measurement by finding the **percent error.** This is also called the percent deviation. This tells you how far away your value is from the accepted value, in a percent form. The formula used is

$$\text{Percent error} = \frac{\text{actual value} - \text{your value}}{\text{actual value}} \times 100$$

Density

The **density** of an object is its mass divided by its volume. Mass is the amount of matter in an object. Volume is the amount of space that an object takes up. Volume can be measured in cm^3 for solids and in milliliters for liquids. One cm^3 equals 1 ml. This value is a physical characteristic for a substance that does not change if the size of the material changes. The reason for this is shown in the following paragraph:

$$D = m/v$$

If the mass is 12 g and the volume is 6 cm^3, the density is 2 g/cm^3. Suppose that the object was cut in half. The mass would be 6 g and the volume would be 3 cm^3. By using the density formula again, the resulting density is the same, 2 g/cm^3. The formula is just a ratio of matter ("stuff") to volume ("space"). If you change both equally, the density will remain the same. If, in a different example, the volume is changed and the mass remains the same, then the density changes. See Figure 1-1 for this concept in more mathematical detail.

Figure 1-1 Changes in density shown mathematically.

$$D = \frac{M}{V} \quad D = \frac{12g}{2cm^3} = 6\ g/cm^3$$

If volume decreases → $V = 1cm^3$

$$D = \frac{M}{V} = \frac{12g}{1cm^3} = 12\ g/cm^3$$

If volume increases → $V = 3cm^3$ $\quad D = \frac{M}{V} = \frac{12g}{3cm^3} = 4\ g/cm^3$

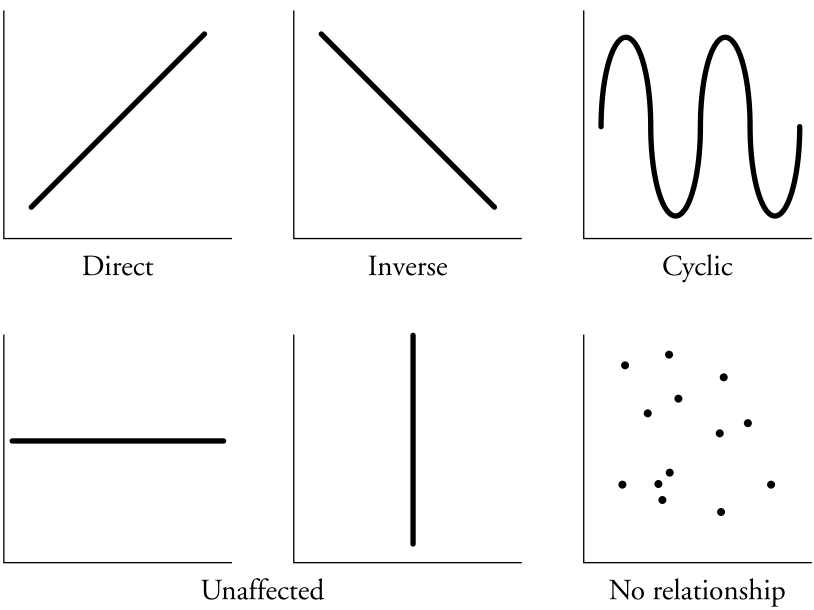
$V = 4cm^3$ $\quad D = \frac{M}{V} = \frac{12g}{4cm^3} = 3\ g/cm^3$

$V = 6cm^3$ $\quad D = \frac{M}{V} = \frac{12g}{6cm^3} = 2\ g/cm^3$

Types of Graphs

The relationship between two measurable factors can be represented by a graph. If both values increase, they are considered to have a direct relationship**.** For example, the more you work, the more money you make. To use a sports analogy, the more you practice, the more points you will score. If one value increases while the other decreases, they have an inverse relationship**.** An example of this is the more you work on your golf swing, the lower your score will be. Cyclic graphs show one variable alternating its value in an increasing and decreasing pattern while the other variable remains constant. Sunspots can be charted to show this pattern. The rising and falling level of the ocean tide is graphed by a cyclic graph. If one variable stays constant while the other increases, the graph shows a horizontal or vertical line. A graph plotting density and size would show this type of relationship. If there is no relationship that can be found between two variables, no line can be drawn on the graph. These graphs are in Figure 1-2.

Figure 1-2 Graphs showing relationships.



Several types of graphs can be used to show relationships. **Line graphs,** which were discussed in the preceding paragraph, are used extensively in Earth Science. Line graphs use a **coordinate system** to plot the points. The independent variable is plotted along the horizontal axis (x-axis) and the dependent variable is plotted along the vertical axis (y-axis). The line drawn can connect the points from dot to dot. A line of best fit can also be drawn. This is a straight line running through most of the points.

A pie chart can be used to organize data in a different way. This chart can show how something is divided into its component pieces. The percentages of the elements that make up the Earth's crust can be depicted clearly in a pie chart.

If one variable is being observed over time, it is sometimes useful to show this with a bar graph. The rainfall for an area can be represented with a bar graph, with a different bar representing each year's rainfall.

Natural Resources and Conservation

The amount of natural resources that we have on the Earth is limited. These are substances that come from the Earth. **Renewable** resources are replenished shortly after they are used. Examples of these are wind, solar, geothermal, and trees. If the resource cannot be replaced for millions of years or at all, it is **nonrenewable.** Fossil fuels (coal, oil, and natural gas), radioactive materials (for nuclear energy), groundwater, minerals and metals from the ground are all nonrenewable resources. Unless we change our ways, the finite amounts of these materials will be used long before they are replenished.

There are several methods that we can use to conserve these resources. Reducing the amount used will help stretch the remaining amount further. By reusing some materials, we can help ensure that the supply won't run out soon. Many areas are recycling their materials, which can help ease the need for new materials. This also decreases the amount of garbage that we make.

Pollution

The Earth is in a balanced state. In a very short time, geologically speaking, humans have disrupted this **equilibrium.** There are many areas that we have polluted. **Pollution** is a substance that harms living organisms or the environment. In some instances, the Earth can return to its original state of **dynamic equilibrium,** but in others it can take a long time, if at all, to repair the damage done. With the increase of industry and technology, we have sped up the pollution process in some instances.

Types of Pollution

Air pollution can be caused by many factors. Carbon dioxide, a **greenhouse gas,** can be made through the process of respiration and as a by-product of burning fossil fuels. Carbon dioxide, as well as other greenhouse gases such as methane and water vapor that are found in the atmosphere, can absorb longwave radiation coming from Earth and can hold this heat, which raises the air temperature.

Water pollution can be caused by many sources. These range from mercury levels that are harmful to humans, to fertilizers that are washed into the water supply.

The ground can also be polluted by human activities. The disposal of garbage and wastes can affect the ground. Chemicals that leach into the soil can be harmful to plants and animals.

Chapter Checkout

Q&A

1. Using a ruler to measure the length of a stick is an example of

a. extending the sense of sight by using an instrument.
b. calculating the percent of error by using a proportion.
c. measuring the rate of change of the stick by making inferences.
d. predicting the length of the stick by guessing.

2. The diameter of Jupiter through its equator is about 143,000 km. What is this distance written in scientific notation (powers of 10)?

a. 143×10^2 km
b. 1.43×10^3 km
c. 1.43×10^5 km
d. 143×10^5 km

3. A pebble has a mass of 35 g and a volume of 14 cm^3. What is its density?

a. 0.4 g/cm^3
b. 2.5 g/cm^3
c. 490 g/cm^3
d. 4.0 g/cm^3

4. A student measures his latitude to be 50.0° N when it is actually 40.0° N. What is the percent deviation (percentage of error) in his measurement?

a. –10%
b. –15%
c. –20%
d. –25%

Answers: 1. a **2.** c **3.** b **4.** d