

Introduction to Earth Science, Observation, Measurement, and the Changing Environment

- I. **Earth Science** - is a broad category of science that studies our planet, its changing systems, and its place in the universe. The earth sciences include major disciplines that include geology, meteorology, astronomy, and oceanography.

- II. **Observation and Measurement** - Observations and measurement are used in all of the sciences. An observation is information obtained directly from one of the five human senses
 - A. **Measurement** - is a means of expressing an observation with great accuracy. Measurements are expressed by both a numerical value and a unit.
 1. **Units of Measurement** - In the United States, we utilize two units of measurement, the English System, and the Metric or International System.
 - i. **Length** - the distance between two points.
 - ii. **Mass** - the amount of matter in an object.
 - iii. **Time** - is the duration of the event being observed.
 - iv. **Temperature** - is a measure of kinetic energy, commonly known as heat.
 2. **Percent Error** - The difference between the measured value and the true value is called the percent error. Percent error is calculated using the

following formula:

$$\text{Percent Error} = \frac{\text{accepted value} - \text{measured value}}{\text{accepted value}} \times 100\%$$

3. **Scientific Notation** - measurements that are very small or extremely large are often recorded in scientific notation, also called exponential notation.
4. **Density** - is a derived unit that measures the concentration of matter (mass) in a given space, or the mass per unit volume of a substance.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

The density of a uniform material is independent of the size and shape of the material. Density is usually measured in grams/cubic centimeter.

- i. **Density and Temperature** - density usually decreases when temperature increases. Therefore, as a substance becomes heated, it becomes less dense.
- ii. **Density and Pressure** - as pressure increases, so does the density of the material. Air under higher atmospheric pressure is more dense than low pressure air.
- iii. **Density and the Three States of Matter** - density usually changes with a change in the state of matter. Gas is least dense, liquid is more dense, and solids are most dense.
- iv. **Density and Water** - water, unlike most substances, is most dense in its liquid form at 4 Celsius. The solid form of water is less dense than the liquid form. This is why ice floats.

Densities of Common Substances

Material	Density (gm/cm ³)	
Liquids		
Water at 4 C	1.0000	
Gasoline	0.70	
Mercury	13.6	
Milk	1.03	
Solids		
Aluminum	2.7	
Copper	8.3-9.0	
Gold	19.3	
Iron	7.8	
Lead	11.3	
Uranium	18.7	
Ice at 0 C	0.92	
Gases at STP		
Air	0.001293	
Carbon dioxide	.001977	
Carbon monoxide	0.00125	
Hydrogen	0.00009	
Helium	0.000178	
Nitrogen	0.001251	

III. **Observation and Inferences** - Observations are based on direct sensory information, however; some observations can be used to make an inference. An inference is an interpretation of observations. For example, you can directly observe that the sun rises in the east, and sets in the west. You can then use this observation to infer that the sun will always rise in the east and set in the west.

IV. **The Changing Environment** - Observations made of the processes that occur on and around earth reveal that they are constantly undergoing change.

A. **Frames of Reference** - change is usually described with respect to location and

time, these are also known as frames of reference. Tracking the change in temperature over the course of the day is a frame of reference.

- B. **Rate of Change** - the rate of change measures how much a measurable aspect of the environment (field value) changes over a specific amount of time. Rate of change can be calculated using the following formula:

$$\text{Rate of Change} = \text{change in field value} / \text{change in time}$$

- C. **Graphing Change** - a graph is a visual representation of data and observations. Graphs are used to show trends that are occurring in specific data. Graphs are plotted in three ways, line graphs, bar graphs, and pie charts.
- D. **Cyclic Change** - many observations made of the environment are cyclic, which means they form a nearly regular pattern that repeats itself over a specific period of time.
- E. **Energy and Change** - most changes that occur on the earth involve the flow of energy from one part of the environment to another. For example heat energy that is absorbed by the ocean, is eventually released into the atmosphere.
- F. **Pollution, Change, and the Environment** - human technology has created many pollutants that have caused changes in the environment. A pollutant is any substance that has a negative affect on a living thing.