

CHECK YOUR ANSWERS

1. Precision is how consistent a measurement is, while accuracy is how close to the actual or true value a measurement is.
2. A hypothesis describes the predictions you were testing.
3. A list of the steps necessary to carry out an experiment
4. A summary of experimental results, a discussion of whether or not the data supported the hypothesis, errors, and questions for further investigation
5. A bias is having a special interest that prevents you from being objective.
6. The person or group conducting the experiment is biased, the data seems unreasonable, and/or the results don't seem replicable.
7. Any situation where making an exact measurement isn't possible, such as estimating the height of a huge tree or calculating a number with a repeating decimal.

Don't worry if your answers to #6 or #7 don't exactly match mine. These questions have more than one correct answer.



Chapter 4



SI UNITS AND MEASUREMENTS

The **SI SYSTEM** has a base unit, or a standard unit, for every type of measurement:

SI stands for *SYSTÈME INTERNATIONAL*, which is French for "International System." How chic!

SI BASE UNITS

QUANTITY MEASURED	SI UNIT (symbol)
Length (or Distance)	meter (m)
Mass	gram (g)
Weight (or Force)	newton (N)
Volume (or Capacity)	liter (L)
Temperature	kelvin (K)
Time	second (s)
Electric Current	ampere (A)
Amount of Substance	mole (mol)
Light Intensity	candela (cd)

Because we want to use SI units to describe both the distance across the classroom and the distance around Earth, we need to be able change the size of a unit to fit the measurement. Scientists devised a system of prefixes that multiplies the base unit by factors of 10. Using this system of prefixes, SI units can be used for measurements big and small:

SI PREFIXES

PREFIX (symbol)	MULTIPLIER
giga- (G)	1,000,000,000
mega- (M)	1,000,000
kilo- (k)	1,000
hecto- (h)	100
deka- (da)	10
[base unit]	1
deci- (d)	0.1
centi- (c)	0.01
milli- (m)	0.001
micro- (μ)	0.000001
nano- (n)	0.000001

Mnemonic for SI Prefixes:

Great Mighty King Henry Died By
Drinking Chunky Milk Monday Night.



SI UNIT CONVERSIONS:

Because the SI prefix system is based on powers of 10, it is really easy to convert between units. Simply move the decimal point to the right as many places as there are zeros after the 1 in the multiplier, or to the left as many places as there are zeros after the multiplier decimal point:

$$1 \text{ centimeter} \rightsquigarrow 0.01 \text{ meter}$$

$$\begin{aligned} 330 \text{ centimeters} &= \\ 3.3 \text{ meters} &= \\ 0.0033 \text{ kilometers} \end{aligned}$$

COMMONSENSE TIP

Remember to use the right unit. If you measured the volume of the ocean with the same units you use to measure a glass of milk, the numbers would be very difficult to work with. (The volume of the ocean should be measured using much larger units.)

TYPES of MEASUREMENT

LENGTH: the distance between two points

VOLUME: the amount of space something occupies

MASS: the amount of matter in a liquid, solid, or gas

WEIGHT: the force exerted by a mass

DENSITY: the amount of matter in a volume. To calculate density, use the formula:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

When you measure someone's weight, you measure the force they exert on the earth.

MASS AND WEIGHT ARE NOT THE SAME!

Mass is the amount of matter in an object, and weight is a measure of the force applied by a mass. Weight relies on gravity (a force), but mass doesn't. For example, the moon has less gravity than the earth, so objects weigh less there than on Earth. Mass always remains the same. Weight changes.

SINK OR FLOAT?

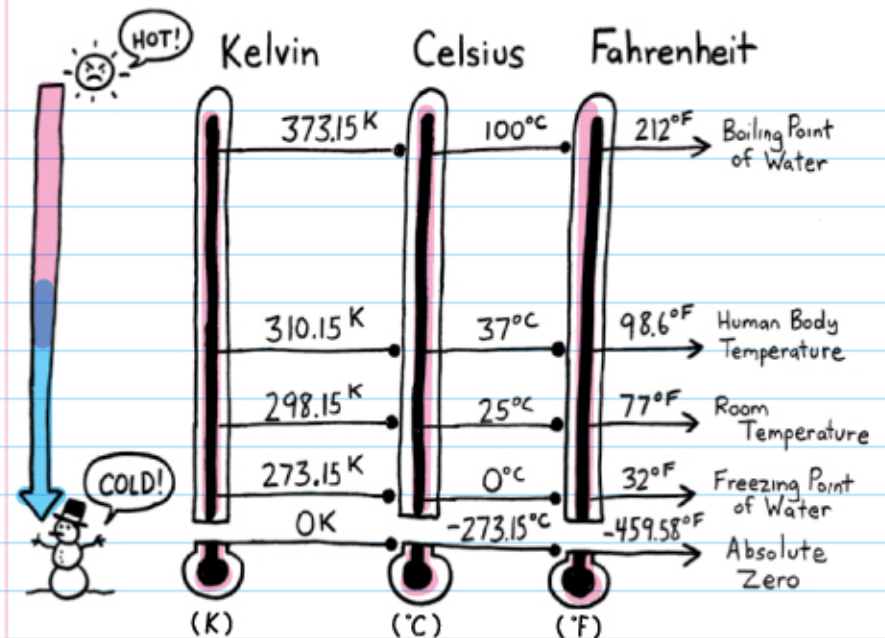
Something denser will sink below something that is less dense. When oil is poured into water, it floats on top of the surface because oil is less dense than water. A stone sinks in water, so it is denser than water.

TEMPERATURE: how hot or cold something is. While the SI unit for temperature is Kelvin, most scientists use the SI-derived unit, Celsius, to measure temperature. This is the conversion for Celsius and Kelvin:

$$1^{\circ}\text{Celsius} = 272.15 \text{ Kelvin}$$

In the United States, we usually use Fahrenheit to measure temperature. This is the conversion for Fahrenheit and Celsius:

$$1^{\circ}\text{Fahrenheit} = \left(1^{\circ}\text{Celsius} \times \frac{9}{5}\right) + 32$$



TIME: the period between events, or how long something lasted. The SI unit for time is seconds. Other units for time include hours, days, months, and years.

MEASUREMENT TOOLS

Distance

METER STICK: Like a ruler, except it is 1 meter long. It is 3.37 inches longer than a yardstick.

TRUNDLE WHEEL: To measure long distances, just roll the trundle wheel on the ground and every time you walk a meter, the trundle wheel makes a clicking sound. Simple—just remember to count the clicks.

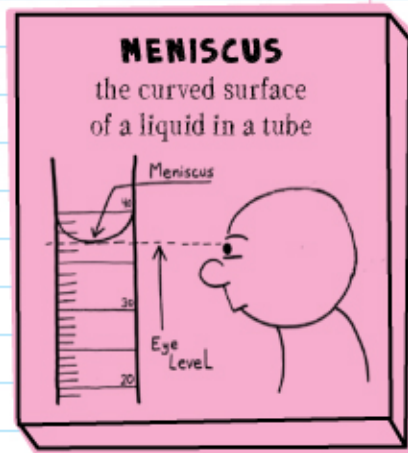
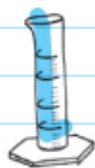
TAPE MEASURE: for measuring distances that would be hard to measure using a meter stick or a trundle wheel, such as the distance around a round object.



Volume

GRADUATED

CYLINDER: a cylinder marked on the outside to indicate how much fluid it contains. Take your volume reading from the bottom of the **MENISCUS**, and make sure you are taking the reading at eye level.



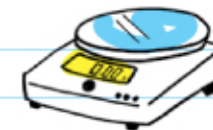
VOLUME OF SOLIDS: To figure out the volume of a solid, simply measure its height, width, and length using any of the tools for measuring distance and then multiply all three. For a regular solid, use the formula:

$$\text{volume} = \text{length} \times \text{width} \times \text{height}$$

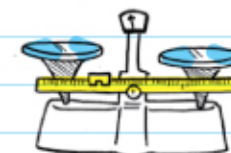
VOLUME OF IRREGULAR SOLIDS: The best way to measure the volume of an irregular solid is to place it in water and to find the volume of water it displaces. The difference between the new and old volume measurements is equal to the volume of the object. (Next time you get into a bathtub, try to figure out the volume of water you displace.)

Mass

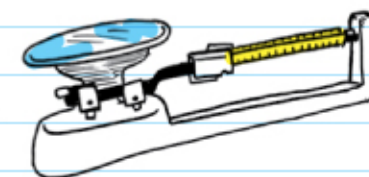
ELECTRONIC BALANCE: If you are measuring something that needs to be in a container, measure the container on its own first, and then subtract the weight of the container afterward.



DOUBLE PAN BALANCE: compares the weight of objects in pans on each side of a balance. To find mass, place something of known mass in one pan, and in the other pan, place the object of unknown mass. When the pans are level, the masses are equal.



TRIPLE BEAM BALANCE: works like a double pan balance, but instead of having a pan on each side of the balance, there is a pan on one side, and three beams, each with sliding weights called riders, on the other.



Density

Because density is simply the amount of matter in a certain volume, you can calculate density by measuring the volume and mass of an object, and using the formula:

$$\text{density} = \text{mass} \div \text{volume}$$

Time

To measure time, you can use a clock or a stopwatch. If you are using a regular clock, subtract the end time from the start time to figure out how much time has lapsed.



Temperature

THERMOMETER: is used to measure temperature. A thermometer is either digital, or it can be a liquid thermometer, which contains a liquid that changes volume with temperature. When taking temperature, make sure the bulb at the end of the thermometer is in the middle of the liquid you are measuring.



CHECK YOUR KNOWLEDGE

1. What are the SI units for mass, length, and volume?
2. What is used to measure long distances?
3. What is the water level you look at to take a volume reading using a graduated cylinder?
4. What is the easiest tool used to measure mass?
5. How do you find the volume of a regular solid?
6. Describe the difference between mass and weight.
7. Convert 50 dekameters to kilometers.
8. Define volume and list some common volumes measured.
9. If the boiling point of water in Celsius is 100° , what is the boiling point in Kelvin?
10. You place a tooth in a cup of soda and it sinks. Which is denser—the tooth or the soda?