MEASUREMENT LAB

Introduction:

Systems of Measurement have been around as long as civilizations have been involved in barter or trade. Whenever people decided to trade one set of goods for another, they determined the quantity or measuring unit to be exchanged. Measuring units simplified trading by defining what amount would be given in each exchange. For example, a farmer would trade a cartload of apples to a butcher for a leg of lamb. However, when the farmer wanted to trade milk for other goods, a cartload was a somewhat awkward quantity. Instead, he swapped buckets of milk. So in his exchange with the butcher, the farmer would trade five buckets of milk for a leg of lamb. Over time, the farmer decided that he wasn't getting a fair deal in this arrangement. Since his agreement with the butcher was for one cartload of apples or five buckets of milk for a leg of lamb, he decided to use a smaller cart and bucket.

In order to prevent this type of squabble between buyers and merchants, eventually a standard "cartload" and "bucket" were determined. Today, we use a system of measurement based on these informal arrangements from the past.

In the United States, most of us have learned the English System of measurement, which uses inches, feet, yards and miles to measure length. Volume is measured with teaspoons, tablespoons, cups, pints, quarts and gallons. And when figuring weights we use ounces, pounds and tons. However, a Canadian quart is equal to 1.136 liters and in the U.S. a quart is equal to 0.946 liters (a liter is the standard volume measurement in the Metric System). Sounds like an American farmer was trading with a Canadian butcher in our example above!

Obviously, the above kinds of discrepancies within the English System would not do in science where precision is necessary. About 100 years ago, around the time when accuracy was becoming more and more important in science, the International Metric System was devised to standardize measurement around the world. This system provides exact precision in powers of 10. In other words there is a **standard**, and on either side of it the units increase by 10, 100, 1000 or decrease by 1/10, 1/100 and 1/1000.

In the International Metric System, the standard unit for weight is the **gram (g)**. The standard unit of volume is the **liter (L)** and the standard unit for length is the **meter (m)**.

The Metric System is used almost exclusively in science. Many European countries and Mexico also rely on this system. However, the United States has been painfully slow in its conversion to the Metric System. Students are still being taught the English System of measurement in U.S. schools and it is an integral part of most business transactions.

Indeed, the change to the Metric System in the U.S. will not be an easy task. Just imagine the problems involved in building a house when the specifications and blueprints all need to be converted to metric units. However, once the conversion has been achieved, there

will be no more fumbling around in the toolbox looking for the standard wrench that sort of fits the metric bolt on your Honda.

The best way to learn the Metric System is to become familiar with it. The key is to practice until you "think" metric. Start by looking at the size and weight of items you purchase in the store. Most packages have the metric equivalent in parenthesis on the label. Instead of buying a 12-ounce can of Coca Cola, buy 355 milliliters (approximately 1/3 liter) of Coca Cola and you will be well on your way to thinking metric!

Metric – English Conversion Data

Metric		**English**	
1 kilometer (km)	= 1000 m	1 statute mile (mi)	= 5280 ft
1 meter (m)	= 100 cm	1 nautical mile (NM)	= 6076 ft
1 centimeter (cm)	= 10 mm	1 fathom	= 6 ft
1 millimeter (mm)	= 1000 microns (μ)	1 yard (yd)	= 3 ft
		1 foot (ft)	= 12 in

Units of Length

1 kilometer	= 0.62 mi	1 mile	= 1.61 km
1 meter	= 1.09 yd	1 yard	= 0.91 m
	= 3.28 ft	1 foot	= 0.31 m
	= 39.37 in	1 inch	= 2.54 cm = 25.4 mm
1 centimeter	= 0.39 in	1 mile	= 8 furlongs

Units of Weight (Mass)

1 kilogram (kg)	= 1000 g	1 ton	= 2000 lb
1 (g)	= 1000 mg	1 pound (lb)	= 16 oz
		16 pound	= 1 stone
1 kilogram	= 2.2 lb	1 pound	= 453.6 g
1 gram	= 0.002 lb	1 ounce	= 28.35 g
1 gram	= 0.035 oz	1 ounce	= 0.028 kg

Units of Liquid Capacity

1 liter (L)	= 1000 milliliters (ml)	1 gallon (gal)	= 4 qt = 8 pt
1 liter	= 2.11 pt	1 quart (qt)	= 2 pt = 32 fl oz
1 liter	= 1.06 qt	1 pint (pt)	= 16 fl oz
1 liter	= 0.26 gal	1 pint	= 0.47 L
		1 quart	= 0.95 L
		1 gallon	= 3.78 L
		1 cup	= 8 oz

(i) Name_____

Exercise #1 — Basic Metric System Report Sheets

The Metric System is a standardized method for defining **length, volume** and **weight**.

The **standard** metric units are the **meter, liter and gram**. Prefixes to these terms tell us which portion of the standard we are using and vary by factors of ten. In other words, when we attach the prefix kilo- to a standard metric unit it tells us that we are using 1,000 standard units. Although there are dozens of prefixes that can be attached to the standard units, we are only concerned with a few.

PREFIX	ABBREVIATION	COMPARED TO STANDARD
milli	m	1/1000
centi	c	1/100
kilo	k	1000

This tells us that a millimeter (abbreviated mm) is 1/1000th of a meter, a centimeter (cm) is 1/100th of a meter and a kilometer (km) is 1000 meters.

Multiplication Rule

When multiplying a number by a factor of ten, the decimal is moved to the **RIGHT** by the number or zeros in the multiplier. Remember to fill in empty spaces with a zero, if necessary.

25 X 10 = _____

25 X 100 = _____

25 X 1000 = _____

2.5 X 1000 = _____

0.25 X 10 = _____

0.00002525 X 100,000 = _____

Division Rule

When dividing a number by a factor of ten, the decimal is moved to the **LEFT** by the number of zeros in the divisor. Remember that in science a zero is always used to hold a space in front of a decimal fraction (e.g. **0**.75 for 75/100ths).

25/10 = _____

25/100 = _____

25/1000 = _____

0.25/10 = _____

2.5/100 = _____

2525/100,000 = _____

1. Which is the smaller unit in size, a centi- or a milli- metric unit?

2. By what factor (how much) does the milli- unit differ from the centi- unit?

3. If you were converting from milli- to centi- units, how many decimal places would you move?

4. In your conversion from milli- to centi- units, would you move the decimal point to the left or the right?

5. In your conversion from centi- to milli- units, would you move the decimal point to the left or the right?

6. Convert the following:

   25.4 centimeters = _____ millimeters

   53 millimeters = _____ centimeters

Length

Recall, the standard metric unit for LENGTH is the **_____.**

We will use the three prefixes previously discussed with this standard unit:
milli (1/1000th), **centi** (1/100th) and **kilo** (1000).

1. How many millimeters (mm) are in one meter (m)?

2. How many centimeters (cm) are in one meter (m)?

3. How many meters (m) are in a kilometer (km)?

4. How many mm are in one cm?

5. 37 cm = _____ m

6. 30 mm = _____ cm

Volume

In the Metric System, the standard unit for VOLUME is the _____.
The same prefixes used for metric length are also used for volume units. However, the only unit we will be using is **milli**. The milli unit of volume is commonly used in scientific measurement.

1. How many milliliters (mL) are in a liter (L)?

2. 355 mL = _____ L (The volume of a can of soda)

3. 750 mL = _____ L (The volume of a bottle of wine)

4. 15 mL = _____ L (The volume of one tablespoon)

5. 1.5 L = _____ mL

6. 4 L = _____ mL

Weight

In the Metric System, the standard unit for WEIGHT is the _____.
In this section of the lab, we will use the prefixes **milli** and **kilo**.

1. How many grams (g) are in a kilogram (kg)?

2. How many milligrams (mg) are in a gram (g)?

3. How many milligrams (mg) are in a kilogram (kg)?

4. 454 g = _____ kg (The weight of a small loaf of bread)

5. 2650 g = _____ kg

6. 11 kg is a familiar weight for a bag of flour. You are baking cookies for a Save The Rain Forest fund drive. It takes 500 g of flour to make one batch of cookies. How many **batches** of cookies can you make with one bag of flour?

(ii) Name_____

Exercise #2 — Measurements & Conversions Report Sheets

The natural world can be observed in two ways: **qualitatively or quantitatively**.

Qualitative observations describe traits that cannot be measured on a continuous scale. Examples: eye color or hair color

Quantitative observations can be measured or counted.
Examples: height or the number of chairs in a room

Give two examples of each type of observation found in this room:

Qualitative: _____

_____

Quantitative: _____

_____

Unit Analysis

In this activity, we will review and practice converting measurements between the English and Metric Systems.

Dimensional analysis can be used to convert one type of unit to another using a fraction called a proportion. Follow the steps below to use dimensional analysis to convert units of measurement from one type to another.

Step 1— Identify units to be coverted.

Convert 10 miles to kilometers.

Step 2 — Find equivalent conversion units.

1 kilometer = 0.62 miles

Step 3 — Set up proportions using multiplication or division so that unwanted units will be eliminated.

$$\textbf{10 miles} \times \frac{\textbf{1 km}}{\textbf{0.62 miles}} = \textbf{\_\_?\_\_}$$

Step 4 — Solve, and you will see that an answer results with the correct units.

Conversion Problems:

1. It is 4 miles from YC to Thumb Butte park. What is this distance in kilometers?

2. It is 100 miles to Flagstaff from Prescott. How far is this in kilometers?

3. An aspirin tablet weights 0.5 grams. How many ounces does it weigh?

4. How many milligrams does an aspirin tablet weigh?

5. A 4 pound bass weights how many grams?

6. A small dog eats 9 ounces of dog food each day. How many pounds is this in one year?

7. A forest snail travels at 5 inches in one minute (5 in/min). Convert this to miles per hour (miles/hr)

Temperature

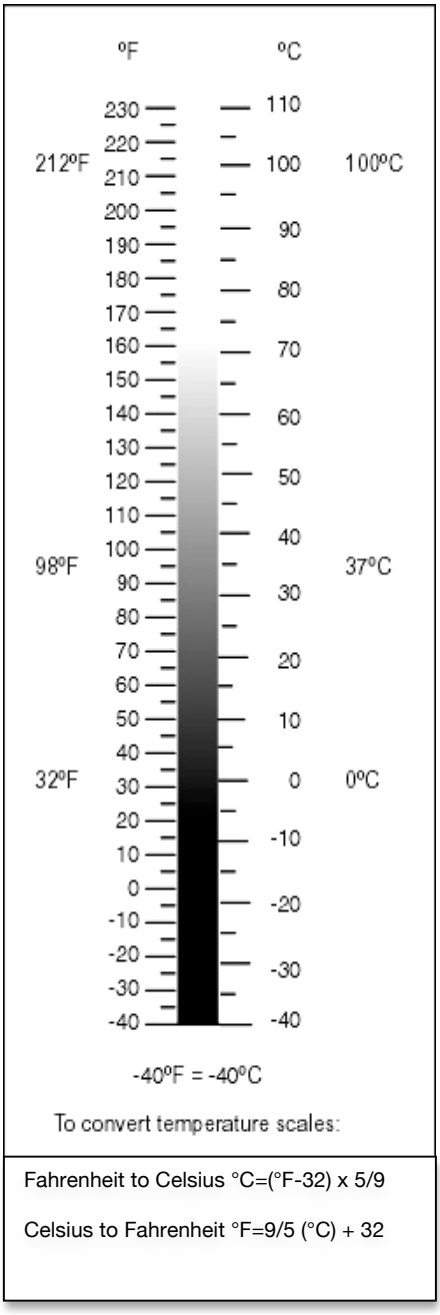
In the English System, temperature is measured in degrees Fahrenheit (°F). On this scale water boils at 212°F and freezes at 32°F.

The Celsius temperature scale is generally used in scientific laboratories and is more like a metric scale. Celsius is the other temperature commonly found on the electronic bank clocks around town. In the Celsius System, water boils at 100°C and freezes at 0°C.

We will use the copy of the dual scale thermometer shown here. You may also be interested in the formulas for converting between degrees Fahrenheit and Celsius.

Fahrenheit to Celsius: °C = (°F - 32)/1.8

Celsius to Fahrenheit: °F = (°C X 1.8) + 32



1. How many degrees °F are there between the 0°C mark and the 100°C mark?

2. Water freezes at what temperature in °F?
   At what temperature in °C?

3. Water boils at what temperature in °F?
   At what temperature °C?

4. What is your favorite air temperature in °F
   What temperature is that in °C?

5. What is your idea of a "hot day" in °F?
   What temperature is that in °C?

6. Normal body temperature for humans is 98.6°F. Your child's forehead seems to be hot. You take her temperature and are perplexed to find the thermometer reads 37°C. Should you rush her to the doctor? Explain.

7. Your cookbook says that a roast beef is rare at 140°F, medium at 160°F and well done at 170°F. What temperature will your **Celsius** thermometer have to reach for the roast to be medium-rare?

8. The temperature gauge on your old Ford reads 85°C. Is the engine overheating again?