

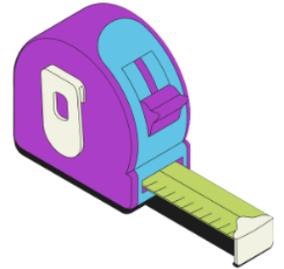
## Lesson 3: Measurements

### Objectives:

1. Record accurate measurements in the metric system.
2. Calculate unit conversions using dimensional analysis

### What is an accurate measurement?

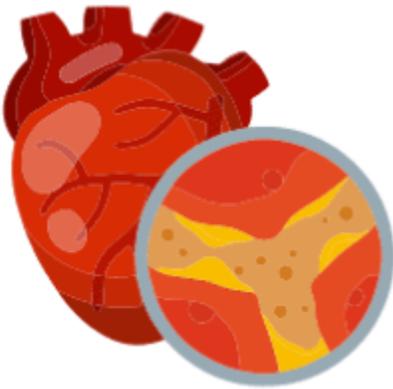
**Activity:** Use a classroom object to measure in a small group or pair. (Examples: stapler, pencil, pencil case, etc). Each member of the group should take their turn making the most accurate measurement possible. Every member should record their measurement down.



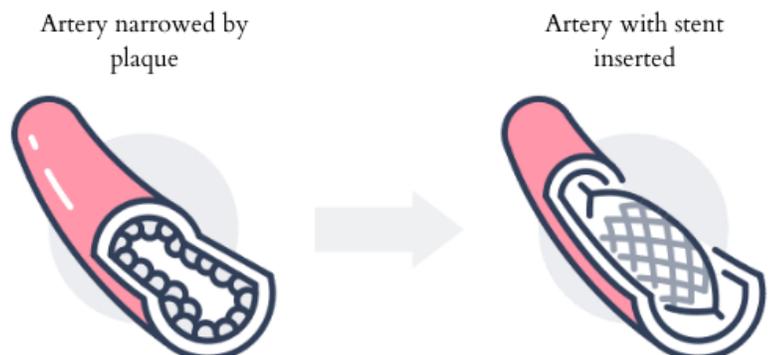
What differences did you notice between the various measurements of the same object?

### Accuracy matters

If you are not accurate about the mass of flour you put into a recipe, you could end up with flat or dry cookies. Or maybe you are practicing the long jump and you are recording your personal growth. If you aren't careful with your measurements, you won't really be sure if the techniques you try are helping you are not. It can also be life saving. As people age, some develop high blood pressure, caused by a condition known as atherosclerosis. Plaque build ups inside arteries, causing them to narrow and inhibit blood flow. This is often caused by a diet high in saturated fats, stress, low exercise, or even genetic predisposition. If this takes place in the heart, it could potentially cause a myocardial infarction, more commonly known as a 'heart attack'.

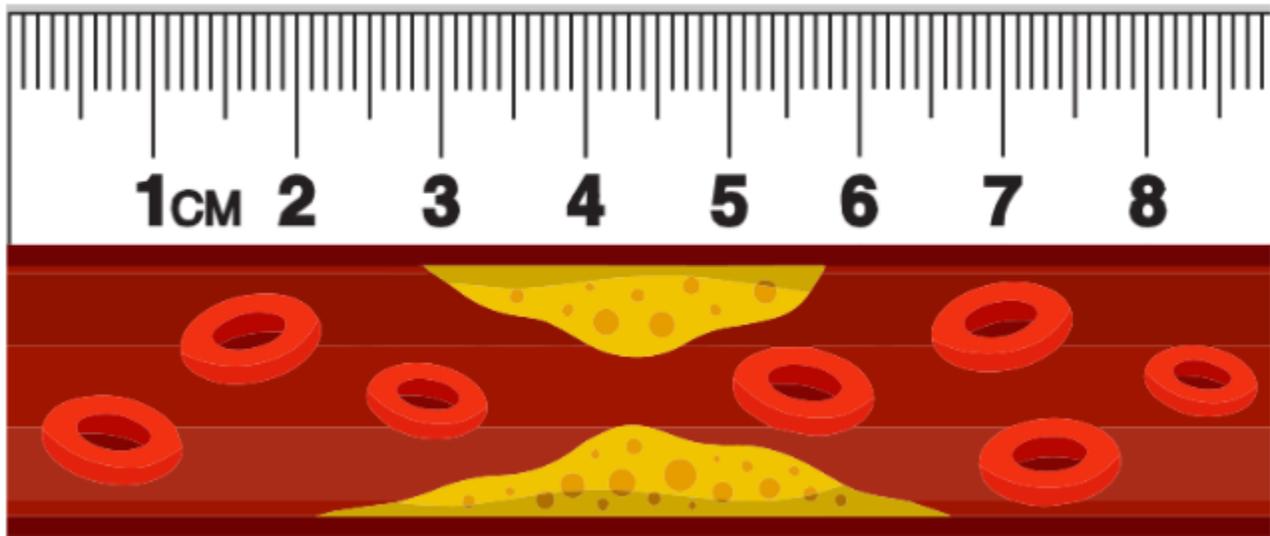


Doctors can help patients at the time of a heart attack, or before as a preventative measure, by inserting a 'stent'. A stent is a small device made of wire or mesh that holds the narrowing artery open so that blood flow is not interrupted. However it has to be inserted in the correct location where the plaque build up is occurring. If not, it won't help.



**Challenge:** You are a surgeon helping to insert a stent into an area of blockage of an artery. The stent is 1.60 cm in length. At what measurement marking will you aim to place the front of the stent? Where will the stent end?

Why may it be important to ensure the correct placement of the stent?



### Metric Units versus US Customary Units

The metric system is a system of measurements with base units consisting of *grams* for mass, *liters* for volume, *meters* for distance. Measurements in the metric system are based on powers of 10. If you understand the prefixes within the metric system, you can deduce the size of the measurement, no matter which base unit is being used.

<i>Prefix</i>	<i>Abbreviation</i>	<i>Number equivalent</i>	<i>Power of 10</i>		<i>Base unit</i>	<i>Prefix</i>
Giga	G	1,000,000,000	$10^9$		gram	(g)
Mega	M	1,000,000	$10^6$		liter	(l)
kilo	k	1,000	$10^3$		meter	(m)
hecto	h	100	$10^2$			
deca	da	10	$10^1$			
<i>base unit</i>		1	$10^0$			
deci	d	0.1	$10^{-1}$			
centi	c	0.01	$10^{-2}$			

milli	m	0.001	$10^{-3}$		
micro	$\mu$	0.000001	$10^{-6}$		
nano	n	0.000000001	$10^{-9}$		

**Application questions:**

1. Rewrite 10 giga liters in abbreviated units.
2. Rewrite 155 millimeters in abbreviated units.
3. How many milliliters are in 1 meter?
4. You have created a 3D printed design in centimeters, and you know that the maximum length your 3D printer can print is 150 mm. How many millimeters is the length of your design?
5. You jogged a distance of 3660 meters. How many kilometers did you jog?

<i>Length</i>	<i>Volume</i>	<i>Mass</i>	<i>Abbreviations</i>
1 foot = 12 inches	1 cup = 8 fluid ounces	1 pound = 16 ounces	Foot (ft) Inches (in) Yard (yd) Mile (mi) Cup (C) Pint (pt) Quart (qt) Gallon (gal) Pound (lb) Ton (t)
1 yard = 3 feet	1 pint = 2 cups	1 ton = 2,000 pounds	
1 mile - 5,280 feet	1 quart = 2 pints		
	1 gallon = 4 quarts		

**Application questions:**

6. Rewrite 3.14 feet using abbreviated units.
7. Rewrite 14 miles using abbreviated units.
8. Liam, a 17-year old, has set a goal for himself to drink more water each day. He has a water bottle that measures in ounces. He read from multiple reliable sources online that drinking 15.5 cups of water a day is considered healthy. How many ounces from his water bottle should he drink?
9. On average, human small and large intestines are about 300 inches in length. How many feet do they measure?

## Converting units

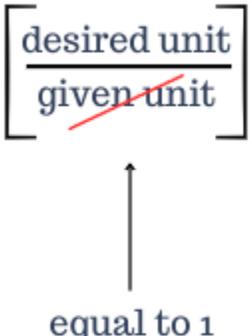
Even though US Customary units are common in the United States, it is imperative to be able to measure using both systems, and to be able to convert units between systems. Boeing, for example, is an international aerospace company which serves more than 150 countries. The manufacturing of airplanes in various countries will undoubtedly require an ability to communicate technical details about the plane in both US customary and metric systems. In order to be able to convert between different units of measurement, it is useful to understand dimensional analysis. Dimensional analysis will work whether you are converting units within the same system, or between systems.

Sample conversions between US and Metric units		
Mass	Length	Volume
1 kg = 2.205 lb	1 m = 3.28 ft	1 cm <sup>3</sup> = 1 ml
1 ton = 2000 lb	1.6 km = 1 mi	1L = 33.8 fl oz
1 lb = 16 oz	2.54 cm = 1 in	1L = 0.264 gal

### Steps of dimensional analysis:

1. Record the *given unit*, which is the value and unit you are starting with.
2. Identify the *desired unit*, which is the unit you want to convert the value to.
3. Create a *conversion factor* that is equivalent to 1. Make sure the *conversion factor* is set up so that it can cancel out the *given units*.
4. Solve and cancel out units in the numerator and denominator.

$$\cancel{\text{given unit}} \times \left[ \frac{\text{desired unit}}{\cancel{\text{given unit}}} \right] = \text{desired unit}$$


  
 equal to 1

Example A) Convert 5 miles to feet.

$$\cancel{5 \text{ miles}} \times \left[ \frac{5,280 \text{ feet}}{\cancel{1 \text{ mile}}} \right] = 26,400 \text{ feet}$$

Example B) Convert 6.33 inches to millimeters..

$$\cancel{6.33 \text{ inches}} \times \left[ \frac{2.54 \text{ centimeters}}{\cancel{1 \text{ inch}}} \right] \times \left[ \frac{10 \text{ millimeters}}{\cancel{1 \text{ centimeter}}} \right] = 160.782 \text{ millimeters}$$

### Application questions:

10. You are about to go scuba diving for the first time! You take a tank of air to use when you go underwater. You learned in your SCUBA course that having about 3.9 gallons of air in your tank is the safest to start a dive. Your scuba instructor is from Germany and tells you that there is about 5 liters of air inside of it. He thinks it might be enough, but he's not sure. Do you have enough air?
11. Ana has found a recipe online for baked bread, which calls for 4 cups of flour. Ana is from Brazil and all she has is a measuring tool in liters. How many liters of flour should she pour?



12. One theory about how the dinosaurs went extinct 65 million years ago is that an asteroid hit Earth, around the Yucatàn peninsula of Mexico. It had an estimated diameter of 180 km, and a depth of 20 km. What is the diameter and depth in miles?