Ref: http://faculty.clintoncc.suny.edu/faculty/michael.gregory/files/Bio 101/Bio 101 Laboratory/Metric System/Metric_System.htm

The Metric System and Measurement (this should be review→ just upload to Google Classroom in 2020)

Introduction

The metric system (or Systeme Internationale, also called SI) is the world standard for measurement. Not only is it used by scientists throughout the world, but most nations have adopted it as their standard of measurement. All of the measurements done in this course will use the metric system.

The table below shows the standard unit of length, weight, volume, and temperature in the metric system. It also shows the English equivalent.

	Metric	**English**
Length	meter	39.37 inches
Weight	gram	0.03527 ounces
Volume	liter	1.0567 quarts
Temperature	degree (Centigrade)	1.8 degrees Fahrenheit

Meters, grams, and liters (see the table above) form the basis for larger or smaller units. The units are named using these prefixes:

Giga = 1,000,000,000

Mega = 1,000,000

Kilo = 1000

Deci = 1/10

Centi = 1/100

Milli = 1/1,000

Micro = 1/1,000,000

Nano = 1/1,000,000,000

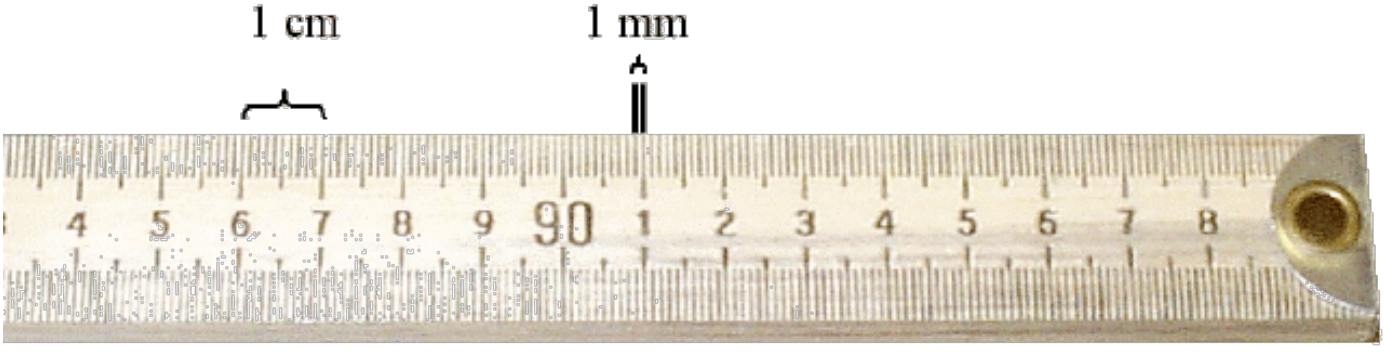
The STANDARD units (from which all other units can be derived) in the SI (metric) system are:
Mass: kilogram
Length: meter
Time: second

The table below shows how meters are related to five other measures of length.

Unit	**Length**
kilometer (km)	1,000 m (1 X 10^3 m)
meter (m)	1 m
centimeter (cm)	0.01 m (1 X 10^{-2} m)
millimeter (mm)	0.001 m (1 X 10^{-3} m)
micrometer (μm)	0.000001 m (1 X 10^{-6} m)
nanometer (nm)	0.000000001 m (1 X 10^{-9} m)
gigameter (Gm)	1,000,000,000 m (1 x 109 ^{m})

Notice that each of the units in the table above are related to meters by a multiple of 10.

The photograph below shows the end of a meter stick. The 90 cm mark can be seen in the center of the photograph. One meter = 100 cm. Notice that each centimeter is divided into 10 mm.



The tables below show similar units based on grams (mass) and liters (volume).

Unit	**Mass**
metric ton (t)	1,000 kg or 1,000,000 g (1×10^6 g)
Kilogram (kg)	1,000 g (1×10^3 g)
gram (g)	1 gram
milligram (mg)	0.001 g (1×10^{-3} g)
microgram (μg)	0.000001 g (1×10^{-6} g)
nanogram (ng)	0.000000001 g (1×10^{-9} g)

Unit	**Volume**
kiloliter (kl)	1,000 liters (1×10^3 l)
liter (l)	1 liter
milliliter (mL)	0.001 liter (1×10^{-3} l), $1cm^3$
microliter (ul)	0.000001 liter (1×10^{-6} l)

Notice in the table above that one milliliter (mL) equals one cubic centimeter (1 mL = 1 cc or cm^3).

Metric Conversions

Exponents

The table below shows how numbers can be written using exponents. For example, a second way to write the number 1,000 is 1×10^3.

$100 = 1 \times 10^2$ $1000 = 1 \times 10^3$ $0.01 = 1 \times 10^{-2}$ $0.001 = 1 \times 10^{-3}$

Examples

$256 = 2.56 \times 10^2$

$3287 = 3.287 \times 10^3$

$0.055 = 5.5 \times 10^{-2}$

Exponents are useful when writing numbers that are very large or very small. For example the number 1,930,000,000,000,000,000 is easier to write as 1.93×10^{18}.

Decimal Point

Metric conversions are done by moving the decimal point. When converting a large unit such as meters to a smaller unit such as millimeters, the decimal point is moved to the right. When converting smaller units to larger units, the decimal point is moved to the left. You must subtract the exponents in order to determine how many places to move the decimal point.

Larger (move decimal point to the left)

Smaller (move decimal point to the right)

Examples

Convert 2.6 cm to mm.

This problem is solved by subtracting the exponents. The exponent for cm is -2; the exponent for mm is -3. Subtract the two numbers: (-2 - (-3) = 1). Therefore, to convert 2.6 cm to mm, you must move the decimal point 1 place to the right.
2.6 cm = 26 mm (this should make sense since you should have a bigger number if you are measuring in a smaller unit!

Convert 57 um to cm.

The exponent for μm is -6. The exponent for cm is -2. You must subtract these two number to determine how many places to move the decimal point. -6 - (-2) = -4. The negative sign indicates that you must move the decimal point 4 places to the left.
So, 57 μm = 0.0057 cm

Sig Fig Review Sheet *Forrest- Physics 2020?2021*

Only discussed in 2019 (not assigned) → just upload to Google Classroom in 2020)

RULES:

1. When adding or subtracting numbers, the answer will be only as precise as the least precise number in the problem. (it helps to arrange the numbers in aligned columns)

EXAMPLE: 4.328
+ 2.6
6.9 → NOTE: Only two sig.

2. When multiplying or dividing numbers, the answer will have the same number of sig fig's as the number with the fewest sig fig's in the problem. EXAMPLES:

(3.14159)(14,000) = 44,000 (2 sig figs --> NOT 43,982.26)
(2.2)(0.36)(3.12) = 2.5 (2 sig fig's ----> NOT 2.47104)

3. Zeros
   a) Any non-zero number is significant.
   b) Zeros to the right of a decimal point (and to the right of another significant digit) are significant.
   c) Zeros between significant digits are significant.
   d) Zeros that are only place holders (such as in 0.00000014 and 45,000,000) and are NOT significant. Each of these examples has only 2 sig figs.

EXCEPTION - A bar over zeros (to the left of the decimal point) indicates that they are significant. For example, if there were five significant digits in the number above it would be written as $\overline{45,000,000}$ (or 4.5000×10^7).

4. When rounding off numbers, if the eliminated digit is less than 5, do not change the preceding digit. If the eliminated digit is 5 or more, add 1 to the preceding digit.

EXAMPLES: 2.673 becomes 2.67 4.896 becomes 4.90 136.655 becomes 136.66

5. Remember ---> Calculators cannot add significance (precision) to measurements; make sure you round off to the correct number of sig. fig's when calculating area, volume, etc.

Problems:

1. Find the number of sig. fig's in each of the following:

a) 1.66 kg
b) 28.0 mL
c) 0.405 cm
d) 0.40500 cm
e) 3,500 m
f) 3,500 m
g) 3500 m
h) 0.080 g
i) 430,000,000 mm
j) 0.157 km
k) 4,000,300.0 mg

2. Round off the following numbers to one less decimal place:

a) 6.54
b) 6.56
c) 6.55
d) 6.65
e) 83,609
f) 83,604
g) 5.63
h) 0.594
i) 0.595
j) 0.958
k) 846.95

3. Multiply and divide the following, expressing answers in sig. fig's:

a) 6.54 x 18 = _____
b) 6.54 x 2 = _____
c) 6.54 x 20 = _____
d) 6.54 x 20 = _____
e) 4.35 x 2.78 x 3.0082 = _____
f) 3.76 / 1.62 = _____
g) 40.8 / 0.03 = _____
h) 40.8 / 0.030 = _____

4. What is the volume of a box (in cubic centimeters) that measures, 10.0 cm by 15.05 cm by 300.00 mm?

ANSWERS - Use these to help you figure out how to use sig. fig's. correctly - you're welcome!

NOTE: For problems 3 and 4, correct answers are given first, and the calculated answers are shown to the right.

1.

a) 3 sig. fig's
b) 3
c) 3
d) * 5
e) 2
f) 3
g) 4
h) ** 2
i) 2
j) 3
k) *** 8

* In d, the zeros are to the right of non-zeros and to the right of the decimal point, thus they show precision.
** In h, the zeros on the left are place holders but the zeros on the right show precision.
*** In k, the zero to the right of the decimal shows the measurement is actually that precise!

2.

a) 6.5
b) 6.6
c) 6.6
d) 6.7
e) 83,610
f) $83,\overline{6}00$
g) 5.6
h) 0.59
i) 0.60
j) 0.96
k) 847.0

3.

a) 120 (2 sig figs) → NOT 117.72
b) 10 (only 1 sig fig) → NOT 13.08
c) 100 (only 1 sig fig) → NOT 130.8
d) 130 (2 sig figs) → NOT 130.8
e) 36.4 (3 sig figs) → NOT 36.378163
f) 2.32 (3 sig figs) → NOT 2.3209877
g) 1,000 (only 1 sig fig) → NOT 1,360
h) 1,400 (2 sig fig's) → NOT 1,360

4. First, get everything in the same units, in this case cm. So convert 300.00 mm to 30.000 cm.

Then multiply: (10.0 cm)*(15.05 cm)*(30.000 cm) = 4,520 cm^3 → NOT 4,515 cm^3
(the correct answer has 3 sig figs)

NOTE: The final units are in cm^3, not just cm!

The take home lesson about using significant figures is that your answers should be based on the precision of the data you collect. And of course, that when mathematically combining really precise data with crappy data, CRAP ALWAYS WINS!

In other words,

GOOD DATA combined with EXCELLENT DATA combined with CRAP DATA = CRAPPY ANSWER