Introduction

Standard Unit: Metric is the preferred unit of measure in science. Metric is often referred to as “S.I” for Systèm Internatianale. Historically, S.I. has been referred to as MKS system for meters, kilograms and seconds.

Example	**Non Standard**	**Standard**
speed	km/s, mph	m/s
volume	L, gal.	m^3
Forces	lbs.	$kg \cdot m/s^2$

Scientific Notation: Often, physicists work with measurements that are either extremely large or extremely small. Scientific notation makes calculations much more manageable.

Example:

when shifting the decimal to the left, the exponent is **positive**

$$37010000m \rightarrow 3.701 \times 10^{7} m$$

when shifting the decimal to the right, the exponent is **negative**

$$0.000003152s \rightarrow 3.152 \times 10^{-6} s$$

Significant Figures: In general all non-zero digits are considered to be significant; however, there are some situations where this does not necessarily apply

Example:

32000m	2 sig. figs. unless otherwise stated (ie. if measurement is more acurate than the value applies). The last 3 zeros are just place holder
1201500m	5 sig. figs. The 0 between the 2 and the 5 is significant.
0.0013200m	5 sig. figs. The leading zeros are not significant they are place holders..
100.0m	4 sig. figs. We do not normally record measurements teminating with a zero on the right side of the decimal place unless it is significant.
$150\tilde{0}0$ m	4 sig. figs. The tildy above the second zero indicates the number is accurate to the tens.

Q: Why are the leading or trailing zeros not considered significant?
A: In general, leading and trailing zeros are just placeholders and are not generated from the measurement itself.

Example:
Consider the following situation. You are given a piece of wood that is exactly one meter long but has no markings on it. You are then asked to measure the length of the room using this as your tool. You find the room is approximately 3.5 meters. Now since your meter stick has no markings, the last digit of your measurement is really a guess and is the least reliable digit.

It is easy to see that this number has 2 significant figures, but consider what happens if you convert the measurement to millimetres

$$3.5m \rightarrow 3500mm$$

The reading is now 3500 millimetres, however, it is misleading to assume the trailing zeros are significant because the tool use to make the measurement is only accurate to the half meter. Therefore $3500mm$ is only accurate to 2 sig. figs, the trailing zero are simply placeholders.

Rounding: Rounding is a relatively simple procedure however, special rules appy for rounding numbers terminating with 5

Rules

1. If the largest digit to be rejected is greater than 5, the last unrejected number is rounded up

   Example: rounding 5.637 to 3 sig figs. becomes 5.64

2. If the largest digit to be rejected is less than 5, the last unrejected number remains the same

   Example: rounding 4.6337 to 3 sig. figs. becomes 4.63

3. In the case where the last rejected digit is 5 and followed by no other non zero digits, the number will be rounded up or down to ensure the rounded value is an even number.

   Example: rounding 3.65 to 2 sig figs. becomes 3.6
   rounding 3.55 to 2 sig figs. becomes 3.6
   rounding 3.5500 to 2 sig figs. becomes 3.6
   rounding 3.651 to 2 sig figs. becomes 3.7

Q: So why do we have this 0.5 rule anyway? Why not just always round up?
A: Rounding always introduces some error. If you are always rounding up the 0.5 values, you will skew the data always in one direction.

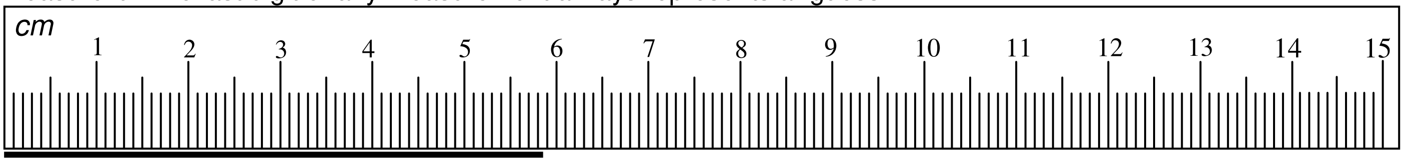
Example: Consider the following value set.
[1.5, 2.5, 3.5, 4.5]

using the simplified round model of rounding up values terminating with 5, we get the following set of values [2,3,4,5]. Now consider the sum of these values: 14

Using the proper rounding method we get a slightly different number set [2,2,4,4]. Now consider the sum of this value set: 12

If we consider the sum of the original value set before round it is evident the second method is more accurate. [1.5+2.5+3.5+4.5=12]

Calculations Involving Measured Quantities: The accuracy of a measured quantity is based on the tool used to measure it. The last digit of any measurement always represents a "guess"



Consider the length of the line above. The maximum resolution of the ruler is the **mm**, however, we can get a more accurate result by approximating to the closest **tenth of a mm**.

For the line above we can approximate its length to be approximately **5.85cm**. By inspection, we can see that **5.85cm** is a much closer approximation to the length of the line than **5.8cm** or **5.9cm** are.

Rule: When making measurements with any tool, always estimate your measurement to the closest tenth of the smallest scale indicated on the tool.

Note: The final digit in any measured value is the estimated tenth of the scale. Although it is technically a guess, the digit is considered to be significant. Therefore, in our above example, the measured value of 5.85cm is accurate to **3 sig. figs** where the ".5" is the least reliable digit.

Definitions:

Accuracy: is indicated by the number of significant digits within a measure quantity.

Precision: is determined by the number of decimal places in a measured quantity.

Addition and Subtraction: When adding and subtracting measured quantities, the final result should not be anymore precise than the least precise measured quantity.

Example

$$\begin{array}{r} 1.6 \\ 2.96 \\ +2.225 \\ \hline 6.785 \end{array}$$

the final answer should be no more precise than the least precise measurement. In this case, 1.6

Rounded result: 6.8 precise to 0.1

Multiplying and Division: When multiplying and dividing measured quantities, the final result should be expressed with no more significant figures than the least accurate measured quantity within the calculation.

Example

Find the area of rectangle that is 9.235m by 5.20m

4 sig. figs. 3 sig. figs.

$$9.235 \times 5.20 = 48.022 \longrightarrow 48.0\text{m}^2$$

3 sig. figs.

Conversions

When converting between the various units, we use a method called “multiplication by ones”

Example: convert $72km/h$ to m/s

These conversion factors reduce to 1

$$x\,m/s = \frac{72km}{h}\cdot\overbrace{\frac{1000m}{1km}}\cdot\overbrace{\frac{1h}{3600s}}$$

$$= \frac{(72)(1000)(1)km\cdot h\cdot m}{(3600)(1)km\cdot h\cdot s}$$

$$= 20\,m/s$$

Common Conversions

1 mile = 5280 ft
1 km = 1000 m
1 km = 0.6214 mile
1 mile = 1760 yd
1 hour = 3600 s
1 m = 3.28 ft
1 m = 100 cm
1000 m = 0.6214 mile
1 lb = 454 g
1 in = 2.54 cm
1 L = 1.06 qt
1 year = 365.24 day

Metric Prefixes

yotta	[Y]	1 000 000 000 000 000 000 000 000	= 10^{24}	*(septillions)*
zetta	[Z]	1 000 000 000 000 000 000 000	= 10^{21}	*(sextillions)*
exa	[E]	1 000 000 000 000 000 000	= 10^{18}	*(quintillions)*
peta	[P]	1 000 000 000 000 000	= 10^{15}	*(quadrillions)*
tera	[T]	1 000 000 000 000	= 10^{12}	*(trillions)*
giga	[G]	1 000 000 000	= 10^{9}	*(billions)*
mega	[M]	1 000 000	= 10^{6}	*(millions)*
kilo	[k]	1 000	= 10^{3}	*(thousands)*
hecto	[h]	100	= 10^{2}	*(hundreds)*
deca	[da]	10	= 10^{1}	*(tens)*
		1		
deci	[d]	0.1	= 10^{-1}	*(tenths)*
centi	[c]	0.01	= 10^{-2}	*(hundredths)*
milli	[m]	0.001	= 10^{-3}	*(thousandths)*
micro	[µ]	0.000 001	= 10^{-6}	*(millionths)*
nano	[n]	0.000 000 001	= 10^{-9}	*(billionths)*
pico	[p]	0.000 000 000 001	= 10^{-12}	*(trillionths)*
femto	[f]	0.000 000 000 000 001	= 10^{-15}	*(quadrillionths)*
atto	[a]	0.000 000 000 000 000 001	= 10^{-18}	*(quintillionths)*
zepto	[z]	0.000 000 000 000 000 000 001	= 10^{-21}	*(sextillionths)*
yocto	[y]	0.000 000 000 000 000 000 000 001	= 10^{-24}	*(septillions)*

Web reference: http://www.ex.ac.uk/cimt/dictunit/dictunit.htm

The above site is an excellent reference for conversions between various units of measure.