# Significant Digits

## Purpose of Significant Digits

Humans invented systems of measure for convenience in making comparisons. Only the size of the object used to define a unit of measure (and there are only four -- see Fundamental Units) is known exactly. All other measurements are estimated. Not all measurements, however, are known to the same accuracy. A good set of calipers, for example, will yield a more accurate measurement of a sphere's diameter than will a meterstick. Significant digits (or sig digs as they are often called), tell readers about the accuracy of a measurement.

## Recording a Measurement Using Significant Digits

When recording a measurement, *include every digit that is absolutely certain plus the first digit that must be estimated*. For example, suppose the length of a table is measured with a rule calibrated to centimeters. A proper measurement would be recorded as 1.524 meters. This indicates the table has a length of 1 meter *plus* 52 centimeters *plus* a little bit more. The table is definitely less than 1.53 meters but greater than 1.52 meters. Hence, the first three digits are known exactly and the fourth digit is estimated. A measurement of the same table with a rule calibrated to millimeters could yield 1.5238 meters.

The final significant digit will always be one unit smaller than the calibration of the measuring instrument. For example, the first measurement above was recorded to the nearest millimeter while the rule was calibrated to only the nearest centimeter. The second measurement was recorded to the nearest tenth of a millimeter while the rule was calibrated to the nearest millimeter.

It is important to record all significant digits -- even if they are zero! Suppose another table is measured with a rule (calibrated to the nearest millimeter) and the edge of the table lies exactly under a centimeter mark. The measurement should be reported as 1.5200 meters. The final two zeros do not change the magnitude of the measurement but they do indicate greater accuracy. A measurement of 1.52 meters indicates 1.52 meters ± 4 centimeters. A measurement of 1.5200 meters indicates 1.52 meters ± 0.4 millimeters.

## Determining the Number of Significant Digits

When counting the significant digits in a number, keep the following rules in mind:

1 All nonzero digits are significant.
Ex: 127 (3 sig digs)
2.5 (2 sig digs)

2 All zeros *between* nonzeros are significant.
Ex: 10204 (5 sig digs)
10.03 (4 sig digs)

3 *Leading* zeros in a decimal are ***not*** significant.
Ex: 0.12 (2 sig digs)
0.034 (2 sig digs)

4 *Trailing* zeros are ***not*** significant *unless* followed by or to the right of a decimal point.
Ex: 1540 (3 sig digs)
320 (2 sig digs)
320. (3 sig digs)
320.00 (5 sig digs)

## Calculations Using Significant Digits

When performing any calculations, remember–the answer ***cannot*** contain more significant digits than the *least accurate* measurement. For multiplication and division, round the final answer to the same number of significant digits as the least accurate measurement.

Ex: $(10.3\text{ m})(0.25\text{ m}) = 10.55\text{ m}^2 = 11\text{ m}^2$

$(43\text{ m}) / (1.25\text{ s}) = 34.4\text{ m/s} = 34\text{ m/s}$

For addition and subtraction, round the answer to the position of the first estimated digit.

Ex:

$$\begin{array}{r} 10.45\text{ m} \\ +\ 2.0765\text{ m} \\ \hline 12.5265\text{ m} = 12.53\text{ m} \end{array} \qquad \begin{array}{r} 130.0034\text{ m} \\ -\ 29.67\text{ m} \\ \hline 100.3334\text{ m} = 100.33\text{ m} \end{array}$$

Note: To report the number 12000 to only three significant figures, use Scientific Notation. The proper expression would be $1.20 \times 10^4$.