

# Significant Figures

## Determining the number of significant figures in a measurement:

1. All nonzero digits are significant.  
Example: 4.79 has three significant figures.
2. Zeros in the middle of a number are significant.  
Example: 1.049 has four significant figures.
3. Leading zeros (at the very beginning of the number) are not significant.  
0.032 has two significant figures. It may be written as  $3.2 \times 10^{-2}$ .  
0.0000411 has three significant figures. (It is also  $4.11 \times 10^{-5}$ .)
4. Zeros at the end of a number are significant **if** the number contains a decimal point.  
1.30 has three significant figures.  
4.00 has three significant figures.  
350. has three significant figures. (The decimal point at the end is the indication that the zero is significant.)
5. Zeros at the end of a number which does not contain a decimal point may or may not be significant (it is unclear). When in doubt, assume they are not significant.  
The number 2500 could have been measured to the nearest  $\pm 100$  or to the nearest  $\pm 10$  or to the nearest  $\pm 1$ . Since it is not indicated, you are forced to assume the worst case: the greatest uncertainty.  
2500 has two significant figures. ( $2.5 \times 10^3$ )  
140 has two significant figures. ( $1.4 \times 10^2$ )

## Determining the number of significant figures in a calculation:

A calculation can't be more precise than the least precise measurement used to do the calculation. (The least precise measurement limits the precision of the result.)

### Multiplication and Division:

1. The number of significant figures in the result should be the same as that in the number with the least significant figures.  
 $3.42 \div 1.3 = 2.630769\dots$  rounds to 2.6 (two significant figures).  
 $43.1 \times 9.227 = 397.6837$  rounds to 398 (three sig figs).

### Addition and Subtraction:

2. The number of decimal places in the result should be the same as in the number with the fewest decimal places.

$$\begin{array}{r} 4.38 \\ +131.4 \\ \hline \end{array}$$

$$\begin{array}{r} 31.5563 \\ - 1.410 \\ \hline \end{array}$$

135.781  
rounds to 135.8  
(one decimal place)

30.1463  
rounds to 30.146  
(three decimal places)

**Notice** that when adding and subtracting, if you were to round to the lowest number of significant figures, you would get the wrong answer.

If you are adding or subtracting numbers that don't contain decimal places, you must instead look at the uncertainty in each measurement. The answer should have the same uncertainty as in the number with the **greatest** uncertainty.

550	(± 10)	
1000	(± 1000)	
+ 36	(± 1)	
1586	(± 1000)	the answer rounds to 2000, or $2 \times 10^3$ . (One significant figure)

### Exact Numbers:

Exact numbers are those obtained by counting or by definition. They have an infinite number of significant figures. They do not limit the number of significant figures used in a calculation.

Examples:

27 students in a room (27 was obtained by counting. It is therefore not a measurement, and does not have any uncertainty.)

1 m = 1000 mm (This is a definition within the metric system. It is not the result of a measurement.)

**Note** that numbers without decimal places are not necessarily exact numbers! If you encounter the number 27, do not assume that it is exact unless it came from counting or a definition. If it is a measurement, it has two significant figures. (It was measured to the nearest ± 1.) If you are unsure, assume that it is not exact.

### Rounding:

If the first number to be removed is:

- a) less than 5, then drop it (and all remaining numbers).
- b) 5 or above, then increase the last digit by 1.
- c) exactly 5, then the last number remaining should end in an even digit.

Examples:

<u>Unrounded number</u>	<u>Rounded to 4 significant figures</u>
12.3845	12.38
12.2683	12.27

12.3651  
12.3650  
12.3750

12.37  
12.36  
12.38

When doing multistep calculations, don't round off the answer until the end of the calculation. Keep the number in your calculator. (If for some reason you cannot keep it in your calculator, keep 1 or 2 extra digits, and then round at the end of the calculation.) If you round off prematurely, you may introduce rounding error.

**Note:** When you round off numbers, be very careful that you do not change the magnitude of a number! (This is a very common mistake for beginning students.)

For example:  $38 \times 122 = 4636$

38 has two significant figures. 122 has three significant figures. When these measurements are multiplied, the result should have two significant figures. Therefore, the result should be rounded to 4600, or  $4.6 \times 10^3$ .

Many students make the mistake of rounding it to 46! It's true that 46 has two significant figures, but 46 is a dramatically different number than 4600! Please do not make this mistake.