

## Rounding Number Rules

Move to the place you are rounding to, and then look at the next digit. When you do so three possibilities exist:

1. If the next digit is greater than five, increase the digit preceding that digit by one.
2. If the next digit is less than five, keep the digit preceding that digit the same.
3. If the next digit is a five there are several possibilities:
  - a. If there is a nonzero number following the five in any position, increase the number preceding the five by one.
  - b. If there is nothing following the five OR zeros ONLY, it then depends on the number in front of the five.
    1. If the digit preceding the five is even, keep it the same.
    2. If the digit preceding the five is odd, then increase that digit by one.

NOTE: In all cases, it may be necessary to add place-holding zeros to preserve the magnitude of the number.

## Rules for Counting Significant Figures

1. Nonzero numbers are always significant.
2. Zeros may or may not be significant depending on where they are found:
  - a. Leading zeros that precedes all of the nonzero numbers are NOT significant.
    - i. *Example:* 0.0000037                      Has two significant figures.
  - b. Zeros between nonzero numbers ARE significant.
    - i. *Example:* 1.0000037                      Has eight significant figures.
  - c. Trailing zeros to the right of a nonzero number may or may not be significant, depending on the source of the number. As a general rule, if the number contains a decimal point, consider them significant.
    - i. *Example:* 1000                      Would be considered to have only one sig. fig.
    - ii. *Example:* 1000.                      Would be considered to have four sig. fig
    - iii. *Example:* 100.00.                      Would be considered to have five sig. fig.
3. Exact numbers are considered to have an infinite number of significant figures. These numbers include counting numbers or defined numbers.
4. As you can see, it is imperative that you learn, follow and use the rules listed above.

## **Rules for Establishing the Number of Significant Figures in a Calculation:**

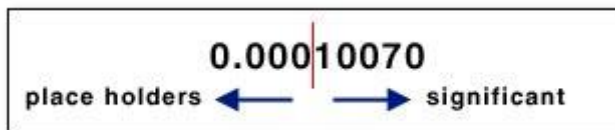
1. **For multiplication and division:** The number of significant figures in the result can have no more significant figures than the least precise measurement in the calculation.
  - a. *Example:*  $2.56 \times 1.2 \times 4.9876 = 15$ 
    - i. The reason for this result is that the least precise measurement (1.2) has two sig. fig.
  
2. **For addition or subtraction:** The result should have the same number of decimal places as the least precise measurement used in the calculation.
  - a. *Example:*  $21.46 + 94.5 + 1.397 = 117.4$ 
    - i. The reason for this result is the number with the least number of decimal places only had one decimal place, so one decimal place in the answer.
  
3. **NOTE:** These are not saying the same thing. Be sure you understand the difference between these rules.

## Significant Figures Work Sheet

In 1960, an international system of units was developed at a conference in France that has become known as Le Systeme International, abbreviated S.I.

The example that is most commonly given to illustrate the concepts of accuracy (The closeness of a measurement to the true value of the quantity that is measured.) and precision (The closeness of agreement of two or more measurements of the same quantity) is that of a target shot by arrows. If you shoot a quiver of arrows at a target, several outcomes are possible. If all of the arrows that you shoot go straight to the bulls-eye, then your aim is both accurate and precise. If, however, the arrows cluster in an area immediately to the right of the bulls-eye, your aim is precise, but not accurate. If, like me, your aim is bad and the arrows hit positions scattered all over the target, then your aim is neither accurate nor precise. The last digit indicated for a measurement is always considered to be a best guess. When you take a measurement, you should read between the lines or graduations to obtain the correct measurement. As an example, you would read the length of the double-ended arrow to the nearest hundredth unit using the top ruler, and to the nearest tenth unit using the bottom ruler.

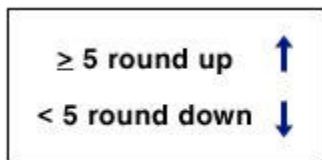
In any given measurement, a degree of uncertainty is implied. For the measurement, 0.55 units, the implied uncertainty is  $\pm 0.01$  units. For a measurement of 10.3 mL, the implied uncertainty is  $\pm 0.1$  mL. But for a number ending in a zero, such as 1000, the amount of uncertainty becomes ambiguous. For instance, examine the figure below. The ruler is marked in units of 100, so the uncertainty is  $\pm 10$  units. However, if we measure the double-ended arrow shown, we would have to say that it was 1000 units long. The measurement, 1000 units, implies that the error in the measurement is  $\pm 1$  unit. Remember, we look to the last digit of a number to determine the uncertainty in a measurement. We know that the measurement is not that accurate. Therefore, we should write the measurement using scientific notation, or  $1.00 \times 10^3$  units, because there are only 3 significant figures in the measurement.



When counting the number of significant figures in a number, count all digits except for the zeros that are used as placeholders. Zeros to the left of a number are placeholders. Zeros that are on the right side of a number, or in the middle of a number are significant. For example, examine the following list of numbers.

Example	Uncertainty	Significant Figures
9.5	$\pm 0.1$	2
10.3	$\pm 0.1$	3
0.672	$\pm 0.001$	3
5	$\pm 1$	1
0.0017	$\pm 0.0001$	2
10,000.0	$\pm 0.1$	6

There



are a few notable exceptions to significant

figures rules. These exceptions are called exact numbers. Exact numbers are considered to have an infinite number of significant figures. Examples of exact numbers include  $\pi$ , constants, conversion factors, and quantities.

When rounding numbers, round up (to the next higher number) if the digit that you are dropping is greater than or equal to 5. Round down (keep the digit the same) if the digit that you are dropping is less than 5.

For example, if we round 10.273 to two decimal places, we would round the number down to 10.27, because the digit that we are dropping is a 3 (less than 5).

However, if we were to round 5.768 to two decimal places, we would round up to 5.77, because the digit that we are dropping is an 8 (greater than or equal to 5).



places, are

When adding and subtracting numbers, the number of *decimal places* is important. The answer can have no more decimal places than the least accurate measurement. Consider the problem below.

When multiplying or dividing, the number of *significant figures* is important. The answer can have no more significant figures than the number with the fewest significant figures. Consider the problem below.

When a problem has a combination of operators (addition, subtraction, multiplication, and/or division), you must apply the rules to each individual step in the equation. In order of operations, multiplication and division come before addition and subtraction. Parentheses and brackets can be used to change the order of operations. Operations enclosed in parentheses must be completed first. The following examples are used to illustrate this point.

### Numerical Manipulations

To avoid confusion about the accuracy of measurements, a system called scientific notation was developed. In scientific notation, only the significant digits are shown and the order of magnitude is indicated by a power of ten.

$$\frac{4.67 \times 5.2}{3.700} = 6.6 \text{ (2 significant figures)}$$
$$(8.0 + 3.2) \frac{15.6}{23.01} = 7.59 \text{ (3 significant figures)}$$
$$\frac{(3.21 - 3.00)}{2.76} = 0.076 \text{ (2 significant figures)}$$

To convert a number written in standard notation into scientific notation, the decimal place is moved (either left or right) until there is only one significant digit to the left of the decimal place. The places that the decimal was moved are counted and the number is rewritten as multiplied by the corresponding power of ten.

<p><b>97,600.0</b> 4-places to the left <math>10^4</math></p>	<p><b>0.00974</b> 3-places to the right <math>10^{-3}</math></p>
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For example 97,600.0 can be written as  $9.76000 \times 10^4$ , and 0.00974 can be rewritten as  $9.74 \times 10^{-3}$ .