**Rules for deciding the number of significant figures in a measured quantity:**

(1) All nonzero digits are significant:

1.234 g has 4 significant figures,  
1.2 g has 2 significant figures.

(2) Zeroes between nonzero digits are significant:

1002 kg has 4 significant figures,  
3.07 mL has 3 significant figures.

(3) Leading zeros to the left of the first nonzero digits are not significant; such zeroes merely indicate the position of the decimal point:

0.001 oC has only 1 significant figure,  
0.012 g has 2 significant figures.

(4) Trailing zeroes that are also to the right of a decimal point in a number are significant:

0.0230 mL has 3 significant figures,  
0.20 g has 2 significant figures.

(5) When a number ends in zeroes that are not to the right of a decimal point, the zeroes are not necessarily significant:

190 miles may be 2 or 3 significant figures,  
50,600 calories may be 3, 4, or 5 significant figures.

The potential ambiguity in the last rule can be avoided by the use of standard exponential, or "scientific," notation. For example, depending on whether the number of significant figures is 3, 4, or 5, we would write 50,600 calories as:

5.06 × 104 calories (3 significant figures)  
5.060 × 104 calories (4 significant figures), or  
5.0600 × 104 calories (5 significant figures).

By writing a number in scientific notation, the number of significant figures is clearly indicated by the number of *numerical figures* in the 'digit' term as shown by these examples. This approach is a reasonable convention to follow.

**Rules for mathematical operations**

In carrying out calculations, the general rule is that the accuracy of a calculated result is limited by the least accurate measurement involved in the calculation.

(1) In addition and subtraction, the result is rounded off to the last common digit occurring furthest to the right in all components. Another way to state this rule is as follows: in addition and subtraction, the result is rounded off so that it has the same number of digits as the measurement having the fewest decimal places (counting from left to right). For example,



100 (assume 3 significant figures) + 23.643 (5 significant figures) = 123.643,

which should be rounded to 124 (3 significant figures). Note, however, that it is possible two numbers have no common digits (significant figures in the same digit column).

(2) In multiplication and division, the result should be rounded off so as to have the same number of significant figures as in the component with the least number of significant figures. For example,



3.0 (2 significant figures ) × 12.60 (4 significant figures) = 37.8000



which should be rounded to 38 (2 significant figures).

**Rules for rounding off numbers**

(1) If the digit to be dropped is greater than 5, the last retained digit is increased by one. For example,

12.6 is rounded to 13.

(2) If the digit to be dropped is less than 5, the last remaining digit is left as it is. For example,

12.4 is rounded to 12.

(3) If the digit to be dropped is 5, and if any digit following it is not zero, the last remaining digit is increased by one. For example,

12.51 is rounded to 13.

(4) If the digit to be dropped is 5 and is followed only by zeroes, the last remaining digit is increased by one if it is odd, but left as it is if even. For example,

11.5 is rounded to 12,   
12.5 is rounded to 12.

This rule means that if the digit to be dropped is 5 followed only by zeroes, the result is always rounded to the even digit. The rationale for this rule is to avoid bias in rounding: half of the time we round up, half the time we round down.

Sample problems on significant figures

1.    37.76 + 3.907 + 226.4 = ?

2.    319.15 - 32.614 = ?

3.    104.630 + 27.08362 + 0.61 = ?

4.    125 - 0.23 + 4.109 = ?

5.    2.02 × 2.5 = ?

6.    600.0 / 5.2302 = ?

7.    0.0032 × 273 = ?

8.    (5.5)3 = ?

9.    0.556 × (40 - 32.5) = ?

10.    45 × 3.00 = ?

11.    What is the average of 0.1707, 0.1713, 0.1720, 0.1704, and 0.1715?

12.    What is the [standard deviation](http://en.wikipedia.org/wiki/Standard_deviation) of the numbers in question 11?

13.    3.00 x 105 - 1.5 x 102 = ? (Give the exact numerical result, and then express that result to the correct number of significant figures).

**Answer key to sample problems on significant figures**

 1.    37.76 + 3.907 + 226.4 = 268.1

 2.    319.15 - 32.614 = 286.54

 3.    104.630 + 27.08362 + 0.61 = 132.32

 4.    125 - 0.23 + 4.109 = 129 (assuming that 125 has 3 significant figures).

 5.    2.02 × 2.5 = 5.0

 6.    600.0 / 5.2302 = 114.7

 7.    0.0032 × 273 = 0.87

 8.    (5.5)3 = 1.7 x 102

 9.    0.556 × (40 - 32.5) = 4

10.   45 × 3.00 = 1.4 x 102

This answer assumes that 45 has two significant figures; however, that is not unambiguous, because there is no decimal point, and because it is not expressed in scientific notation. If 45 is an exact number (e.g., a count), then the result should be 1.35 x 102.

11. What is the average of 0.1707, 0.1713, 0.1720, 0.1704, and 0.1715?   
The average of these numbers is calculated to be 0.17118, which rounds to 0.1712 .

12.    3.00 x 105 - 1.5 x 102 = ? (Give the exact numerical result, and then express that result to the correct number of significant figures).   
Doing the math right is the first step.