SNAP Centre Workshop

Significant Figures

Introduction

Significant figures are the standard method used to denote which digits in a measurement are associated with that measurement's degree of precision.

There are several rules that determine which digits in a number are considered significant, most of which are related to the treatment of zeros.

The digits in a number that are considered significant are:

1) Any non-zero digits.
2) Zeros that are located between non-zero digits.
3) Zeros that are part of a decimal fraction that come after non-zero digits.
4) All digits that come after a non-zero digit and before a specially marked digit.

The digits in a number that are not considered significant are:

1) "Placeholder" or "leading" zeros in a decimal fraction. These are zeros that are to the left of the first non-zero digit, including the zero in the ones place, and any zeros to the right of the decimal point before the first non-zero digit in a decimal fraction. Leading zeros are very rarely seen outside of decimal fractions.
2) Zeros to the right of the last non-zero digit in a whole number measurement.
3) Digits that come are after a specially marked digit.

Examples of Significant Figures

The significant figures in the following terms are highlighted in bold.

$$\mathbf{6}$$

A single digit in the ones place has 1 significant figure.

$$\mathbf{72}$$

Similarly, this number has 2 significant figures since both digits are non-zeros.

$$\mathbf{7}00$$

Despite consisting of 3 digits, 700 only has 1 significant figure since the 2 zeros are to the right of the last non-zero digit in a whole number.

$$\mathbf{56\ 2}00$$

Like 700, there are 2 insignificant zeros here. Each of the 3 non-zero digits are significant.

$$\mathbf{80\ 9}00$$

We count the zero between the 2 non-zero digits here, giving us 3 significant figures total. As in the last example, the 2 zeros after the non-zero digit are insignificant.

$$\mathbf{101\ 01}0$$

There are 5 significant figures in this example. The only digit that is not significant is the zero in the ones place.

$$00\mathbf{2\ 540\ 6}00$$

Although a measurement is very unlikely to be written this way, we can still count the significant figures. There are 5 sig figs, as we do not include the zeros before and after our first and last non-zero digits, respectively.

$$\mathbf{45\ 000\ 0\bar{0}}0$$

In this example, a small bar is placed over the zero in tens place, indicating that it is a sig fig. We treat it just as we would a non-zero digit, giving us 7 sig figs total. Different professors have different tendencies when it comes to using special markers like this. Some are common, such as the bar in the example, while others may be unique to that particular person.

$$\mathbf{1\ 200}.$$

When the decimal point is included in the measurement despite the measurement being a whole number, we treat all digits to the left of the decimal as sig figs. In this example, that gives us 4 total.

$$0.\mathbf{1}$$

The zero in the ones place does not count as a significant figure as it is a leading zero. Because of this, we only have 1 sig fig.

$$0.0\mathbf{100}$$

Again, the leading zeros are not counted as being significant, however, the zeros after our final non-zero digit are, giving us 3 total. This is because they are part of the decimal fraction.

$$\mathbf{150.0120}$$

Each digit in this number are significant, giving us 7 total sig figs.

$$0.0\mathbf{85\bar{6}}074$$

Here, the specially marked digit prevents us from counting the three digits that come after it, giving us 3 sig figs total.

Addition and Subtraction

Any sum or difference calculated involving significant figures will be precise to the same place as the number with the **least precise place** involved in the calculation.

Once we have a calculated value, we need to round off to the final significant place in our number. Although there are slight variations in the rules, the general rules for rounding off are as follows:

1) If the first digit after the last significant figure is less than 5, round down.
2) If the first digit after the last significant figure is greater than 5, round up.
3) If the first digit after the last significant figure is 5, round the significant figure to the closest even number.
4) **Do not round off until you reach your final answer**.

Following are examples of addition and subtraction with the sig figs in the final rounded answers in bold:

$$505\bar{6}0 + 1000 - 55 = \mathbf{51}\,505 = \mathbf{52}\,000$$

$$1.462928 \ + \ 74.81 \ + \ 0.730001 \ + \ 8.2731 = \mathbf{85.27}6029 = \mathbf{85.28}$$

$$0.04216 \ - \ 0.0004134 + 0.522 = 0.\mathbf{563}7466 = 0.\mathbf{564}$$

Multiplication and Division

When multiplying or dividing, the number of significant figures in our product or quotient will be equal to the number of sig figs in the term with the lowest number of significant figures. Following are examples of this:

$$\frac{(25\,600)(0.001)}{1\,563} = 0.0\mathbf{1}637879 = 0.0\mathbf{2}$$

$$\frac{(8.91)(302)}{(1\,900)(0.01502)} = \mathbf{94.}28901 = \mathbf{94}$$

$$\frac{5026}{(0.00152)(855)} = \mathbf{386}7.3438 = \mathbf{387}0$$

Significant Figures When Using Scientific Notation

The number of significant figures in measurements expressed in scientific notation are easy to determine due to the nature of the format. Generally, the only digits expressed in our coefficient term are significant figures. Again, an exception to this is when a special marker is present. If there are non-zero digits following a sig fig marker, it is a good idea to include them in the coefficient term as well, unless rounding a final answer.

Note: The significant figures in the exponential term are not counted.

$$\mathbf{15}0\,000 = \mathbf{1.5} \times 10^5$$

$$\mathbf{600.} = \mathbf{6.00} \times 10^2$$

$\mathbf{89\ 050\ 001} = \mathbf{8.9050001} \times 10^7$

$\mathbf{700\ 2\bar{0}}0 = 7.0020 \times 10^4$

$\mathbf{5\ 6\bar{5}}2 = \mathbf{5.6\bar{5}}2 \times 10^3$

$0.00\mathbf{1502} = \mathbf{1.502} \times 10^{-3}$

$0.0\mathbf{25000} = \mathbf{2.5000} \times 10^{-2}$

$0.00\mathbf{62\bar{5}}23 = \mathbf{6.2\bar{5}}23 \times 10^{-3}$

If two terms in scientific notation have the same exponential term, we can factor it out and add or subtract the coefficient terms. If this is the case, we follow our addition and subtraction rules for determining final sig figs.

$\mathbf{6.2\bar{5}}23 \times 10^{-3} - \mathbf{1.502} \times 10^{-3}$

$= \left(\mathbf{6.2\bar{5}}23 - \mathbf{1.502}\right) \times 10^{-3}$

$= \mathbf{4.75}03 \times 10^{-3}$

$= \mathbf{4.75} \times 10^{-3}$

When multiplying or dividing terms in scientific notation, we determine significant figures by our product and quotient rules.

$\frac{(6.00\times10^2)(2.5000\times10^{-2})}{7.0020\times10^4}$

$= \frac{(6.00)(2.5000)}{7.0020} \times 10^{2-2-4}$

$= \mathbf{2.14}224 \times 10^{-4}$

$= \mathbf{2.14} \times 10^{-4}$

Exact Numbers

Exact numbers are counted quantities, rather than measurements, and are not subject to precision considerations. For example, counting 6 apples gives you an exact figure that represents the number of apples you have.

When using exact figures in calculations with measurements, they do not affect the number of significant figures in a final answer.