1.6: Significant Figures

Experimental work in scientific laboratories will generally involve measurement. Whenever we make a measurement, we always strive to make our value as accurate as possible.

The distance is more than 50 mm, the last numbered digit shown before the second arrow. If we look very carefully, we see that the second arrow is about half-way between the fourth and fifth division following the 50 mm mark. The measurement is therefore greater than 54 mm and less than 55 mm and is about 54.5 mm. The last digit in our measurement is estimated, but the first two digits are exact. In any measurement, like this, the last digit that you report is always an estimated digit. If we were to say that the measurement was 54 mm, that would be incorrect, because we know it's larger. If we were to say the measurement was 54.5567 mm, that would be nonsense because our scale does not show that degree of accuracy. In a measurement in science, the estimated digit is called the least significant digit, and the total number of exact digits plus the estimated digit is called the number of significant figures in the measurement. Thus the measurement in the figure, 54.5, has three significant figures (3 SF). By adhering to this rule, we can look at any measured value and immediately know the accuracy of the measurement that was done. In order to properly interpret the number of significant figures in a measurement, we have to know how to interpret measurements containing zeros. For example, an object is found to have a mass of 602 mg. The last digit (the 2) is estimated and the first two digits are exact. The measurement therefore is accurate to three significant figures. We could also express this measurement in grams using the metric conversion ratio $\left({}^{1\text{ g}}/_{10^3\text{ mg}}\right)$, making the measurement 0.00602 g. We now have three additional digits in our number (called leading zeros), but is our number any more accurate? No; in a measurement, leading zeros (zeros that appear before the number) are never significant.

Let's consider another measurement; we are told that a distance is 1700 m. The first thing to notice is that this number does not have a decimal point. What this tells us is that the estimated digit in this number is the 7, and that this number only has two significant figures. The last two zeros in this measurement are called trailing zeros; in numbers without a decimal point, trailing zeros are never significant. If, however, the distance was reported as 1700.00 m, the presence of the decimal point would imply that the last zero was the estimated digit (zeros can be estimated too) and this number would have six significant figures. Stated as a rule, in a number containing a decimal point, trailing zeros are always significant. These simple rules for interpreting zeros in measurements are collected below:

Rules for Handling Zeroes when interpreting Significant Figures

In numbers with a decimal point

- leading zeroes are never significant
- trailing zeroes are always significant

In numbers without a decimal point

- trailing zeroes are never significant

In all numbers

- zeroes which appear between non-zero digits are always significant

Applying these rules to some examples:

- 117.880 m contains six significant figures; the number has a decimal point, so the trailing zero is significant.
- 0.002240 g contains four significant figures; the number has a decimal point so the trailing zero is significant, but the leading zeros are not.
- 1,000,100 contains five significant figures; the number does not have a decimal point, so the trailing zeros are not significant. The zeros between the first and fifth digits, however, are significant.
- 6.022×10^{23} contains four significant figures. In scientific notation, all of the significant figures in a measurement are shown before the exponent. (Remember this when you are converting measurements into scientific notation.)

Exercise 1.6.1

Determine the number of significant figures in each of the following numbers:

a. 2,057,000
b. 1.250600
c. 9.300×10^{-4}
d. 6.05×10^{4}