Significant Digits

The following table summarizes the rules for assigning significant digits used in this course.

Rule	Example
Non-zero numbers are always significant.	5.23 has 3 significant digits
Zeros between non-zero digits are always significant.	5.203 has 4 significant digits
Zeros at the beginning of a number are never significant—they serve only to locate the decimal.	0.05203 has 4 significant digits
Zeros at the end of a number and to the right of the decimal point are significant.	1.300 has 4 significant digits. For example, an extremely accurate balance can measure masses accurately to the third decimal place.
Zeros at the end of a number and before the decimal point may or may not be significant. It depends on the precision of the measuring device used.	36 500 may have 3 or 5 significant digits (see explanation below).

As mentioned in the last example above, the number 36 500 might have three or five significant digits:

- Three significant digits—Suppose a transport truck pulls into a roadside truck weigh station. The scale at the station is designed to measure large objects. It can only give an approximate mass of 36 500 kg for the mass of the truck and its contents. The actual value may be between 36 400 kg and 36 600 kg. However, the scale isn't sensitive enough to measure masses in kilograms or even tens of kilograms.
- Five significant digits—The truck and all its contents are taken apart and massed on smaller, more precise scales than can measure to the kilogram. The total mass is found to be exactly 36 500 kg.

Expressing a measurement in **scientific notation** removes all doubt about how many significant digits there are. To return to the example of 36 500:

- 36 500 kg = 3.65×10^4 kg 3 significant digits

- 36 500 kg = 3.6500×10^4 kg 5 significant digits

Rounding

Being able to round numbers off to the correct number of significant digits is necessary before you can perform calculations involving measurements. Use the following rules when rounding numbers.

1. If the measurement ends with a digit greater than or equal to 5, round up. For example,

   3.268 g becomes 3.27 g

   3.65 g becomes 3.7 g

2. If the measurement ends with a digit less than 5, discard the digit. For example,

   3.263 g becomes 3.26 g (but 3.260 stays as 3.260 if you need that significant digit!)

Exact or Counting Numbers

Ask for a dozen doughnuts at the local doughnut shop. You should get exactly 12 doughnuts every time. There is no uncertainty in the number 12. Similarly, when we say there are 1000 mL in 1 L, all the digits in the number 1000 are known exactly. The last zero in 1000 is not an estimate. We can describe counting (or exact) number as having an infinite number of significant digits.

Calculations Involving Significant Digits

The following conventions for rounding off answers after a series of calculations are used in this course.

When to Round Off

In a numerical problem involves a series of calculations, round off only at the end. Rounding off after each calculation increases errors in the final answer.

Addition and Subtraction

The value with the least number of decimal places determines the number of significant digits in any equation. For example, suppose you had to add three different masses of chemicals found using three different balances.

12.003 g
1.06 g
22.1 g
36.163 g (before rounding)

AND

36.2 (after rounding)

The answer was rounded to the first decimal place because of 22.1 g.

Multiplication and Division

The number with the fewest number of significant digits determines how many significant digits should be in the answer. For example,

20.4 g ÷ 2.2 mL = 9.2727272727 g/mL (this is what appears on your calculator display)

= 9.3 g/mL (after rounding)

In this example, 2.2 mL determines that the final answer must have only two significant digits.

In summary, do the calculation, and then round off to the least number of significant digits.

Be careful with counting numbers! If you recall, counting numbers or defined numbers have an infinite number of significant digits. For example, when calculating the mass of two beakers, the number of significant digits in the mass measurement determines the number written in the answer.

$$2\ \cancel{\text{beakers}} \times \frac{110.07\ \text{g}}{\cancel{\text{beaker}}} = 220.14\ \text{g}$$

Another example of when exact numbers are used is the conversion of one unit to another. For example, when converting litres to millilitres, the number of significant digits should not change.

$$2.5\ \cancel{\text{L}} \times \frac{1000\ \text{mL}}{1\ \cancel{\text{L}}} = 2500\ \text{mL}$$

In this case, 2.5 and 2500 have the same number of significant digits—two.