Identifying Significant Digits

1. All non-zero digits are significant.

   1.234 g has 4 significant digits
   1.23 g has 3 significant digits

2. Zeroes located between non-zero digits are significant.

   1.204 g has 4 significant digits
   1.03 g has 3 significant digits

3. Leading zeroes to the left of the first non-zero digit are <u>not</u> significant.

   0.034 g has 2 significant digits
   0.004 g has 1 significant digit

4. Trailing zeroes to the right of the decimal point <u>are</u> significant.

   1.200 g has 4 significant digits
   1.20 g has 3 significant digits

5. Trailing zeroes in a number without a decimal point may or may not be significant.

   12340 may have 4 significant digits or 5 significant digits. The only way to know for sure is to use scientific notation (1.2340×10^4 has 5 significant digits; 1.234×10^4 has 4 significant digits).

Multiplying and Dividing with Significant Digits

When multiplying or dividing two numbers, the answer has the same number of significant digits as the least accurate of the two numbers. For example, if an object has a mass of 32.014 g (5 significant digits) and a volume of 25.0 cm^3 (3 significant digits) then its density is

$$\frac{32.014\ \text{g}}{25.0\ \text{cm}^3} = 1.28\ \text{g/cm}^3$$

which has 3 significant digits.

Adding and Subtracting with Significant Digits

When adding or subtracting two numbers, the answer cannot have any digits to the right of the number with the lowest accuracy. For example, if the mass of a bucket full of aggregate is 15.4 kg (which is accurate to the nearest 0.1 kg) and the bucket has a mass of 0.27 kg (which is accurate to the nearest 0.01 kg) then the mass of the aggregate in the bucket is

$$\begin{array}{r l} 15.4 & \text{kg} \\ \underline{-\ 0.27} & \underline{\text{kg}} \\ 15.1 & \text{kg} \end{array}$$

which is accurate to the nearest 0.1 kg.

NOTE: Be careful when combining addition/subtraction with multiplication/division. For example,

$$\frac{926 - 923.4}{4.3} = \frac{3}{4.3} = 0.6$$

actually has only one significant digit in the answer because the numerator has only one significant digit after you've applied the rules for addition and subtraction to the numerator.

Rules When Using Calculators

In a complicated calculation, it is common to do the calculation in parts, stopping to write down intermediate results as you go along. It is important to keep at least one or two more significant digits in those intermediate results than are justified by the rules above, then round only the final answer to the correct number of significant digits. That way you get the same answer whether you do the calculation in parts or work the entire calculation without stopping to write anything down, relying on the calculator's memory to store all of the intermediate results.

If one of the intermediate results is itself an answer to a given question, you should report the answer to the correct number of significant digits, but use the version with additional digits in subsequent calculations so you don't lose accuracy along the way.

For example, let's say a rigid cube with dimensions of 11.1 × 11.2 × 11.3 cm has a mass of 3131 g. If the mass density of water is 0.9974 g/cm^3 what is the specific gravity of the material?

If we do the calculations all at once:

$$G_s = \frac{3131}{(11.1)(11.2)(11.3)(0.9974)} = 2.2345 = 2.23$$

If we calculate the density of the cube first:

$$\rho_s = \frac{3131}{(11.1)(11.2)(11.3)} = 2.2288 = 2.23\ g/cm^3$$

$$G_s = \frac{2.23}{0.9974} = 2.2358 = 2.24$$

If we calculate the volume of the cube first:

$$V = (11.1)(11.2)(11.3) = 1404.8 = 1400\ cm^3$$

$$\rho_s = \frac{3131}{1400} = 2.2364 = 2.24$$

$$G_s = \frac{2.24}{0.9974} = 2.2458 = 2.25$$

So is the specific gravity 2.23, 2.24, or 2.25?

If we keep just one extra significant digit in our intermediate calculations, we get the same answer all three ways.

If we do the calculations all at once:

$$G_s = \frac{3131}{(11.1)(11.2)(11.3)(0.9974)} = 2.2345 = 2.23$$

If we calculate the density of the cube first:

$$\rho_s = \frac{3131}{(11.1)(11.2)(11.3)} = 2.2288 = 2.229$$

$$G_s = \frac{2.229}{0.9974} = 2.2348 = 2.23$$

If we calculate the volume of the cube first:

$$(11.1)(11.2)(11.3) = 1404.8 = 1405\ cm^3$$

$$\rho_s = \frac{3131}{1405} = 2.2285 = 2.229\ g/cm^3$$

$$G_s = \frac{2.229}{0.9974} = 2.2348 = 2.23$$

So the answer, to the correct number of significant digits, is G_s = 2.23.