Significant Figures

Skills to Develop

- Be able to understand how to interpret and report significant figures

Suppose you were measuring the diameter of the box below and you needed to report its circumference. You used a ruler and found the diameter to be 31 mm. Then you do the calculation on your calculator and get 97.389372261284 mm. So what do you say the circumference of the circle was? You certainly don't know the circumference more precisely than you knew the diameter, which was between 30 and 32 mm. Going through the calculations with these values would tell you that the circumference was between 94.25 mm and 100.53 mm. This is where significant figures come in handy.

A circular box

Significant figures, often called sig figs, are the number of digits in a given value, or number. For instance, 18 has 2 sig figs, and 3.456 has 4 sig figs. However, both 10 and 1000 have only 1 sig fig. The reason is because the zeros have to be there to show what the number is, so they don't count as significant digits. What about 1001? It has 4 sig figs. We could have "rounded" it to 1000, showing that the last digit wasn't significant, but we didn't. This shows that the 1 on the right is significant, and so if the smallest digit (representing 1s) is significant, then the bigger ones (representing 10s and 100s) must be also. However, if the zeros are significant, then a period or decimal point would be added to the end. For example, if given a problem in which 20. mL are used, then there are 2 sig figs in the number 20.

> You may forget to include the decimal point, particularly in your lab notebook when working in the lab. But you can assume that you used the standard measuring tools in the lab and use the significant figures based on the tools' accuracy. For example, a graduated cylinder could be accurate to 2 mL. So recording 20. mL would be like saying the measurement was between 18 - 22 mL. This means that recording the data with 2 sig figs would be correct. Generally, including an extra sig fig, especially in the middle of calculations is reasonable.

When measuring a quantity, the significant figures describe how precise the measurement was by listing the digits in a measured value which are known with certainty. For example, suppose you measure the length of a box with a normal ruler with increments, or markings, for millimeters (mm). You can be sure that your measurement is no more than 1 mm different from the real length of the box if you measured carefully. So, for instance, you could report the length as 31 mm or 3.1 cm. You wouldn't round to 3 cm or 30 mm since you were able to measure the box more precisely than that. But since you were only able to accurately measure to the nearest millimeter, the certainty of your measurement is within a millimeter of the reading. So you would read your measurement of 3.1 cm as 31 mm ± 1 mm.

Now suppose you wanted to know the length of the box much more precisely. To do that you will need a better tool. For instance, you could use a dial caliper to measure to the nearest 0.02 mm. Now you could report your length as, say, 31.14 mm, which means that your are certain your measurement was between 31.12 mm and 31.16 mm. If you measured with a ruler but wrote 31.1 mm, or 31.12 mm, people going through your numbers would probably think that you used a better tool than you actually did, so that would be almost dishonest

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A dial caliper.

Going back to the original problem, one rule for using sig figs when doing multiplication with a measured number is to report the answer with the same number of sig figs and the number you started with: 2 sig figs, so 97 mm. The uncertainty is a little bigger than it was before, 97 ± 3 mm. But you shouldn't write 100 mm (1 sig fig) because you don't mean 0 - 200 mm, but you also don't mean 90 - 110 mm (sig fig change!).

> If you wanted to say 100 mm with 2 sig figs, you would have to write it as 10. cm or use scientific notation and write it as 1.0 x 10^2 mm.

Some numbers are counted or defined, meaning that they are not measured. These are exact numbers. For instance, there are exactly 1000 grams (g) in 1 kilogram (kg), because that's the definition. Or if you use a volumetric pipette to add 1.00 mL of liquid twice, then the total amount added was 2 x 1.00 mL = 2.00 mL. You used the pipette exactly twice, so the 2 is exact, and you don't have to round to 1 sig fig (2 mL) for the total volume.

Contributors and Attributions

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