Significant Digits and Scientific Notation

Significant Figures (digits)

- Scientists take the ideas of precision and accuracy very seriously.
- You can actually take entire courses in University that show how to figure out the precision and accuracy of measurements.

- We need to know that when another scientist reports a finding to us, we can **trust the accuracy and precision** of all the measurements that have been done.
- A set of guidelines is needed while we do calculations so that we get rid of all those "**4.243956528452940472**" kind of answers you see on your calculator.
- The guidelines are there so we will know how many digits we should round off the final answer **to show the correct precision**.

- All of this boils down to something called "**Significant Digits**", more commonly referred to as **Sig Digs** or **Sig Figs**

To determine how many significant (important) digits a number has, follow these rules:

- Non-zero numbers are always significant

- 13.869 -> Five sig digs. All the numbers are digits between 1 and 9.

- Zeros between non-zero numbers are always significant

- 1.304 -> Four sig digs. The zero counts because it appears to the right of the "3"

- Zeros before the first non-zero digit are NOT significant

- 0.0008 -> One sig dig. The zeros don’t count, because they are to the left of the non-zero digits.

- Zeros at the end of the number after a decimal place are significant

- 576.00 -> Five sig digs. The zeros count because they appear to the right of the "6"

- Zeros at the end of a number before a decimal place are ambiguous (10,300)

- 10,300 could have 3, 4, or 5 sig figs
- That’s why we write numbers in scientific notation
- We will count this number as having three sig figs.

Sig Fig Rules Recap

- Non-zero numbers are always significant
- Zeros between non-zero numbers are always significant
- Zeros before the first non-zero digit are NOT significant (ex. 0.003 has 1 s.f.)
- Zeros at the end of the number after a decimal place are significant ex. 200.0 (4)
- Zeros at the end of a number before a decimal place are ambiguous (10,300)

7007 has how many sig figs ?

- Each digit here is significant.
- So…there are **4** sig figs.

0.0007 has how many sig figs ?

- The zeros just hold places in this case.
- There is only **1** sig fig here.

- If the number had sig figs after the 7, they would each be significant.

700 000 000 has how many sig figs ?

- Again, the zeros only hold places.
- There is no decimal to say that they are significant, so they aren't.

- This number has only **1** sig fig.

Addition and Subtraction

- When you add or subtract numbers, always check which of the numbers is the least precise (least numbers after the decimal). Use that many in your final answer.

- **Example 2:**
- 11.623 + 2.0 + 0.14 = ?
- If you type this on a calculator, you'll get 13.763. Round it off to a final answer of **13.8**, since the number "2.0" is the least precise... it only has one sig fig after the decimal.

Multiplication & Division

3. When you **multiply** or **divide** numbers, check which number has the **fewest sig figs**. Round off your answer so it has that many sig figs.

- **Example 3:**
- 4.56 x 13.8973 = 63.371688 = **63.4**
- We round off our final answer to three sig figs, because "4.56" has the fewest sig figs... three sig figs.

Scientific Notation

- What do you do if you multiply numbers like 537 x 269 = 144 453... you are supposed to only have three sig digs, but your answer sure has more than three sig digs!
- What if you have a large number like **4 500 000 000** km (the distance from Neptune to the sun), or a small number like **0.000 000 010** cm (the diameter of an atom) and you don't want to be bothered with writing out all those zeros?

- To get around these problems, we use **Scientific Notation** (sometimes called *Exponential Notation*).

- This system makes use of "powers of 10", raising 10 to whatever value you need.
- You can get either really big numbers by using **positive** powers like $10^5 = 100\,000$
- You can also show really small numbers by using negative powers like $10^{-5} = 0.00001$

Example 1:

- 10^{5} = 10 x 10 x 10 x 10 x10 = 100 000
- 10^{-5} = 1/10 x 1/10 x 1/10 x 1/10 x 1/10 = 0.00001
- Don't worry about spending half a minute using your calculator to figure out what 10^{5} equals. Instead, notice that 10^{5} written out has five zeros.
- 10^{-5} has five places to the right of decimal

Rules

1. Move the decimal over so that only **one non-zero number** is to the left of the decimal.

- **4 500 000 000** -> **4.500 000 000**
- **0.000 000 010** -> **000 000 01.0**

2. Count how many spaces over you moved the decimal. If you moved it to the left it's positive, if you moved it to the right it's negative.

- **4.500 000 000** -- moved **9** spaces left **(+9)**
- **000 000 01.0** -- moved **8** spaces right **(-8)**

3. Get rid of any numbers that are **not** sig digs.
   This might depend on the numbers you used in your calculation.

- **4.500 000 000** -> **4.5**
  I'm assuming that all those other zeros were probably just place holders, although I'd need a reason to do this in a real question.
- **000 000 01.0** -> **1.0**
  I'll keep this last zero. Since it was written in the original number for such a small number, it's probably significant.

4. Write down the number, multiplied by 10 to the power of however many spaces you found in step **2**.

- **4 500 000 000 = 4.5 x 10^9**
- **0.000 000 010 = 1.0 x 10^{-8}**

- If you ever need to change a number in scientific notation back to regular form, do the reverse of the above.
- ***Warning!***
  When you do this, you might be writing a number down with more sig digs than it actually has. The only time you should do this is if your calculator can't do exponents.

Convert 56789 to scientific notation.

- We must move the decimal **<u>4</u>** places, so the number becomes…
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- **5.6789 x 104**

Convert 6.2 x 10-4 to standard notation.

- We must move the decimal **4** places to the left since it is a negative exponent.
- So… we add 3 zeros to the left and place the decimal.
- **0.00062**

- **Scientific Notation on Your Calculator**
- Most calculators now have a key on them for doing scientific notation. Look for one of the following...
- **EXP** (*most Casio calculators*)
- **EE** (*most TI calculators, and you might have to use the 2nd function key to use it*)
- **10x**
- **S.N.**

- Do **NOT** use the "hat" symbol on your calculator to enter scientific notation (eg. 4.5 x 10^5).
- Your calculator will treat this as two separate numbers, and you will get some calculations wrong because of it (it screws up the proper order of operations).

- TI-83 would show the numbers like this. Example, **4.587e4** instead of **4.587×10^4**

That’s all Folks