A Brief on Significant Figures

1) Integers:

The zeros at the end of an integer do not count as significant. **1000** has only **1** sig. fig.. **1,000,000** has only **1** sig. fig.. If I say that I have about $1000 in my pocket, it could vary from over $500 to under $1500. The precision is not good. It is good only to 1 sig. fig..

Having about $1100 in wallet means from over $1050 to under $1150. The precision of 1100 is to 2 sig. fig..

Having about $1110 in wallet means from over $1105 to under $1115. The precision of 1110 is to 3 sig. fig..

Having about $1111 in wallet means from over $1110.5 to under $1111.5. The precision of 1111 is to 4 sig. fig..

As you may have noticed, the last zeros of an integer number do not count as significant.

Exercise 1: How many significant figures does each quantity have?

1) 107cm Ans.: ....

2) 10,700cm Ans.: ....

3) 1,270cm Ans.: ....

4) 12,703cm Ans.: ....

5) 1,060,809cm Ans.: ....

6) 1,040,700cm Ans.: ....

7) 10,407,005cm Ans.: ....

8) 100,000,002cm Ans.: ......

9) 100,000,000cm Ans.: ......

Answers: (3, 3, 3, 5, 7, 5, 8, 9, 1)

2) Decimal Numbers

For a decimal number that is less than 1, all figures are significant except the leading zeros after its decimal point. For example 0.235kg is less than 1 and has 3 sig. figs. This is equivalent to 235 grams. Suppose instead we have 0.000235kg. The three zeros before 235 but after the decimal point do not count as significant. This is equivalent to 235milli-grams and has 3 sig. figs., again.

Now, if the decimal number is greater than 1, such as 1.235kg, it has 4 sig. figs.. This is equivalent to 1,235 grams and has 4 sig. figs..

Suppose now we have 8.0235kg that can be written as 8,023.5 grams. It has 5 sig. figs.. Here, the zero after its decimal point but leading the 235 part counts as significant because the number is greater than 1 and has a non-decimal part that is 8.

Look at 8.000235kg that has 7 sig. figs. and 0.000235kg that has 3 sig. figs. only. These are equivalent to 8,000,235 micrograms and 235micrograms, respectively.

The numbers 7.01044400kg has 9 sig. figs. For a decimal number the very last zeros count as significant. If we convert this to micrograms by multiplying by 1,000,000 we get 7,010,444.00micrograms. The two zeros after its decimal point shows that the precision of the measuring device is to 1/100 of a microgram. (Note that milli means (1/1000)th and micro means (1/1000,000) th.

As another example, if you write the amount of money in your wallet as $0120.74, the first 0 is redundant and does not count. There are 5 significant figures in this number. If you write a length measurement as L = 7.60 cm, the number is good to 3 sig. fig.. It is a decimal number and the last zero counts. The precision of measurement is to the hundredth of one centimeter. You may use a more precise tool and come up with L = 7.602 cm. This shows the superiority of the measurement device used. It has a precision to one thousandth of one cm, ten time better. Therefore, we have to be careful in writing down our measurements. If the precision of the dial caliper you use is to the tenth of a millimeter, and you measure the length of a box to be 12.8mm, it must be written down as 12.8mm to reflect the precision of one tenth of a mm. If you use the same caliper and measure the length of a similar box as 13 mm, you should write it down as 13.0mm to reflect the precision of the device used.

Exercise 2: How many significant figures does each quantity have?

1) 0.13070kg Ans.: ....

2) 1.07000cm Ans.: ....

3) 0.0007cm Ans.: ....

4) 22.0000cm Ans.: ....

5) 0.000009cm Ans.: ....

6) 1.0400700cm Ans.: ....

7) 10.407005cm Ans.: ....

8) 100.000,0020cm Ans.: ......

9) 100,000,000.0cm Ans.: ......

10) 100,000,000,000cm Ans.: ......

Answers: (5, 6, 1, 6, 1, 8, 8, 10, 10, 1)

Operations Rules

For multiplication, division, raising to a power, or taking any roots, if the participating numbers have the same number of sig. figs., the final result must be rounded to the same number of sig. figs..

If the participating numbers have different numbers of sig. figs., the final result must be rounded to the number of sig. figs. of the number that has the lowest sig. figs.. For example, if 12 (2 sig. figs.) is multiplied by 25 (also 2 sig. figs.), the resulting number is 300 but must be written in a form that shows it is good to 2 sig. figs.. You may either put a tiny bar on the zero after 3, or write the number as $3.0\text{x}10^2$.

As another example, if 12.0 (3 sig. figs.) is multiplied by 25 (2 sig. figs.), the result must be written in 2 sig. figs. again as 300 with a tiny bar on the zero after 3 or as $3.0\text{x}10^2$.

For addition or subtraction, the precisions of the numbers being added or subtracted are important. For example, if the mass of a bolt is measured with a scale that is good to one gram precision, and the mass of its corresponding nut is measured with another scale that is good (or precise) to one milligram (1000 times better precision), and we want to add the masses of the two, the high precision on the mass of the nut is worthless compared to the low precision on the mass of the bolt!

Let the bolt be 8 grams (8000milligrams, 1 sig. fig.) and the nut be 675milligrams (3 sig. fig.) that is equivalent to 0.675 grams. The total may not be written as 8.675grams! We need to first round the 0.675milligrams to the nearest grams that is 1gram and then do the addition. The result is 9 grams (9000 milligrams). The good precision of the nut is lost in the bad precision of the bolt. We end up with 1 sig. fig. only!

If the precisions are the same, we just add them and sometimes, we may end up with a greater number of sig. figs. than the number of sig. figs. each individual number has. For example, if the bolt and the nut were both measured with the better precision device and the measurements were 7795milligrams for the bolt and 675milligrams for the nut, then the total would be 8470. milligrams. Here each number is good to the precision of one milligram, and therefore, the sum must also be good to the precision of one milligram and writing the number as just 8470 (3 sig. figs.) is wrong. We should either place a tiny bar on the ending zero, or write it in scientific notation as 8.470×10^3 milligrams. Recall that the last zeros of a decimal number count as significant.

Exercise 3: Do the following operations and write the results with the correct number of significant figures:

1) 75m x 4m =

2) 75cm x 4.0cm =

3) 0.750 ft x 4.000 ft =

4) 7500 in. x 0.004 in.=

5) 125m / 25s =

6) 80ft / 16s =

7) 33,333mi / 3h =

8) 3750km / 2.50s =

9) (25m - 16m) / 0.0003s =

Answers: $3 \times 10^2 m^2$ (1 sig. fig.), $3.0 \times 10^2 m^2$ (2 sig. fig.), $3.00 ft^2$ (3 sig. figs.),

3.0×10^1 in^2 (2 sig. fig.), 5.0 m/s (2 sig. fig.), 5 ft/s (1 sig. fig.)

10,000 mi/h (1 sig. fig.), 1.50×10^3 km/s (3 sig. figs.), 30000 m/s (1 sig. fig.)

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