Significant figures

SIGNIFICANT FIGURES are a way to indicate the amount of uncertainty in a measurement.

The significant figures in a measurement are all of the CERTAIN DIGITS plus one and only one UNCERTAIN (or estimated) DIGIT

Example:

From our classroom experiment,

$\underbrace{1.6}\underbrace{2}$ cm

We estimated the last digit, It's uncertain

These digits were obtained in all measurements. They are certain

THIS MEASUREMENT HAS "THREE SIGNIFICANT FIGURES"!

Determining significant figures

When you read a measurement that someone has written using the significant figures convention, you can tell how precisely that measurement was made.

1.473 g ±0.001

This was measured to the nearest +/- 0.001 g
The last digit is always UNCERTAIN (or estimated)

21 m ±1

37.26 kg ±0.01

Some other examples

3.2076 g ±0.0001g

last significant digit

27.3m ±0.1m

last significant digit

A small problem

The number ZERO has several uses. It may be a measured number, but it may also be a mere "placeholder" that wasn't measured at all!

So how do we tell a measured zero from a placeholder? There are a few ways:

1: BEGINNING ZEROS: Beginning zeros are NEVER considered significant.

$\underset{\uparrow}{.}15\text{ g}$

$\underbrace{0}.\boxed{15}\text{ g}$

This zero merely indicates that there is a decimal point coming up!

$\underbrace{0.0}\boxed{15}\text{ m}\quad(1.5\text{ cm})$

These zeros are placeholders. They'll disappear if you change the UNITS of this number!

$\underbrace{0.000}\boxed{63}\text{ mm}$

None of these zeros are considered significant

2: END ZEROS are sometimes considered significant. They are significant if

- there is a WRITTEN decimal point in the number
- there is another written indicator that the zero is significant. Usually this is a line drawn over or under the last zero that is significant!

$\boxed{1.5\underbrace{0}}$ km ± 0.01 km

This zero IS considered significant. There's a written decimal.

$\boxed{15}\underbrace{00}$ m ± 100 m

These zeros ARE NOT considered significant (no written decimal, and no other indication that the zeros are significant)

$\boxed{143\underbrace{\bar{0}}}\underbrace{00}$ g ± 100 g

These zeros are not significant.

This zero IS significant. It's marked.

How many significant figures are there in each of these measurements?

76.070 g ± 0,001 g

5

85000. mm ± 1 mm

5

decimal point

0.001030 kg ± 0,000001 kg

4

156.0002 g ± 0.0001 g

7

0.10 s ± 0.01 s

2

17000000 mg ± 1,000,000 mg

2

$120\bar{0}00$ km ± 100 km

4

1350 ms ± 10 ms

3

Calculations with measurements

When you calculate something using measured numbers, you should try to make sure the ANSWER reflects the quality of the data used to make the calculation.

An ANSWER is only as good as the POOREST measurement that went into finding that answer!

$14.20\underline{6}$	± 0,001
$154.7\underline{2}$	± 0.01
$1.\underline{6}$	± 0.1
$+\ 0.22\underline{2}$	± 0.001
$170.\underline{748}$	

How should we report this answer? How much uncertainty is in this answer?

$\boxed{170.7}$

* If you add an uncertain number to either a certain or an uncertain number, then the result is uncertain!
* If you add certain numbers together, the result is certain!

For addition and subtraction, round FINAL ANSWERS to the same number of decimal places as the measurement with the fewest decimal places. This will give an answer that indicates the proper amount of uncertainty.

For multiplication and division, round FINAL ANSWERS to the same number of SIGNIFICANT FIGURES as the measurement with the fewest SIGNIFICANT FIGURES!

$$\overset{4}{\underline{15.62}} \times \overset{3}{0.0\underline{667}} \times \overset{3}{\underline{35.0}} = 36.4|6489$$

How should we report this answer?

$$\boxed{36.5}$$

$$\overset{3}{\underline{25.4}} \times \overset{2}{0.000\underline{23}} \times \overset{5}{\underline{15.201}} = 0.088|804242$$

How should we report this answer?

$$\boxed{0.089}$$

Round the answer here to TWO significant figures. Since beginning zeros aren't significant, the first significant figure is the first "8"

A few more math with significant figures examples:

$$\overset{5}{15047} \times \overset{2}{11} \times \overset{4}{0.9876} = 163464.5892$$

$$\boxed{160000}$$

1.6×10^5

Placeholder zeroes (or scientific notation) required here since we need to know where the decimal goes!

Don't just chop off the number! ~~16~~

~~160000.0000~~

Don't use TOO MANY placeholders!

Addition:

147.3 ± 0.1

2432 ± 1

0.97 ± 0.01

+ 111.6 ± 0.1

2691.87

$$\boxed{2692}$$

DENSITY CALCULATION

$$\frac{\overset{6}{14.7068}\ \text{g}}{\underset{2}{2.7}\ \text{mL}} = 5.446962963\ \text{g/mL}$$

$$\boxed{5.4\ \text{g/mL}}$$

The only way to improve the precision of this density measurement is to improve the precision of the VOLUME measurement, since it limits the precision of the answer.

(We can actually use a LESS precise balance than the one we're currently using and still have the same quality density measurement!)