Procedures for significant figures and rounding

Introductory comments

Q: Why do we need to worry about significant figures when working with scientific data (measurements and calculations)?

A: We must have some measure of how much confidence can be placed in a specific set of measurements. Scientific data are used to draw conclusions and make predictions. The level of confidence we place in the conclusions drawn and predictions made is influenced by significant figures.

Imagine taking a person's temperature to determine whether they have a fever. You don't need a thermometer that reads accurately to 0.01° F, because it is not important whether the patient has a temperature of 102.6 or 102.64. Either way, you know they have a fever and you may need to examine the patient further to decide if treatment may be appropriate. Similarly, you would not want a thermometer that was so crude that you could not accurately distinguish between a patient with no fever (98.6° F, 37.0° C) and one with a high fever (say 103° F).

Q: In real life, what determines the number of significant figures?

A: The equipment used to make a measurement (thermometer, ruler, balance, *etc.*) determines how many significant figures the resulting data should have. See comments on pp. 4-5 of your Basic Techniques Lab exercise. As we do calculations with these data, the number of significant figures assigned to the data may change depending on the calculation performed.

Q: If I see a number on a test or lab exercise, how do I know how many significant figures it has, and which place is the last (farthest to the right) significant place?

A: Assume all places given in the value are significant (unless a count or defined quantity is involved).

How many significant figures, significant to what place?

For each value you measure, use, etc., you should be able to determine how many significant figures it contains (s.f.) and the place farthest to the right that is significant. The examples shown below cover most of the areas where students have problems.

22.9898	6 s.f., sig. to ten-thousandths place
5.02	3 s.f., sig. to hundredths place. Captive zeros <u>are</u> significant.
10.000	5 s.f., sig. to thousandths place. Trailing zeros to right of decimal <u>are</u> significant.
400	1 s.f.???, sig. to hundreds place. Trailing zeros in this circumstance are usually place holders.
0.007	1 s.f., sig. to thousandths place. Leading zeros are not significant.
6.1×10^4	2 s.f., sig. to thousands place. Scientific notation is the least ambiguous way to represent these values.

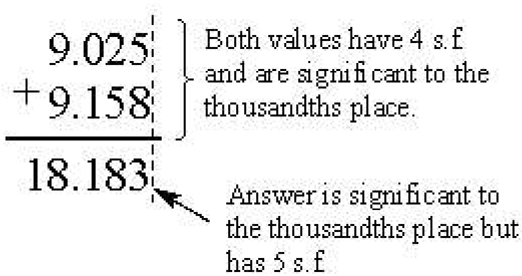
Calculations ↔ significant figures

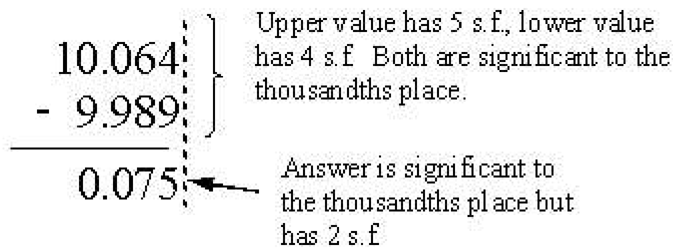
There are two major procedures to follow when keeping track of significant figures during calculations. One procedure is used for addition and subtraction operations use one procedure while a different procedure is used for multiplication and division operations.

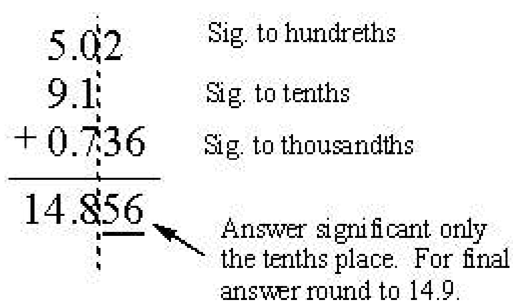
<u>+/− procedure</u>:

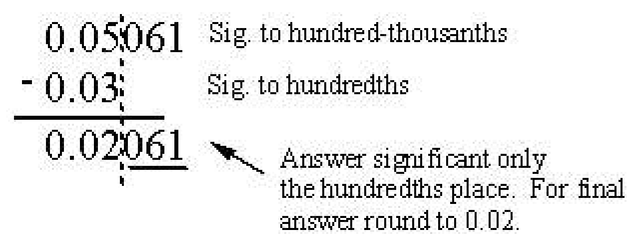
1. Line up the numbers in the calculation according to place (ones, tens, *etc.*)
2. Perform the operation
3. Find the number in the operation with the highest value place (ones, tens, *etc.*) that is not significant.
4. Draw a vertical line to the left of that place.
5. All places in the answer to the left of this line are significant, places to the right are not significant.

Examples:





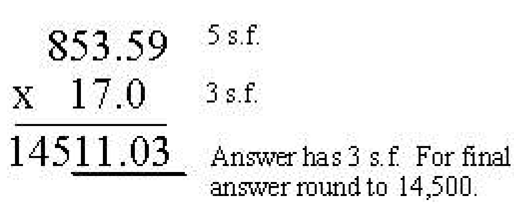


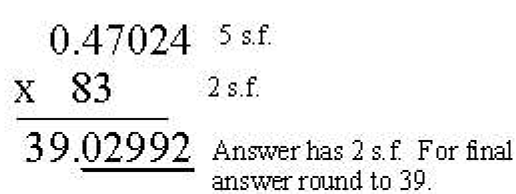


<u>×/÷ procedure</u>:

1. Determine the number of significant figures in each of the values involved in the operation.
2. The properly expressed answer has the same number of significant figures as the operator value with the smallest number of significant figures.

Examples:





Reading between the lines of your calculator

When you perform mathematical computations on your calculator, the result displayed will sometimes not represent appropriate form for the answer. Example: Assume you weighed two objects (weights 9.778 and 9.528 g) on one of the balances in Smith 401 and then wanted to find the weight difference between the objects.

But what is the correct way to express this?

$$\begin{array}{r} 9.778 \\ -\ 9.528 \\ \hline 0.25 \end{array}$$

Calculator expresses this as 0.25, but you should "round" it to 0.250, because of your confidence that the value in the thousandths place is zero.

Remember when you have generated a rounded answer in a problem to use pre-rounded numbers when performing additional calculation with that value.