

Section 1 - Significant Figures

1. Before beginning any mathematical or scientific work it is critical that the idea and understanding of significant figures is properly addressed. Any numbers obtained from a measurement are referred to as significant figures. It is assumed, unless otherwise stated, that the rightmost digit reported is estimated. In other words, it is considered to be uncertain. Nearly every science book on the market refers to the concept of significant figures. It is necessary to stress the basics because all calculations in this workbook series will closely follow the significant figure rules.

Determining Significant Figures

First, the correct way to identify the number of significant figures in a value.

A. All digits, in a number, that are not a zero are automatically significant.

** 67 liters has two significant figures while 293 meters has three significant figures. In both cases, the last significant figure reported is in the "ones" position. The last reported significant figure is always considered estimated. Therefore, in this specific example, both numbers may vary by ± 1 . 67 liters could vary from 66 liters to 68 liters, while 293 meters could vary from 292 meters to 294 meters.

B. Zeros that appear between nonzero digits are considered significant.

** 1203 grams has four significant figures while 10,304 miles has five significant figures. Once again, in both cases, the last significant figure reported is in the "ones" position. Therefore, 1203 grams could vary from 1202 grams to 1204 grams, while 10,304 miles could vary from 10,303 miles to 10,305.

C. Zeros that appear to the right of a nonzero digit but to the left of an understood decimal point are considered to be nonsignificant.

** 1200 kilometers has two significant figures while 12,010 kilograms has four significant figures. The last significant figure reported for 1200 kilometers is in the "hundreds" position (± 100), while the last significant figure reported for 12,010 kilograms is in the "tens" position (± 10). Therefore, 1200 kilometers could vary from 1100 kilometers to 1300 kilometers, while 12,010 kilograms could vary from 12,000 kilograms to 12,020 kilograms.

D. Zeros appearing to the right of a nonzero digit and to the right of the decimal point are considered to be significant.

** 433.00 inches has five significant figures while 809.600 °C has six significant figures. The last significant figure reported for 433.00 inches is in the "hundredths" position (± 0.01), while the last significant figure reported for 809.600 °C is in the "thousandths" position (± 0.001). Therefore, 433.00 inches could vary from 432.99 inches to 433.01 inches, while 809.600 °C could vary from 809.599 °C to 809.601 °C.

E. Any zeros appearing to the right of a decimal point but not to the right of a nonzero digit are not significant.

** 0.003 yards has one significant figure while 0.0563 PSI has three significant figures. The last significant figure reported for 0.003 yards is in the "thousandths" position (± 0.001) while the last significant figure reported for 0.0563 PSI is in the "ten thousandths" position (± 0.0001). Therefore, 0.003 yards could vary from 0.002 yards to 0.004 yards while 0.0563 PSI could vary from 0.00562 PSI to 0.0564 PSI.

- F. Number that involves an exact count is considered to be a pure number and, therefore, have an infinite number of significant figures.**

** 5 students has an infinite number of significant figures, while 12 cars also has an infinite number of significant figures. These numbers are not estimated but, instead, represent an exact count. For example, if there are five students in class no one will argue that they see six. Furthermore, if there are twelve cars in a parking lot no one will argue that they see 12.35 cars. Therefore, these pure (counting) numbers cannot vary at all from their original value. Five students means 5.000000000.... students. Twelve cars represents 12.000000.... cars.

- G. All digits used before the power of ten, in scientific notation, are considered to be significant.**

** 4.670×10^5 meters has four significant figures while $1.03 \times 10^{-3} \mu\text{m}$ has three significant figures. The last significant figure reported for 4.670×10^5 meters is in the "thousands" position (± 1000) while the last significant figure reported for $1.03 \times 10^{-3} \mu\text{m}$ is in the "hundred thousandths" position (± 0.00001). Therefore, 4.670×10^5 meters could vary from 466,000 meters to 468,000 meters while $1.03 \times 10^{-3} \mu\text{m}$ could vary from 0.00102 μm to 0.00104 μm .

Significant Figures and Calculations

2. Almost always, the numbers measured are used to calculate other values, and people/students must be extremely careful in reporting the proper number of significant figures in the intended result.

Generally, there are two basic significant figure rules to follow when working running calculations.

- A. When multiplying or dividing significant figures the answer cannot exceed the minimum number of significant figures used in the calculation.

$$** \frac{3 \text{ feet} \times 12 \text{ inches}}{1 \text{ foot}} = 40 \text{ inches}$$

** It does not equal 36 inches because one significant figure (3 feet) is multiplied incorrectly by two significant figures (12 inches). According to our rule, round the answer to only one significant figure. Therefore, 36 inches becomes 40 inches.

- B. When adding or subtracting significant figures, the answer cannot exceed the least precise position reported.

$$\begin{array}{r} ** 123.50 \text{ meters} \\ - 22.4 \text{ meters} \\ \hline 101.1 \text{ meters} \end{array}$$

** It does not equal 101.10 meters because the subtracted number was precise to the tenths position (22.4 meters) from a number that was precise to the hundredths position (123.50 meters). According to the rule, we will have to limit the answer has to be limited to the least precise reported position.

- C. When using conversion factors in significant figure calculations, do not allow their digits to affect the significant figures of the final answer.

$$** \frac{1408 \text{ meters}}{1609 \text{ meters}} \times \frac{1 \text{ mile}}{1 \text{ mile}} \times \frac{5280 \text{ feet}}{1 \text{ mile}} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 55,440 \text{ inches}$$

** It does not equal 60,000 inches. It is assumed, when using conversion factors, that the conversions are perfectly equal to each other. In other words, 1 mile = 1609 meters is a simplified form of 1.00000... miles = 1609.00000... m. Therefore, to save space, conversion factors are written with only one "supposed" significant figure. The bottom line, in this example, is one measured value – the rest of the numbers are conversion factors. Therefore, the measured value will be the limiting factor in deciding the number of significant figures to report. 1408 meters has four significant figures. Following the above rule in A, the answer will have four significant figures.