Uncertainty in Measurement

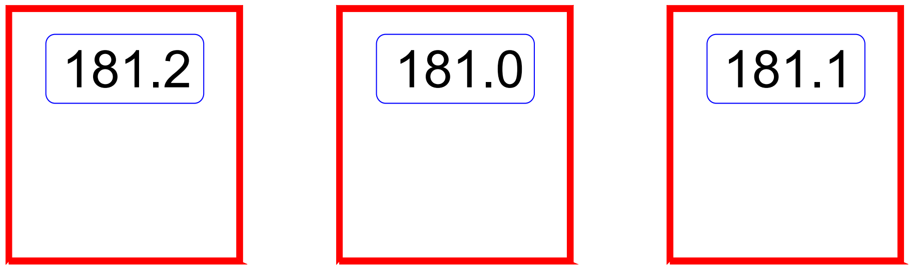
L *Measured* quantities are always inexact.

Accuracy Agreement between the measured value and the true value.

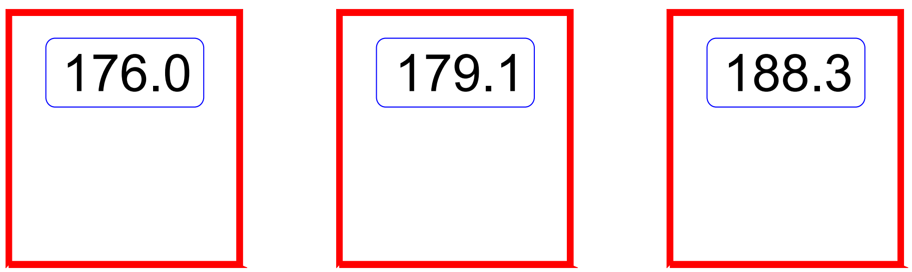
Precision Repeatability of a measured value.

Examples of Precision and Accuracy

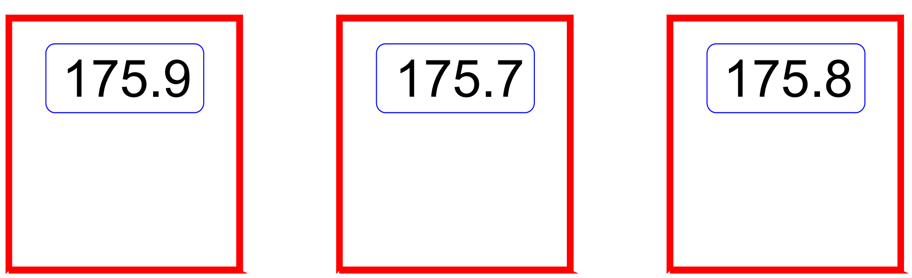
"True Weight" = 181 lbs.



Good Precision - Good Accuracy



Poor Precision - Good Accuracy



Good Precision - Poor Accuracy

Rules for Determining Significant Figures

1. For decimal numbers with absolute value >1, all digits are significant.

	2.620	4 sig. figs.
	50.003	5 sig. figs.

2. If there is no decimal point, zeroes that set magnitude only are not significant.

	103,000	3 sig. figs.
But,	103,000.	6 sig. figs.

3. For decimal numbers with absolute value <1, start counting significant figures at the first non-zero digit to the right of the decimal point.

	0.0012	2 sig. figs.
	0.0070	2 sig. figs.
But,	2.0070	5 sig. figs.

4. In multiplication and division, the answer may have no more significant figures than the number in the chain with the fewest significant figures.

$\frac{(9.97)(6.5)}{4.321}$ ' 15 2 sig. figs.

5. When adding or subtracting, the answer has the same number of *decimal places* as the number with the fewest *decimal places*. The number of significant figures for the result, then, is determined by the usual rules *after establishing the appropriate number of decimal places*.

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  3.0031      4 decimal places; 5 sig. figs.
+7.41         2 decimal places; 3 sig. figs.
10.4131 = 10.41
              2 decimal places; 4 sig. figs.
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6. *Exact numbers*, which are inherently integers or are set by definition, are not limited in their significant digits.

Some exact numbers:

(a) All integer fractions: $\frac{1}{2}$, $\frac{1}{3}$, $\frac{7}{8}$

(b) Counted numbers: "15 people"

(c) Conversions *within* a unit system:

12 inches / 1 foot

Relationships between units in *different* unit systems are *usually* not exact:

2.2 lb. = 1.0 kg	2 sig. figs.
2.2046223 lb. = 1.0000000 kg	8 sig. figs.

But, the following inter-system conversion factors are now set by definition and are **exact**:

2.54 cm / 1 inch (exactly)

1 calorie / 4.184 Joules (exactly)

Standard Scientific Exponential Notation

Standard scientific exponential notation consists of a coefficient whose magnitude is greater than 1 and less than 10 multiplied by the appropriate power of ten. All digits in the coefficient are significant.

1.03×10^5	3 sig. figs.
1.030×10^5	4 sig. figs.
1.0300×10^5	5 sig. figs.
1.03000×10^5	6 sig. figs.

L Note that the difference between ordinary exponential notation and *standard scientific* exponential notation is the size restriction on the coefficient, which never has more than one digit to the left of the decimal.

Std. Sci. Exp. Not.:	1.03×10^5
Not Std. Sci. Exp. Not.:	10.3×10^4

When to Use
Standard Scientific Exponential Notation

- Use with very large or very small numbers, which would require many digits to express otherwise.

1.23×10^5	not	123,000
1.23×10^{-5}	not	0.0000123

- Do not use exponential notation for numbers that fall between 10^{-2} and 10^2, unless otherwise impossible to indicate the proper number of significant figures unambiguously.

123.4	not	1.234×10^2
0.1234	not	1.234×10^{-1}

But,

1.20×10^2 not 120 if 3 sig. figs. required

Dimensional Analysis

$$(\text{given quantity \& } \cancel{\text{given units}}) \times \frac{\text{wanted units}}{\cancel{\text{given units}}}$$

$$= (\text{wanted quantity in wanted units})$$

- Dimensional analysis uses the units to help solve the problem.

- The ratio wanted units/given units is one of two possible conversion factors that can be written from a statement of equality between different units.

  Given: 12 inches = 1 foot

  Conversion factors: $\left(\frac{12\ \text{inches}}{1\ \text{foot}}\right)$ $\left(\frac{1\ \text{foot}}{12\ \text{inches}}\right)$

- The conversion factor to use is the one that gives the needed unit cancellation, leaving the wanted units.