PHYSICS PHOR PHUN
PASO ROBLES, CA

MEASUREMENT

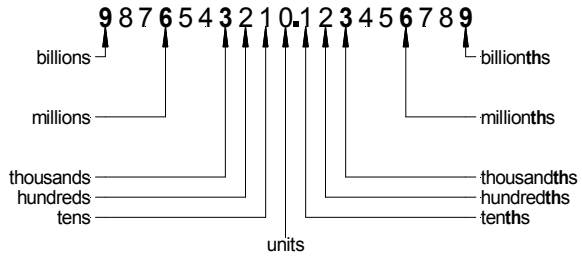
PHACTS

MATH AND SCIENCE TUTORING
805-610-1725

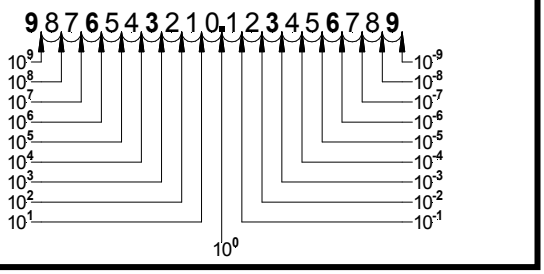
Scientific Notation

In science we study things that are very big like stars and galaxies, things that are very small like molecules and atoms, and things that are in between like elephants and ants. Using words like "big" and "small" is called a "qualitative" comparison. To compare things "quantitatively" we use numbers.

Decimal Places



Powers of Ten



To write a number in scientific notation…

1. Count the number of places from the decimal point to the space just right of the first non-zero digit from the left.
2. Write the number with the decimal point in the space just counted so it is a number from ±1 to 10 (excluding 10).
3. Multiply by 10^E, where E is the number counted in step 1:
   - E is positive if the decimal moved left,
   - E is negative if the decimal moved right.
4. To undo, move decimal E spaces right if +E, left if –E.

Examples

$186{,}000 = 1.86 \times 10^5$

$1.234 = 1.234 \times 10^0$

$0.00000126 = 1.26 \times 10^{-6}$

Arithmetic

Adding/subtracting only matters if the E's are close:

$$1.86\times10^5 + 1.26\times10^{-6} = 186000.00000126 \approx 1.86\times10^5$$

Multiplying/dividing uses the properties of exponents:

$$(1.86\times10^5)\times(1.26\times10^{-6}) = (1.86\times1.26)\times(10^{5+(-6)})$$

Units, Dimensions, and Measuring

- A measurement consists of a *number* and a *unit*.
- A unit relates a *dimension* to a *standard*.
- Accuracy relates how close a measurement is to the *actual* value; it is determined by *calibration*.
- Precision relates how *exact* a measurement is; it is determined by *significant figures.*

SI base units	dimensions
seconds (s)	time
meters (m)	distance
kilograms (kg)	mass
mole (mol)	number
kelvin (K)	energy
ampere (A)	elect. current
candela (cd)	luminosity

- Only like units can be added or subtracted.
- When units are multiplied or divided they are *converted* to other units.
- Analog measurements have one uncertain digit estimated between *graduations*.
- Digital displays show the exact number of significant figures.

Significant Figures

What is "significant"?

1. All non-zero digits are significant.
2. Zeros between non-zero digits are significant:
   - 402.08 has **5** significant figures.
3. Trailing zeros right of the decimal are significant:
   - 0.32000 has **5** significant figures.
4. Leading zeros are *not* significant:
   - 0.00047 has **2** significant figures.
5. Trailing zeros with no decimal are *ambiguous*:
   - 4200 doesn't show significant figures; 4200. has **4**.
6. If a logarithm is taken, digits left of the decimal are *not* significant.
7. Exact and counted numbers are *infinitely* significant.
8. In scientific notation *all* digits are significant.

Arithmetic

1. For addition & subtraction, the number with the fewest significant figures *right* of the decimal determines the number of decimal places in the answer; *round* your answer properly.

$$\begin{array}{r} 12.354 \\ +\ 67.8 \\ \hline 80.2 \end{array}$$

2. For multiplication & division, including powers & roots, the number with the fewest significant figures determines the number of significant figures in the answer; *round* your answer properly.

$$\begin{array}{r} 12.354 \\ \times\ 67.8 \\ \hline 838. \end{array}$$

3. For logarithms the answer has as many decimal places as the argument has significant figures.