# SIGNIFICANT FIGURES AND CALCULATIONS

All measurements involve uncertainty. Since it is very important that the uncertainty in the final result is known, rules have been developed for counting the significant figures in each number and determining the correct number of significant figures in the final result of calculations.

SIGNIFICANT FIGURES IN ANY MEASURMENT INCLUDE:

1. All the digits known in the measurement with certainty.
2. Plus one digit that is estimated (uncertain)

RULES FOR COUNTING SIGNIFICANT FIGURES IN MEASURMENT GIVEN:

1. Nonzero integers ALWAYS count as significant figures.
2. Zeros. There are three classes of zeros.
   a. Leading zeros are zeros that come before all the nonzero digits.
      These are NOT significant figures.
      Examples:

   b. Captive zeros are zeros between nonzero digits.
      These ARE significant figures.
      Examples:

   c. Trailing zeros are zeros to the right of the nonzero digits.
      They are significant ONLY if the number contains a decimal point.
      Examples:

3. Exact numbers comes in two classes, too.
   a. Numbers determined by counting are exact. (Assume infinite sig fig)
      Examples:

   b. Numbers arising from definitions (i.e. conversion factors) are exact.
      Examples:

We ***Love*** SCIENTIFIC NOTATION because

1. The number of significant figures is easily notated
2. Fewer zeros must be written for very large and very small numbers

## RULES FOR SIGNIFICANT FIGURES IN MATHMATICAL OPERATIONS

1. Multiplication/Division
   The number of significant figures in the result(product) is the same as the nember of digits in the factor with the least number of digits (least precise).
   Examples:

2. Addition/Subtraction
   The number of significant figures in the result is the same number of decimal places as the least precise measurement used in the calculation.
   Example:

## RULES FOR ROUNDING

1. In the actual calculation, carry the extra digits throughout the final result, THEN ROUND!!!

2. If the digit to be removed
   a. Is less than 5, the preceding digit stays the same.
      Examples:

   b. Is equal to or greater than 5, the preceding digit is increased by 1.
      Examples:

# SIGNIFICANT FIGURES
# or
# SIGNIFICANT DIGITS

## Does the measurement have a decimal?

| NO | YES |
|---|---|
| 1. Find the first non-zero. | 1. Find the first non-zero. |
| 2. Find the last non-zero. | 2. Count **THAT NUMBER** and all others **AFTER IT**. |
| 3.Count the **FIRST** and **LAST** number and all others **BETWEEN** | |

## Calculations

| MULTIPLICATION/DIVISION | ADDITION/SUBTRACTION |
|---|---|
| 1. Identify the number of **SIGNIFICANT FIGURES.** | 1. Identify the **LEAST PRECISE MEASUREMENT**. |
| 2. Calculate | 2. Calculate |
| 3. **ROUND** the answer using **SIGNIFICANT FIGURES.** | 3. **ROUND** the answer to match the **LEAST PRECISE MEASUREMENT.** |

# Why The Rule for Significant Digits Gives the Correct Answer

Take a look at the calculation of the density of a liquid, and use the example to see why this rule about significant digits exists. In this example, we're showing the actual ±uncertainty we can expect. This uncertainty tells us how large, or how small our actual measured data might be. Here's the data:

| | **Measured Result** | **Could be as high as** | **Could be as low as** |
|---|---|---|---|
| Mass of liquid | 68.24 ±0.01 g | 68.25 g | 68.23 g |
| Volume of liquid | 90.2 ±0.2 mL | 90.4 mL | 90.0 mL |

Since density = mass/volume, we can use this data to calculate the biggest (divide the largest possible mass by the smallest possible volume) and smallest (divide the smallest possible mass by the largest possible volume) densities we could have.

| | **Mass (g)** | **Volume (mL)** | **Density (g/mL)** |
|---|---|---|---|
| Largest density | 68.25 | 90.0 | 0.7583333333333 |
| Smallest density | 68.23 | 90.4 | 0.7547566371681 |

We've highlighted in red the digit at which the two answers are different. Notice that it is at the third significant digit. If the numbers are different at the third significant digit, then obviously all the other answers to right of them are totally meaningless. The rule we have works: **always round off the answer to the shortest number of significant digits** – in this case the three digits in the volume. So you should calculate the density measured here as (68.24 g)/(90.2 mL) = 0.7565410199557 and then report it rounded off to 0.757 g/mL at the third significant digit.