Comprehensive Guide to Significant Figures

I. Core Definition

- **Reliability & Precision:** Significant figures (or significant digits) are specific digits in a number that carry **reliability and necessity** in conveying a quantity
- **Composition:** They consist of all digits in a measurement that are **known accurately (reliable)**, plus the **first digit that is uncertain**
- **Purpose:** They prevent conveying a **misleading level of precision** that exceeds what a measuring instrument can actually resolve

II. Identification Rules

1. **Non-Zero Integers:** All non-zero digits are always significant (e.g., 412,945 has 6 sig figs)
2. **Trapped Zeros:** Zeros located **between non-zero digits** are always significant (e.g., 1.02 has 3 sig figs)
3. **Leading Zeros:** Zeros to the **left of the first non-zero digit** are never significant; they serve only as placeholders to indicate the decimal position (e.g., 0.012 has 2 sig figs)
4. **Trailing Zeros (With Decimal):** Zeros to the **right of the last non-zero digit** in a number containing a decimal point are significant (e.g., 0.120 has 3 sig figs)
5. **Trailing Zeros (No Decimal):** Zeros at the end of an integer without a decimal point are **ambiguous** and generally not significant unless denoted by a decimal point or scientific notation (e.g., 1,000 might have 1, but 1,000. has 4)
6. **Exact Numbers:** Numbers known with complete certainty (e.g., counting 35 people or defined constants like 60 seconds in a minute) have an **infinite number of significant figures**

III. Arithmetic Operations

- **Multiplication and Division:** The result must be rounded to the **same number of significant figures** as the measurement with the **fewest significant figures**
- **Addition and Subtraction:** The result must be rounded to the **same number of decimal places** (the leftmost decimal place position) as the measurement with the fewest decimal places
- **Logarithms:** Only the digits in the **mantissa** (numbers to the right of the decimal point) should match the number of significant figures in the original value

- **Intermediate Steps:** In complex calculations, you should **retain at least one extra digit** during intermediate steps to avoid cumulative rounding errors, rounding only the final result

IV. Standard Rounding Rules

- **Less than 5:** If the digit following the last significant figure is < 5, the preceding digit remains unchanged
- **Greater than 5:** If the digit is > 5, increase the preceding digit by one
- **Exactly 5:**
  - **Scientific Practice ("Round half to even"):** If the digit is exactly 5, round to the **nearest even number** to avoid statistical bias (e.g., 1.25 rounds to 1.2; 1.35 rounds to 1.4)
  - **Alternative Lab Rules:** Some lab-specific policies require **rounding up** whenever the digit is exactly 5

Analogy : Think of significant figures as the **"honest digits"** of a story. If someone tells you they walked "about 100 miles," only the '1' is the honest part of the distance; the zeros are just filling space to show how big the number is. But if they say they walked "100.0 miles," every zero is an **"honest digit"** proving they measured the distance down to the very last fraction of a mile.