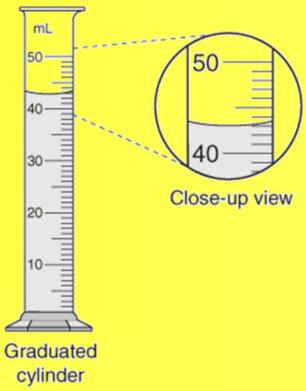
Topic 11: Measurement and Data Processing



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Scientific Measurements

- There are two types of measurements:
  - qualitative (do not involve numbers);
  - quantitative (numerical).
- Quantitative Data
  - exact numbers (values known exactly, such as things that are counted);
  - inexact numbers (measurements containing a degree of uncertainty) - all measurements are inexact.

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Temperature

There are three temperature scales:

- Kelvin Scale
  - Used in science.
  - Same temperature increment as Celsius scale.
  - Lowest temperature possible (absolute zero) is zero Kelvin.
  - Absolute zero: 0 K = -273.15 ºC.
- Celsius Scale
  - Also used in science.
  - Water freezes at 0 ºC and boils at 100 ºC.
  - To convert: K = ºC + 273.15.

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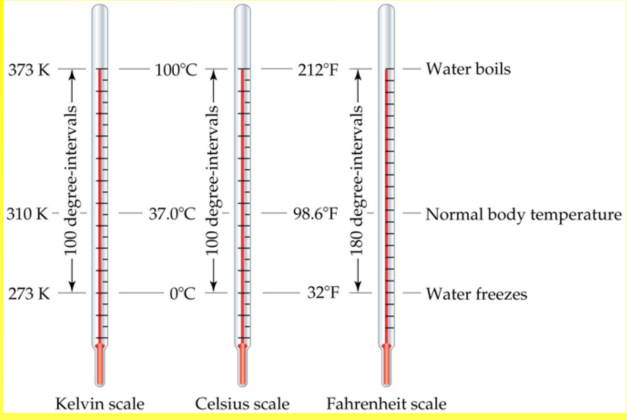
Temperature



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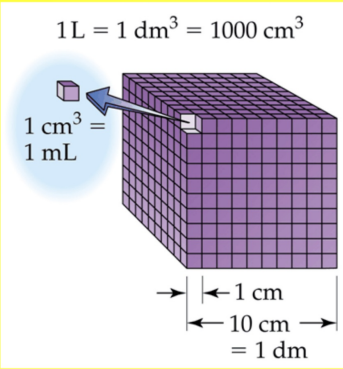
Volume

- The units for volume are given by (units of length)^3.
  - SI unit for volume is 1 m^3.
- We usually use 1 mL = 1 cm^3.
- Other volume units:
  - 1 L = 1 dm^3 = 1000 cm^3 = 1000 mL.



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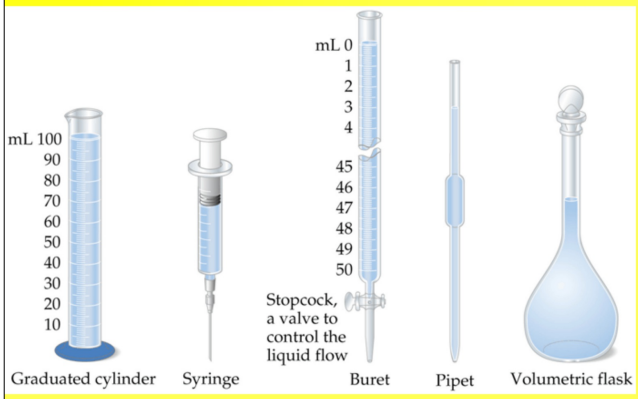
Volume



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Uncertainty in Measurement

- All scientific measures are subject to error.
- These errors are reflected in the number of figures reported for the measurement.
- These errors are also reflected in the observation that two successive measures of the same quantity are different.

Precision and Accuracy (11.1.2)

- Measurements that are close to the "correct" value are *accurate*.
- Measurements that are close to each other are *precise*.

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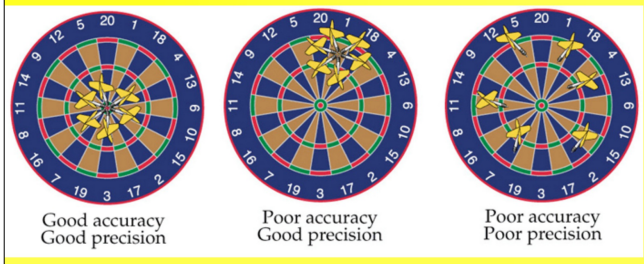
Precision and Accuracy



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Types of Uncertainty (11.1.1)

* **Systematic** errors – Inaccuracy results from problems with apparatus or improper technique. (examples – improperly calibrated instrument or misreading meniscus in graduated cylinder). Usually result in readings that are precise but not accurate. Usually corrected by improving experimental design

* **Random** errors/uncertainties – Equally likely to be too high or too low. Can be reduced by taking repeated measurements. (examples – variations in glassware due to temperature fluctuation or judgment of when an indicator changes color) (11.1.3)

Recording Measurements with Random Uncertainty (11.1.4)

All measurements have uncertainty (limits of measuring devices), and this uncertainty should be reflected in the measurement by including a ± term:

35.07 g ± 0.01 g

85.3 mL ± 0.1 mL

Uncertainty is generally accepted to be 1 unit in the last significant digit.

Percentage Uncertainties (11.2.1)

Uncertainty can also be expressed as a percentage:

10.53 g ± 0.05 g or

10.53 g ± 0.47%

Some measuring devices provide tolerance in absolute terms, while others provide tolerance in percentages.

Significant Figures

- The number of digits reported in a measurement reflect the accuracy of the measurement and the precision of the measuring device.
- All the figures known with certainty plus one extra figure (estimated digit) are called significant figures.
- In any calculation, the results are reported to the fewest significant figures (for multiplication and division) or fewest decimal places (addition and subtraction).

Significant Figures

- Non-zero numbers are always significant.
- Zeros between non-zero numbers are always significant.
- Zeros before the first non-zero digit are not significant. (Example: 0.0003 has one significant figure.)
- Zeros at the end of the number after a decimal point are significant.
- Zeros at the end of a number before a decimal point are ambiguous (e.g. 10,300 g).

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Look for a Decimal Point

Pacific

Present

Atlantic

Absent

Moving from the proper side, skip all zeros until you get to the first non-zero digit. All remaining digits, including zeros, are significant.

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Examples: How many significant figures are in each of the following?

1. 52300 m
2. 0.000487 kg
3. 29.0400 s
4. 507 people
5. 230,050 cm
6. 45.600 A

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Examples: How many significant figures are in each of the following?

1. 52300 m 3
2. 0.000487 kg 3
3. 29.0400 s 6
4. 507 people exact
5. 230,050 cm 5
6. 45.600 A 5

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