2.5 Temperature

- The Celsius scale
  - 0ºC → freezing point of water
  - 100ºC → boiling point of water
- The Fahrenheit scale
  - 0ºF → freezing point of salt/water mixture
  - 100ºF → body temperature
  - water freezes at 32ºF and boils at 212ºF

⇒100 Celsius degrees ↔ 180 Fahrenheit degrees

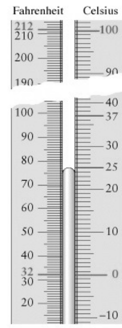


Fig. 2.5

$$\left(\frac{180°\text{F}}{100°\text{C}}\right)=\left(\frac{9°\text{F}}{5°\text{C}}\right)$$

$$T°\text{F}=\left(\frac{9°\text{F}}{5°\text{C}}\right)T°\text{C}+32°\text{F}$$

$$T°\text{C}=\left(\frac{5°\text{C}}{9°\text{F}}\right)\left(T°\text{F}-32°\text{F}\right)$$

- The Kelvin scale - absolute temperature scale
  - 0 K → lowest possible temperature
  - 0 K = -273.15°C
  - same size of the graduation as Celsius

⇒water freezes at 273.15 K and boils at 373.15 K

- ***T* K = *T*°C + 273.15**
- ***T*°C = *T* K - 273.15**

Example:

- Convert -40°F in °C and K.
- ***T*°C = (5°C/9°F)×[-40°F - 32°F] = = (5/9)×(-72)°C = -40°C**
- ***T* K = -40°C + 273.15 = 233 K**

2.6 Uncertainty of Measurements

- Represents the reliability of measurements
- Reported as: **number ± uncertainty** (4.88 ± 0.05 kg)
- If not reported: assume **±1 in the last reported digit** (3.7 cm → 3.7 ± 0.1 cm)
- Exact numbers - no uncertainty (5 tables, 10 apples, 1 min = 60 s, 1 in = 2.54 cm)

- Significant figures - digits of a number known with some degree of certainty
  - all non-zero digits
  - all zeros after the first non-zero digit
  - exception - trailing zeros in numbers without decimal point are not significant

Examples:

1.32 → 3 sf
0.005030 → 4 sf
4500 → 2 sf
4500. → 4 sf

- Scientific notation - representation in the form $\rightarrow$ $A \times 10^a$
  - A - decimal number between 1 and 10
  - **a** - positive or negative integer
- **Examples:**

  $0.00134 = 1.34 \times 10^{-3}$

  $134 = 1.34 \times 10^{2}$

  - all digits in A are significant

Table 2.4 *Examples of significant figures*

Decimal notation	Scientific notation	Number of sf
0.751	7.51×10^{-1}	3
0.007 51	7.51×10^{-3}	3
0.070 51	7.051×10^{-2}	4
0.750 100	$7.501\,00 \times 10^{-1}$	6
7.5010	7.5010	5
7501	7.501×10^{2}	4
7500	7.5×10^{3}	2*
7500.	7.500×10^{3}	4

*In this text, treat trailing zeros as insignificant unless they are followed by a decimal point or other information is given. sf, significant figure.

- Significant figures in calculations
  - rounding off (only at the end of a calculation)
    - round up, if next digit is **above 5**
    - round down, if next digit is **below 5**
    - round to the nearest even number, if next digit is **equal to 5** and it is the last digit in the number (if 5 is not the last digit, round up)

Examples: Round to 3 sf.

3.7643 $\rightarrow$ 3.76

3.7683 $\rightarrow$ 3.77

3.7653 $\rightarrow$ 3.77

3.765 $\rightarrow$ 3.76

- Addition and subtraction
  - the number of decimal places in the result is the same as the smallest number of decimal places in the data

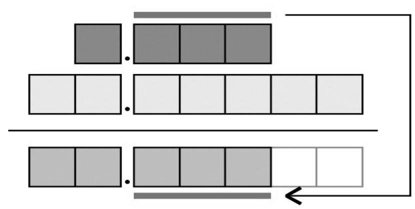


Fig. 2.9

- Multiplication and division
  - the number of significant figures in the result is the same as the smallest number of significant figures in the data

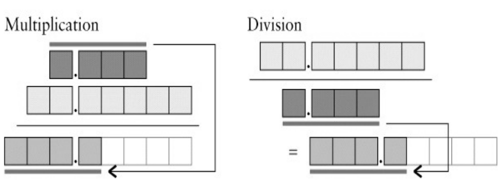


Fig. 2.10

Examples:

$0.0354 + 12.1 = 12.1 \leftarrow (12.1354)$

$5.7 \times 0.0651 = 0.37 \leftarrow (0.37107)$

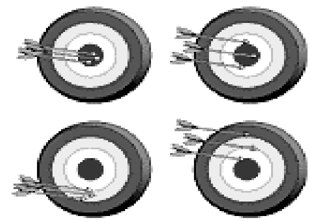
$5.7/0.0651 = 88 \leftarrow (87.55760369)$

$3.568\ \text{in} \times (2.54\ \text{cm}/1\ \text{in}) = 9.063\ \text{cm}$

2.7 Accuracy and Precision

- Precision - agreement among repeated measurements
  - random error - deviation from the average in a series of repeated measurements
  - small random error ↔ high precision
  - high precision ↔ more sf in the result

- Accuracy - agreement of a measurement with the true or accepted value
  - systematic error - deviation of the average from the true value (present in the whole set of measurements)
  - small systematic error ↔ high accuracy



Example:

- A car is moving at exactly **60 mi/hr**. Compare the precision and accuracy of the following two series of speed measurements using two different radars.

  A → 61.5, 58.3, 62.7, 63.5, 57.1 (average 60.6)

  B → 62.0, 62.5, 61.8, 62.2, 62.1 (average 62.1)

A → more accurate, less precise

B → less accurate, more precise