Chapter 1

Introduction to Engineering Calculations

Principles of Chemical Processes I

Course Learning Outcomes

At the end of this course students will be able to

- Convert one set of units in a function or equation into another equivalent set

2.1 Units and Dimensions

- **Dimension** - property that can be measured such as
  - ✓ length
  - ✓ time
  - ✓ mass
  - ✓ temperature
  - ✓ multiplying or dividing other dimensions
- **Unit** - measured and counted quantity has
  - ✓ value (2.35)
  - ✓ unit (2.35 gram)
- It is essential to write the *value* and *unit* in equation
  - ✓ 2 meters, 0.3 second, 4.5 kilograms, 5 gold rings

Properties of Units

- Units can be treated like algebraic variables
  - ✓ added and subtracted when having same units

    3 cm - 1 cm = 2 cm (3x - x = 2x)

    but

    3 cm - 1 mm (or 1 s) = ? (3x - y = ?)
  - ✓ can always be combined by multiplication or divisions

    3 N x 4 m= 12 N.m

    $$\frac{5.0\ \text{km}}{2.0\ \text{h}} = 2.5\ \text{km/h}$$

    $$\frac{6\ \text{cm}}{2\ \text{cm}} = 3$$ (3 is a dimensionless quantity)

2.2 Conversion of Units

- When having appropriate dimensions, measured quantity can be expressed in term of other units

ft/s → miles/hr → cm/yr

- The equivalence between two expressions is given by ratio known as conversion factor

$$\frac{1\,\text{cm}}{10\,\text{mm}}$$ (1 centimeter per 10 millimeters)

$$\frac{10\,\text{mm}}{1\,\text{cm}}$$ (10 millimeters per 1 centimeter)

Conversion Factors

- A given quantity is expressed into new unit by using a conversion factor *(new unit/old unit)*

$$(36\text{ mg}) \times \frac{1\text{ g}}{1000\text{ mg}} = 0.036\text{ g}$$

- Alternative way to write this equation

36 mg	1g
	1000 mg

= **0.036 g**

Method for using Conversion Factor

- Set up a dimensional equation
  - write the given quantity and its unit on the left
  - write the units of conversion factors (new unit/old unit)
  - fill in the values of the conversion factors
  - carry out the indicated arithmetic operations to find the desired values

- *Example* : Convert acceleration of 1 cm/s^2 to km/y^2

Conversion factor and units

- Problems:

1) Change 400 in^3/day to cm^3/min

2) If a plane travels at twice the speed of sound (assume the speed of sound is 1100 ft/s), how fast is it going in miles per hour?

2.3 Systems of Units

- ***Base Units*** **- units for dimensions of mass, length, time, temperature, electrical current, and light intensity**
  - ✓ kilogram, meter, kelvin, ampere, candela
- ***Multiple units*** **- multiples or fraction of base unit**
  - ✓ minutes, hours, milliseconds or all in term of base unit second
- ***Derived units*** **- obtained in one of two ways**
  - ✓ Multiplying and dividing base units (cm^2, ft/min, $kg.m/s^2$) which are known as *compound units*
  - ✓ Defined as equivalents of *compound units* (1 erg = 1 $g.cm/s^2$, 1 lb_f = 32.174 $lb_m.ft/s^2$)

Systems Of Units

System Internationale d'Unites

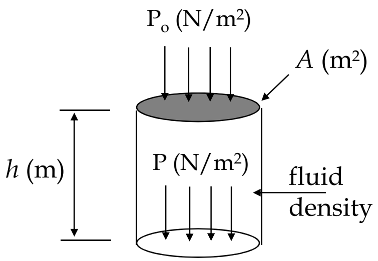
Length	meter (SI) centimeter(CGS)
Mass	kilogram (SI) gram (CGS)
Moles	gram-mole (mol)
Time	second (s)
Temperature	kelvin (K)
Electric current	ampere (A)
Light intensity	candela (cd)

American engineering system

Length	foot (ft)
Mass	pound mass(lb_m)
Moles	lb_m-mole(lb_mmol)
Time	second (s)
Temperature	Rankin (°R)
Electric current	ampere (A)
Light intensity	candela (cd)

Pressure

- *Pressure is the ratio of a force to the area*
  - ✓ Units N/m^2, $dynes/cm^2$, and lb_f/in^2
  - ✓ the *SI* pressure unit is N/m^2 or called *pascal* (Pa)



Temperature

- **Two most common temperature scales are defined using the freezing point (T_f) and boiling point (T_b) of water at 1 atm**
  - ✓ **Celsius (or centigrade) scale**
    - T_f is assigned 0°C and T_b is 100°C
    - Absolute zero on this scale falls at -273.15°C
  - ✓ **Fahrenheit scale**
    - T_f is assigned 32°F and T_b is 212°F
    - Absolute zero on this scale falls at -459.67°F
  - ✓ **The Kelvin and Rankin scale are defined at absolute value of Celsius and Fahrenheit**

$$T(K) = T(°C) + 273.15$$
$$T(°R) = T(°F) + 459.67$$
$$T(°R) = 1.8\ T(K)$$
$$T(°F) = 1.8T\ (°C) + 32$$

Degree (^{o}) Definition As Temperature Interval

Degree as Temperature Interval

- Consider the temperature interval between 0°C and 5°C
- There are 9°F and Rankin degree in this interval
- An interval of 1°C or Kelvin contains 1.8°F or Rankin degree

Conversion factor for the interval

$$\frac{1.8\ ^{\circ}F}{1\ ^{\circ}C}, \frac{1.8\ ^{\circ}R}{1\ K}, \frac{1\ ^{\circ}F}{1\ ^{\circ}R}, \frac{1\ ^{\circ}C}{1\ K}$$

Example

Find the number Celsius degrees between 32°F and 212°F

$$\Delta T(^{\circ}C) = \frac{(212-32)^{\circ}F}{} \bigg| \frac{1^{\circ}C}{1.8^{\circ}F} = 100^{\circ}C$$

To find the Celsius temperature corresponding to 32°F *you cannot use this formula*

$$T(^{\circ}C) = \frac{32^{\circ}F}{} \bigg| \frac{1^{\circ}C}{1.8^{\circ}F}$$

Temp reading (32°F) — Temp interval (1°C / 1.8°F)