Principles of unit conversion

- Dimensional equation: Equation containing **numerical value** and **its unit**

- For example; 10 BTU/(h ft °F) = 56.78 W/m °C is an dimensional equation.

- Whatever the mathmatical procedure is applied to the numerical value in dimensional equation, the same procedure is applied to the units in dimensional equation.

During unit conversion

- Prepare an equation
- In the equation, the followings should occur:
  - Conversion factor
  - the unit of final answer
  - the unit being converted
  - conversion units
- Calculate the conversion factor from the equation

Steps in conversiton of units

- Place the units of the final answer on the left-hand side of the equation and the unit being converted on the right hand side of equation.
- Do **not** add the numerical value of the unit being converted to the equation.
- Then, put an equal sign between two expression.

- Conversion units are found from conversion tables for the units to be converted in the right hand side of equation.
- Set up the conversion units as a ratio, using Appendix Table 1.
- Sequantially multiply the conversion factors such that the original units are systematically eliminated by cancellation replacement with the desired unit.

- After cancellation of units in the right hand side of equation, appropriate conversion factor is calculated.

- The numerical value in front of the unit converted is now taken into consideration. This numerical value is put on both side of equation.

Example 1: Covert thermal conductivity in English Engineering System (10 BTU/(h ft °F)) to **SI unit** system.

Result:

CF = 1.73

10 BTU/(h ft °F) = 17.3 J/(m s K)

Example 2: Specific heat of orange juice concentrate with 45% water soluble solid content is c_p = 0.64 BTU/lb_m °F. Express this value in **SI unit** system.

Result:

CF = 4186.5

0.64 BTU/ lb_m °F = 2679.4 J/kg K

Example 3: Heat transfer coefficient of salami at 21°C is h_s = 210 BTU/ft^2 h °F. Express this value in **SI unit** system.

Result:

CF = 5.6780

210 BTU/ h ft^2 °F = 1192.4 J/m^2 s K

Example 4: The density of cow milk is 64.5 lb_m/ft^3. Express this value in **SI unit** system.

Result:

CF = 16.02

64.5 lb_m/ft^3 = 1033.3 kg/m^3

Example 6: For a fluid passing through a pipe, type of flow (laminar, turbulant) depends on the pressure (ρV^2) and viscosity forces ($\mu V/D$) of fluid. And, the ratio of these values gives Reynold number (RN). RN is used to determine the type of flow. If RN is:

- below 2300, the flow is laminar,
- above 4000, the flow is turbulant,
- In between 2300-4000, the flow is transition (mixed).

$$Re = \frac{\rho V^2}{\mu V/D} = \frac{\rho V D}{\mu}$$

where;

D : diameter of the pipe in which the liquid flows, m,

V : velocity, m/s,

ρ : density, kg/m^3,

μ : viscosity, kg/m s.

In a milk processing plant, the type of flow of milk is found to be turbulant (Re=50000). The velocity (V) of milk flowing in a diameter (D) of 1 in. of a pipe is 13.5 ft/s and the density (ρ) at 294 K is 64.3 lb_m/ft^3. Wall thickness of the pipe is 0.1 in. Determine the viscosity (μ) of milk at 294 K in:

- SI unit system,
- cgs unit system.

- **Example 7 :** A tube is filled with a fruit juice with the height of h cm and density of ρ. The pressure exerted to the base of the tube by this fruit juice is P atmosphere. Calculate the density of fluid in the SI system.

Answer: $1 \times 10^6 \text{ kg/m}^3$

- **Example 8:** In a milk processing plant, once the milk is brought to the plant, first, the milk is placed in a pre-storage tank and then centrifuged to remove somatic cells, leucosits, blood coagulates and some microorganisms (clarification process). During this clarification process, the milk is pumped to the centrifuge which is 5 m higher than the storage tank at a velocity of 120 kg/min. During transportation, the friction loss in pipes is 45 J/kg and calculate the necessary power of pump is “SI” unit system.

Answer: 188.1 W

- **Example 9:** The heat loss through the walls of an electrical oven is 6500 BTU/h. If the oven is operated for 2 h, how many kilowatt-hours of electricity will be used just to maintain the oven temperature (heat input = heat loss)?

Answer: 3.8 kW h

- **Example 10:** The height of a pomegranate juice with a density of 1.068 g/cm^3 in a tube is 8.325 in. Calculate the pressure applied by pomegranate juice in the SI system.

Answer: 2215.1 kg/(m s^2) (Pa)

Lenght units
in English engineering sytem

- 1 in = 2.54 cm
- 1 foot = 12 in
- 3 feet = 1 yard
- 3.28 feet = 1 m

Volume units

in English engineering sytem

- 1 gal = 3.79 L
- 1 gal = 4 quarts
- 1 quart = 2 pints
- 1 pint = 16 fluid ounce (fl oz)
- 1 quart = 32 fluid ounce

- **Example 11:** Calculate your height in “feet” and “in.” (173 cm)

Answer: 5’8’’

- **Example:** Calculate the area of rectangular with the measurement of 2' 5''$^{1/16}$ and 5' 9''$^{3/32}$ in SI unit system.

Answer: 2.1 m^2

- **Example 12:** Calculate the volume of a car tank with the capacity of 40 L in “gallons” and “pints.”

- **Example 15:** Express the viscosity values given below as the unit asked.

Viscosity is the resistance of fluids to movement.

Viscosity = Pressure x time

Viscosity is expressed as:

cgs $\rightarrow \dfrac{g}{cm\ s}$ = poise

SI $\rightarrow \dfrac{kg}{m\ s}$

EES $\rightarrow \dfrac{lb_m}{ft\ s}$

a) Express 20 cp in “Pa s.”

b) Express 15 cp in “EES.”

c) Express “30 $lb_m/(ft\ h)$” in “SI” unit system.

Answers

a) 20 cp = 0.02 Pa s

b) 15 cp = 0.01 $lb_m/(ft\ s)$

c) 30 $lb_m/(ft\ h)$ = 0.0124 kg/(m s)

- **Example 16:** Pressure is expressed in the SI system in Pascals. Calculate the English equivalent of 8 Pa.

  ($lb_f = 4.44823\ N$)

Answer:

$$8\ \text{Pa} = 0.00116\ \frac{\text{lb}_\text{f}}{\text{in}^2}$$

- **Example 17:** Calculate the power in (SI system) required for peach nectar which flows down the raceway of a reservoir at a rate of 525 lb_m/min from a height of 12.3 ft.

Answer: 146 W