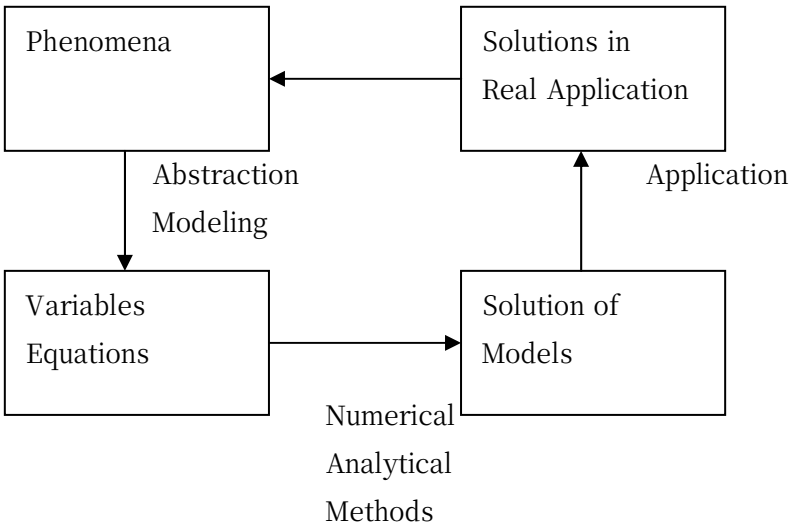
Chapter 2. Introduction to Engineering Calculation

● General Approach to Scientific / Engineering Problems



- We have to deal with variables and equations (mathematical models).

Example of applications in chemical engineering

- Biotechnology
- Consulting
- Drugs and pharmaceuticals
- Fats and oils
- Fertilizers, agricultural
- Food, beverage
- Lime and cements
- Man -made fibers, synthetic resins and plastics
- Pesticide and herbicide
- Even politics , …

2.1 Units and Dimensions

Dimensions : Basic concept of measurements
Units : Means of expressing dimensions

Ex)

Dimensions	Units
Length	m cm km ft
Time	hr s min

- Each measured quantities have values and units

ex) L = 1 m (value + unit)

* Manipulation of quantities
  - You can add, subtract or equate quantities only if the units are the same
  - You can multiply or divide unlike units.

2.2 Conversion of Units

→ follow the examples

ex 2.2 -1) conversion $1\ cm/s^2$ → km / yr^2

$1\ cm$	$3600^2\ s^2$	$242\ hr^2$	$365^2\ day^2$	$1\ m$	$1\ km$
$1\ s^2$	$1\ hr^2$	$1\ day^2$	$1\ yr^2$	$100\ cm$	$1000\ m$

$= 9.95 \times 10^{9}\ km / yr^{2}$

2.3 System of Units (단위 체계)

Base Units : units for mass, mole, length, time, temperature, electrical current, light intensity (7 dimensions)

Derived Units

- By multiplication and division of base or derived units
  → m/s , m^3, m^3/kg 등
- By definition
  → $1\ erg = g\ cm\ /s^2$, $1\ lbf = 32.174\ lb_m\ ft\ /\ s^2$

SI Systems (Systeme Internationale d'Unites, 1960)
CGS Systems
Metric Systems
American engineering systems, English systems, British systems

Table.1 System of Units

	Dimension	SI	Metric	English
Base Units	Mass	kg	kg	lb_m
	Mole	kg -mol	kg -mol	lb -mol
	Length	m	m	ft
	Time	s	s	s
	Temperature	K	^oC	^oF
	Electrical Current	A	A	A
	Light Intensity	cd	cd	cd
Derived Units	Volume	m^3	m^3	ft^3
	Force	N	kg_f	lb_f
	Presure	Pa	kg/cm^2	psi
	Energy, Work	J	kcal	Btu
	Power	W	kcal/s	hp

CGS system → cm, g, erg, dyne → not used today

Three Important sources for unit conversion

1. "Perry's Chemical Engineer's Handbook"
2. NIST publication
3. Web site: thermo.korea.ac.kr →KDB → General DB → Units

2.4 Force and Weight

Newton's second law

$$F = m a / g_c = m g / g_c$$

If g varies, F also varies…

Definition of force units

1 N = 1 $kg.m/s^2$

1 dyne = 1 $g.cm/s^2$

1 lbf = 32.174 $lb_m.ft / s^2$

Conversion factors

g_c = 1 (kg.m /s^2) / N = 1 (g.cm/s^2) / dyne = 32.174 (lb_m.ft/s^2)/lb_f

Weight : force exerted by gravitational force

W = m g / g_c

G = 9.8066 m / s^2 = 980.66 cm / s^2 = 32.174 ft / s^2

Example 2.4 –1) $\rho = 62.4 lb_m / ft^3$, $g = 32.139\, ft/s^2$

Weight of water 2 ft^3 ?

$$M = \rho V = (62.4 lb_m / ft^3) \times (2\, ft^3) = 124.8 lb_m$$

$$W = m\frac{g}{g_c} = 124.8 lb_m \times (32.139\, ft/s^2) \times (\frac{lb_f}{32.174 lb_m\, ft/s^2}) = 124.7 lb_f$$

2.5 Dimensional Homogeneity and Dimensionless quantities

Dimensional Homogeneity

- Every equation must be dimensionally homogeneous

Ex) V = V_0 + g t

V : m/s

V0 : m/s

g : m/s^2

t : s

→ Dimensionally homogeneous

V = V_0 + g → Not valid

Dimensionless quantities

Ex) M/M0 (ratio of molecular weight), $N_{RE} = \frac{DV\rho}{\mu}$

2.6 Arithmetic Calculation

Scientific notation of numbers

123 000 000 → 1.23×10^8 or 1.230×10^8

Significant digits -> indicate the precision of measured quantities

Number	Significant Digits	Range
2.3×10^3	2	2.25×10^3 to 2.35×10^3
2.30×10^3	3	2.295×10^3 to 2.305×10^3
2.300×10^3	4	2.2995×10^3 to 2.3005×10^3

Manipulation of numbers

×÷ → Use lowest number of significant figures
+− → Use digits farthest to the left
-5 → even – drop / odd – add 1

2.7 Process data representation and analysis

Process variables
– directly or indirectly measured quantities
– unknown quantities

Example of indirect measurement
Concentration vs. thermal conductivity
- Relation between Conc. And Thermal conductivity → Calibration experiment
- (보정실험)

Interpolation and Extrapolation (내삽과 외삽)