

The Thinking Person's Guide to Dimensional Analysis

- 1) Write down all variables:
 - a. Geometry
 - b. Fluid (density, viscosity, etc)
 - c. Flow "in" (velocity, pressure, etc)
 - d. Flow "out" (drag, lift, measurements)
- 2) Write down units of each variable in terms of Length, Time, Mass & Temperature (or if you prefer, Length, Time, *Force* and Temperature)
 - a. $[V] = L$.
 - b. $[m] = M$
 - c. $[p] = \frac{M}{LT^2}$
 - d. Etc.
- 3) How many non-dimensional Pi groups are there?
- 4) Form Pi groups
 - a. Geometric ratios (e.g. aspect ratio = Diameter/Length, etc)
 - b. Force Ratios - Think about physics – what is the right force to scale with – inertial, viscous, surface tension...
 - c. Velocity ratios (e.g. Mach number = velocity / sound-speed)
 - d. Time-scale ratios. – Think about physics – inertial time vs viscous time
 - e. Etc
- 5) When in doubt, to find the last few groups use *Formal Dimensional Analysis*.
- 6) The end result is: $\Pi_1 = F(\Pi_2, \Pi_3, \dots)$, etc.

Useful scales:

- 1) Forces: (per unit area, or pressure, or stress) $\left[\frac{M}{LT^2} \right]$

- a. Inertial: ρV^2
- b. Viscous: $\frac{\mu V}{d}$
- c. Surface Tension: $\frac{\sigma}{d}$
- d. Gravity: ρgH

- 2) Timescales:

- a. Inertial: $\frac{d}{V}$
- b. Viscous: $\frac{\rho d^2}{\mu}$
- c. Gravitational: $\sqrt{\frac{d}{g}}$