

Chapter 1

DIMENSIONAL ANALYSIS AND SCALING

Most problems are first formulated in physical units (such as meters, kilograms, seconds etc. in case of the 'metric system' else maybe in 'imperial units' or even in mixed units, say nautical miles for distances). In some cases, metric units can be used throughout. However, there are often strong reasons to 'non-dimensionalize' a problem - change dependent and independent variables in such a way that the equations - even the numbers measuring the variables - become entirely independent of the choice of measuring units. The primary reasons for this are:

1. The form of the equations becomes often much simpler,
2. The process will often reveal that many apparently independent free parameters can be combined into much fewer ones. To fully explore the full parameter space for all possible solutions, it may prove sufficient to vary only one or two parameters instead of many more, and
3. A further procedure called *scaling* allows equations to be brought to forms well suited for subsequent *perturbation analysis* - a very powerful collection of analytical techniques to find approximate solutions to problems impossible to solve analytically and difficult and/or expensive to solve numerically.

Following several earlier works (e.g. Lin and Segel, 1974, Holmes, 1995), we start by describing a projectile problem which is well suited to illustrate the techniques in both this chapter and in the beginning of the next one (on perturbation methods).