GFT

CHAPTER TWO

A Discussion of Dimensional Analysis

Several equations derived/created in the Gyroscopic Force Theory rely upon the application of dimensional analysis. Before delving into the Gyroscopic Force Theory it is essential that this technique first be discussed. The GFT fully acknowledges that dimensional analysis is not a fully rigorous technique and may give the reader some pause. It is, none the less, a very valuable mathematical tool. Every student of science, at some time during his or her academic life has had an instructor exhort them to "keep track of your units!" Though dimensional analysis is a much more rich and complex subject than this would seem to indicate it this bookkeeping of units that has, essentially, been employed as the foundation for several of the GFT derivations. The creation of these derivations involves the simple algebraic manipulation of units.

The essential concept embodied by dimensional analysis is that *the solution to an equation is invariant to changes in measurement units*. This concept is one of the most powerful, and yet regrettably, unappreciated concepts in all of science. Dimensional analysis is the ideal tool for the mathematical unification of any expressions of potential energy. The application of dimensional analysis, in this case, involves unifying seemingly disparate physical quantities by mathematically tracing a common set of units shared between them. Initially, algebraic equations comprised of the requisite units are created. To these units physical quantities are arbitrarily assigned. This arbitrary assignment is primarily intuitive and its use facilitates the tracking of unit sets from one equation to the next. There are no firm rules as to these assignments, only that the units defined by the physical quantities on the left side of the equation equal those on the right. (There is actually a much more systematic, logical, rigorous approach that can be employed but for our purposes this simplified approach will suffice) A general equation is then created consisting of these common units, thus unifying these physical quantities. For example, the common expression of units signifying a force is $\frac{Kgm}{s^2}$**. To these units a variety of physical quantities can be arbitrarily assigned, e.g.** $F = ma$ **or** $F = m\frac{dv}{dt}$ **or**

$F = \frac{[d(mv)]}{dt}$ **or** $F = \left(\frac{dm}{dt}\right)c$ **.**

Through dimensional analysis, by algebraically manipulating the units, these four equations of force are created, all of which are algebraically equivalent. However, it can only be stated with some certainty that the first three equations are physically true for they have been confirmed both mathematically and

experimentally. As for the last equation, where $F = \left(\frac{dm}{dt}\right)c$ it can only be said that it is algebraically sound by virtue of its left side units being equal to those on the right. It is all that can be said. This form of dimensional analysis does not, indeed, cannot speak to the physical verisimilitude of these equations. Such truth can only be confirmed through experiment. Conversely, the very power of the dimensional argument lies not in its ability to provide a rigorous mathematical proof of fundamental physical principles. Indeed, such an application would be erroneous and misses the point. ***The value of dimensional analysis lies in its ability, independent of a prevailing physical theory, to provide various expressions by which nature might choose to manifest her principles mathematically. It is ideal for demonstrating mathematical relationships between any given set of physical quantities, particularly between any two expressions of potential energy*****. Bridgman states [15]: "Identity of dimensional formulas must not be thought, therefore to indicate an** ***a priori*** **probability of any sort of physical relation. When there are so many kinds of different physical quantities expressed in terms of a few fundamental units, there cannot help being all sorts of accidental relations between them, and without further examination we cannot say whether a dimensional relation is real or accidental.**

The converse of the theorem attempted above does hold, however. If there is a true physical connection between certain quantities, then there is also a dimensional relation. This result may be used to advantage as a tool of exploration."