22.1: Mass, Length and Time

Any mechanical quantity can be expressed in terms of three fundamental quantities, *mass*, *length* and *time.* For example, speed is a length divided by time. Force is mass times acceleration, and is therefore a mass times a distance divided by the square of a time.

We therefore say that [Force] = MLT^{-2}. The square brackets mean: "The dimensions of the quantity within". The equations indicate how force depends on mass, length and time. We use the symbols MLT (not in *italics*) to indicate the fundamental dimensions of mass, length and time. In the above equation, MLT^{-2} are *not* enclosed within square brackets; it would make no sense to do so.

We distinguish between the *dimensions* of a physical quantity and the units in which it is expressed. In the case of MKS units (which are a subset of SI units), the units of mass, length and time are the kg, the m and the s. Thus we could say that the *units* in which force is expressed are kg m s^{-2}, while its dimensions are MLT^{-2}.

For electromagnetic quantities we need a fourth fundamental quantity. We could choose, for example, quantity of electricity Q, in which case the dimensions of current are QT^{-1}. We do not deal further with the dimensions of electromagnetic quantities here. Further details are to be found in my notes on Electricity and Magnetism, http://orca.phys.uvic.ca/~tatum/elmag.html

To determine the dimensions of a physical quantity, the easiest way is usually to look at the definition of that quantity. Most readers will have no difficulty in understanding that, since work is force times distance, the dimensions of work (and hence also of energy) are ML^2T^{-2} . A more challenging one would be to find [dynamic viscosity]. One would have to refer to its definition (see Chapter 20) as tangential force per unit area per unit transverse velocity gradient.

Thus [dynamic viscosity] = $\left[\frac{\text{force}}{\text{area}}\frac{\text{distance}}{\text{velocity}}\right] = \frac{\text{MLT}^{-2}}{\text{L}^{-2}}\frac{\text{L}}{\text{LT}^{-1}} = \text{MLT}^{-1}\text{L}^{-1}$.