3.1: Introduction to Systems of Particles

By systems of particles I mean such things as a swarm of bees, a star cluster, a cloud of gas, an atom, a brick. A brick is indeed composed of a system of particles – atoms - which are constrained so that there is very little motion (apart from small amplitude vibrations) of the particles relative to each other. In a system of particles, there may be very little or no interaction between the particles (as in a loose association of stars separated from each other by large distances) or there may be (as in the brick) strong forces between the particles. Most (perhaps all) of the results to be derived in this chapter for a system of particles apply equally to an apparently solid body such as a brick. Even if scientists are wrong and a brick is not composed of atoms but is a genuine continuous solid, we can in our imagination suppose the brick to be made up of an infinite number of infinitesimal mass and volume elements, and the same results will apply.

What sort of properties shall we be discussing? Perhaps the simplest one is this: *The total linear momentum of a system of particles is equal to the total mass times the velocity of the center of mass.* This is true, and it may be "obvious" - but it still requires proof. It may be equally "obvious" to some that "the total kinetic energy of a system of particles is equal to $\frac{1}{2}M\overline{v}^2$ where M is the total mass and $\overline{v}$ is the velocity of the center of mass" - but this one, however "obvious", is not true!

Before we get round to properties of systems of particles, I want to clarify what I mean by the *moment* of a vector such as a force or a momentum. You are already familiar, from Chapters 1 and 2, with the moments of *mass*, which is a scalar quantity.