Up until now, we have analyzed the motion of objects that we treated as so-called point masses, where literally all of the mass of the object was treated as lying at a single point.

This is obviously an unrealistic idealization.

Real objects have spatial extent and come in various sizes and shapes, some regular and some highly irregular.

The mass distribution within these extended objects might be smooth and uniform or highly non-uniform and lumpy.

Moreover, sometimes, we will be interested in simultaneously analyzing a large system of particles or objects.

To deal properly with such situations, it is necessary to introduce a new physical quantity called the momentum, which is a vector that we traditionally denote with the symbol P. For a single point mass, the momentum is the product of the mass and the velocity vector.

The form of Newton's second law that we have used so far, F equals ma, is actually only true for the special case of a point mass.

The more general form of the Newton's Second Law is that F equals dp/dt, that is that the force is equal to the time derivative of the momentum vector.

This is applicable to either a single particle or to a system of particles.

This more general form provides us the way to address extended objects or multi-particle systems.

We will once again appeal to a calculus-like argument, breaking down an extended distribution into a large number of small elements, treating each element separately, and then summing the results.

As part of this process, we will introduce the concept of the center of mass, a sort of mass weighted average position for an extended object or system.

Momentum is also the first of several special measurable quantities that we will discuss that obey special powerful rules called conservation laws.

The other two quantities are energy and angular momentum.

Conservation laws are principles to provide that the given measurable quantity remains unchanged during the evolution of a system with time as long as certain requirements are met, essentially the requirement that a system remains isolated.

With this restriction in place, the possible evolution of motion of a particle or system of particles is greatly restricted, simplifying its calculation.

We will see how this can be used to our advantage in understanding what will happen.