

## 3.1 INTRODUCTION

Kinematics deals with the basic physical quantities necessary for a description of motion. We use a properly marked three-dimensional Cartesian coordinate system and a clock to define position, displacement, velocity and acceleration of an object in precise mathematical language. The coordinate system is called the **reference frame** or simply the frame. The choice of origin and the directions of axes of the coordinate system are arbitrary. We will see that true vectors such as displacement and velocity are independent of this choice. The choices are made to simplify the mathematical description of the motion.

If we assume that the three-dimensional space we inhabit consist of geometrical points, then each point of space will have unique values for Cartesian coordinates  $(x, y, z)$  in a particular frame. The coordinates of the geometrical points in space can be used to indicate the location of an object if the object occupies only one space point at a time. Fundamental particles are assumed to be point-like in this sense, and we refer to them as **point particles**. However, we would also like to study extended objects such as boxes, people, cars, planets, stars and galaxies, which occupy some volume of space containing infinitely many points of space.

How can we follow the motion of extended, non-point-like, objects? We will demonstrate in a later chapter that there exists a special geometrical point for each object, called the center of mass, whose motion is like that of a point particle. We will find that the motions of various parts of an extended object naturally separate into a motion of its center of mass and another motion, such as rotation or deformation, about the center of mass.

Until we have a demonstration of this separation, you can assume that, whenever we discuss the motion of a large object by assigning one point to it, we are looking at the motion of the center of mass. If an object does not change shape or orientation, then all points on the object would have the same motion as the center of mass. Therefore, for non-rotating rigid bodies, you could choose a convenient point of the object for describing its motion. For instance, for a moving train, the position of the train can be said to be given by the front end or back end of the train as long as the train does not rotate.