a rectangular coordinate system consisting of three mutually perpendicular axes, labelled X-, Y-, and Z- axes. The point of intersection of these three axes is called origin (O) and serves as the **reference point**. The coordinates (x, y. z) of an object describe the position of the object with respect to this coordinate system. To measure time, we position a clock in this system. This coordinate system along with a clock constitutes a **frame of reference**.

If one or more coordinates of an object change with time, we say that the object is in motion. Otherwise, the object is said to be at rest with respect to this frame of reference.

The choice of a set of axes in a frame of reference depends upon the situation. For example, for describing motion in one dimension, we need only one axis. To describe motion in two/three dimensions, we need a set of two/ three axes.

Rest or motion are relative terms

Description of an event depends on the frame of reference chosen for the description. For example, when you say that a car is moving on a road, you are describing the car with respect to a frame of reference attached to you or to the ground. But with respect to a frame of reference attached with a person sitting in the car, the car is at rest.

To describe motion along a straight line, we can choose an axis, say X-axis, so that it coincides with the path of the object. We then measure the position of the object with reference to a conveniently chosen origin, say O, as shown in Fig. 3.1. Positions to the right of O are taken as positive and to the left of O, as negative. Following this convention, the position coordinates of point P and Q in Fig. 3.1 are +360 m and +240 m. Similarly, the position coordinate of point R is –120 m.

Path length

Consider the motion of a car along a straight line. We choose the x-axis such that it coincides with the path of the car's motion and origin of the axis as the point from where the car started moving, i.e. the car was at $x = 0$ at $t = 0$ (Fig. 3.1). Let P, Q and R represent the positions of the car at different instants of time. Consider two cases of motion. In the first case, the car moves from O to P. Then the distance moved by the car is OP = +360 m. **This distance is called the path length traversed by the car.** In the second case, the car moves from O to P and then moves back from P to Q. During this course of motion, the path length traversed is OP + PQ = + 360 m + (+120 m) = + 480 m. Path length is a scalar quantity — a quantity that has a magnitude only and no direction (see Chapter 4).

Displacement

It is useful to define another quantity displacement as the change in position. Let x_1 and x_2 be the positions of an object at time t_1 and t_2. Then its displacement, denoted by Δx, in time $\Delta t = (t_2 - t_1)$, is given by the difference between the final and initial positions :

$$\Delta x = x_2 - x_1$$

(We use the Greek letter delta (Δ) to denote a change in a quantity.)

If $x_2 > x_1$, Δx is positive; and if $x_2 < x_1$, Δx is negative.

Displacement has both magnitude and direction. Such quantities are represented by vectors. You will read about vectors in the next chapter. Presently, we are dealing with motion along a straight line (also called **rectilinear motion**) only. In one-dimensional motion, there are *only two* directions (backward and forward, upward and downward) in which an object can move, and these two directions can easily be specified by + and – signs. For example, displacement of the car in moving from O to P is :

$$\Delta x = x_2 - x_1 = (+360 \text{ m}) - 0 \text{ m} = +360 \text{ m}$$

The displacement has a magnitude of 360 m and is directed in the positive x direction as indicated by the + sign. Similarly, the displacement of the car from P to Q is 240 m – 360 m = – 120 m. The

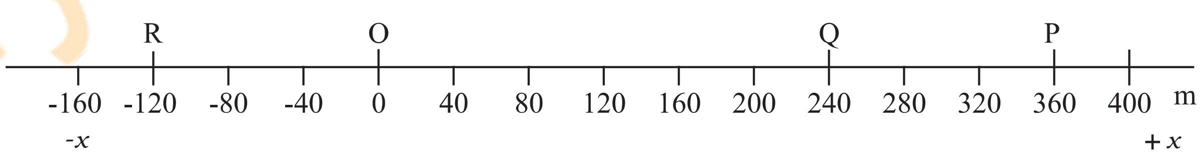

Fig. 3.1 *x-axis, origin and positions of a car at different times.*