2.1 MOTIVATION FOR VECTORS

Imagine trying to follow the motion of a car on a flat planar surface. Suppose the car starts from some place marked O and goes to point A, 300 m to the north, as given in Fig. 2.1. The car then turns right, and goes 400 m in that direction and arrives at point B. The final

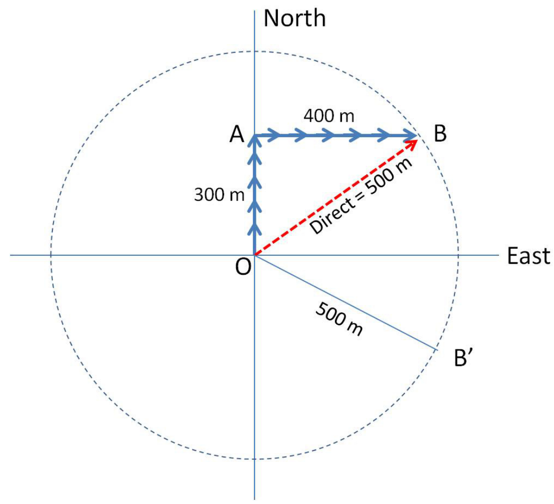

Figure 2.1: The displacement of the car from O to B is give by the direct distance from O to B and the direction from O to B. Note that the direct distance $\overline{OB}$ is not equal to the sum of distances $\overline{OA}$ and $\overline{AB}$.

point B is clearly not 700 m from the starting place O as far as the direct distance $\overline{OB}$ is concerned. Of course, B is 700 m from O on the road $O-A-B$. Using the Pythagoras theorem, we find that the point B is only 500 m away from O. But, if someone said to you that the final place of the car is 500 m away from the starting place, you wouldn't know if the car is at B or at some other place such as B' on the circle of radius 500 m. You know instinctively that you also need a direction in addition to the distance. In a planar motion just one angle with a reference axis is sufficient to nail down the direction. By using elementary trigonometry, we find that B is in the direction of approximately 37° North of East from the starting place O, i.e. $\angle$ *East*-*O*-*B* is approximately 37°.

The direct distance along with the direction of the net movement is called **displacement**. Geometrically, we represent a displacement by an arrow in space whose size represents the direct distance using a definite scale and the direction corresponds to the direction of the net movement. Thus, the displacement of the car shown in Fig. 2.1 is represented by an arrow from O to B and denoted symbolically by drawing an arrow over segment name OB, i.e. by $\overrightarrow{OB}$. This displacement has a magnitude given by the length of the segment

$\overline{OB}$ and a direction given by the direction of the arrow from point O to point B.

Notice that the successive displacements $\overrightarrow{OA}$ and $\overrightarrow{AB}$ make up the entire displacement $\overrightarrow{OB}$. Although the lengths $\overline{OA}$ and $\overline{AB}$ do not add to give the length of $\overline{OB}$, we introduce special rule of addition between quantities like displacement so that the displacements $\overrightarrow{OA}$ and $\overrightarrow{AB}$ do add to give the displacement $\overrightarrow{OB}$. The special rule needed to add the displacements is called the parallelogram law of addition. This law can be described as follows.

- Represent a displacement by an arrow of appropriate size.
- If you put the arrow for the second displacement at the end of the arrow for the first displacement, then the arrow from the start to finish is the sum of the two displacements. This way of adding physical quantities that have both a magnitude and a direction is called the **parallelogram law of addition**.

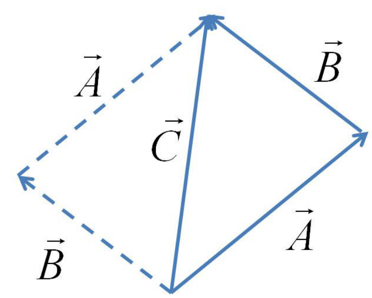

Figure 2.2: The parallelogram law of addition. Here the diagonal $\vec{C} = \vec{A} + \vec{B}$. The other diagonal gives the difference of the two vectors as we will see below.