Introduction

(Image credit: David T. Marx)

The monument shown above is located at a truck stop that is about $39\,\mathrm{miles}$ to the east of Joplin, Missouri. The sign gives information about distances to other cities relative to location of the monument. Those distances assume that one is driving along interstate highways. Distance is a length without a specified direction, which is called a **scalar quantity**. Scalar quantities are just numbers and units that are associated with the number. Another example is the temperature on the December day that this picture was taken, which was $45\,°\mathrm{F}$.

Knowing the distance alone is not enough information to get to the town; we must also know the direction from the monument to the town. The direction, together with the distance, is a **vector quantity** commonly called the **displacement** vector. While the distance from this monument to Tulsa, OK, is given as $150\,\mathrm{miles}$ as you drive on

interstate highways. The displacement from the monument to Tulsa is a straight line distance of 117 miles at a direction of $28.1° \text{ south of west}$

Vectors are essential to physics and engineering. Many fundamental physical quantities are vectors, including displacement, which is the quintessential vector. In introductory physics, vectors are quantities that have geometric representations as arrows in one dimension (along a line), in two dimensions (in a plane), or in three dimensions. They can be added, subtracted, or multiplied. In this chapter, we explore elements of vector algebra for applications for Mechanics and for Electricity and Magnetism, later. Vector operations also have numerous generalizations in other branches of physics.