1. **Definition:** A vector is a quantity that has both magnitude and direction.

   It is useful to think of a vector as an arrow. The length of the arrow represents the magnitude of the quantity, and the arrow gives the direction.

**Physical Examples:**

- An airplane is flying north-east at 500 mph. Its velocity is a vector:
2. **Definition:** A **scalar** is a quantity that has only magnitude. It’s useful to think of scalars as just ordinary numbers.

   **Examples:**
   - 75 degrees Celsius
   - \(-2\)
   - \(C\), where \(C\) is any unknown constant.
   - \(x\), if \(x\) is any variable that you have encountered previously.

3. Know the difference between a scalar, a vector, and a point. Scalars are not hard to identify, since they are ordinary numbers. But vectors and points are subtly and closely related.

   One way to think about this is, “A point is a location. A vector is an arrow that points to that location.”

   **Example:** In the figure at right:
   - \(P\) is the point \((-1, 2)\).
   - The arrow pointing to \(P\) is a **vector**.
4. The fact that a vector points to a point gives rise to more vocabulary, as well as a common notation for vectors.

**Definition:** The **terminal point** of the vector is the point at the end of the arrow. This is also called the head of the vector.

**Definition:** The **initial point** of the vector is the point at the beginning of the arrow. This is also called the tail of the vector.

**Example:** In the example above, if $O$ is the origin, then

- $O$ is the initial point.
- $P$ is the terminal point.
- The vector is denoted $\overrightarrow{OP}$.

**Example:** There is no requirement that the initial point be the origin. In the figure at right,

- The initial point is $Q = (-1, 0)$.
- The terminal point is $R = (1, 1)$.
- The vector is denoted $\overrightarrow{QR}$.

5. **Definition:** Suppose that a vector has initial point at the origin and terminal point $P = (a, b)$. That is, the vector points from the origin to $(a, b)$.

We say that $a$ and $b$ are the **components** of the vector. The **component form** is a notational way of writing the vector that distinguishes it from the point that it points to.

The notation uses angle brackets:

$$\overrightarrow{OP} = \langle a, b \rangle$$

In the example at right,

$$\overrightarrow{OP} = \langle -1, 2 \rangle$$
Note: Component form also applies to vectors that are not based at the origin.

Think of component form as
\[
\langle \text{how far over, how far up} \rangle
\]

For the example at right:
\[
\overrightarrow{QR} = \langle 2, 1 \rangle
\]

6. Definition: When a vector is based at the origin, say \( \overrightarrow{OP} \), then the vector is called the position vector for the point \( P \).

7. Often vectors are written as single letters. In order to distinguish this from a scalar, the letter will be bold face, or it will have an arrow over it, or both.

Examples:

\[
\overrightarrow{v} = \langle 2, 1 \rangle \quad \text{or} \quad \overrightarrow{w} = \overrightarrow{OP}
\]

8. Definition: The magnitude of a vector is the length of the arrow. The notation is the same as absolute value.

Example: In the figure above the magnitude of \( \overrightarrow{QR} \) is
\[
|\overrightarrow{QR}| = \sqrt{1^2 + 2^2} = \sqrt{5}
\]

General Formula:
\[
|\langle a, b \rangle| = \sqrt{a^2 + b^2}
\]

9. Definition: A unit vector is a vector that has magnitude = 1.

Learning Goals:

1. Learn all of the above notation and vocabulary.
2. Distinguish between scalars, points, and vectors.
3. Compute the magnitude of a vector.
4. Compute the component form of a vector using any combination of defining characteristics.
5. Compare direction of vectors. In particular, determine whether or not vectors have the same direction or opposite direction.