

Vectors, Displacement, and Velocity

30 minutes, 3 stages

Understanding the difference between scalar and vector quantities is essential to describing motion accurately. Displacement, velocity, and acceleration are vector quantities that depend on direction, while distance and speed are scalars ([Outcome](#)). This homework builds your ability to define and compare these quantities ([Outcome](#)) so you can solve motion problems with precision.

Stage 1: Scalar and Vector Comparison (8 min)

For each quantity below, write whether it is scalar or vector. Then write a brief definition that includes direction if it is a vector.

1. Speed: a car travels at 60 km/h on the highway.
2. Velocity: a car travels at 60 km/h due north.
3. Distance: you walk 2 km around a park.
4. Displacement: you walk 2 km around a park and end up 1.4 km directly north of where you started.
5. Acceleration: an object speeds up at 5 m/s^2 .
6. Acceleration: an object changes direction at 5 m/s^2 toward the west.

After you finish, check your work: scalar quantities have magnitude only (a number and unit). Vector quantities have both magnitude and direction.

Stage 2: Displacement and Velocity Problems (15 min)

Solve the following problems. Show your work and include units and direction in your answer.

Problem 1: A cyclist travels 8 km north, then 6 km south along the same road. Calculate the total distance travelled and the displacement from the starting point.

Problem 2: A runner completes a 400 m lap on a circular track in 80 seconds. Calculate the average speed and the average velocity. Explain why they are different.

Problem 3: A car travels 120 km north in 2 hours, then 80 km south in 1.5 hours. Calculate the average velocity for the entire trip (magnitude and direction).

Problem 4: Two hikers walk from the same camp. Hiker A walks 5 km east. Hiker B walks 5 km north. After 1 hour, which hiker has greater displacement from the camp? Explain your answer.

Stage 3: Graphical Analysis (7 min)

A velocity-time graph shows an object moving in one dimension. The object starts at 0 m/s, reaches 20 m/s after 4 seconds, and maintains 20 m/s for the next 6 seconds.

1. Sketch this velocity-time graph on paper. Label the axes with time (s) on the horizontal axis and velocity (m/s) on the vertical axis.
2. On your graph, shade the area under the line from $t = 0$ to $t = 10 \text{ s}$.
3. Calculate the area under the curve. This area represents the displacement. What is the displacement of the object?
4. What is the acceleration during the first 4 seconds? (Hint: acceleration is the slope of the velocity-time graph.)

Self-check

Answer these questions to confirm your understanding.

1. A ball is thrown upward and caught at the same height. The distance travelled is greater than the displacement. Explain why, using the definitions of distance and displacement.
2. You drive 50 km east, then 50 km west, returning to your starting point. Your average speed is 80 km/h. Is your average velocity also 80 km/h? Why or why not?
3. On a velocity-time graph, how do you find the acceleration of an object? How do you find its displacement?