How fast is the butterfly moving? What direction is it moving?

To describe motion, you must state the direction the object is moving as well as how fast the object is moving. You must also tell its location at a certain time.

# Choosing a Frame of Reference

**What is needed to describe motion completely?**

A **frame of reference** is a system of objects that are not moving with respect to one another.

**To describe motion accurately and completely, a frame of reference is necessary.**

# Choosing a Frame of Reference

## How Fast Are You Moving?

How fast the passengers on a train are moving depends on the frame of reference chosen to measure their motion.

**Relative motion** is movement in relation to a frame of reference.

- As the train moves past a platform, people standing on the platform will see those on the train speeding by.
- When the people on the train look at one another, they don't seem to be moving at all.

# Choosing a Frame of Reference

To someone riding on a speeding train, others on the train don't seem to be moving.

# Choosing a Frame of Reference

## Which Frame Should You Choose?

- When you sit on a train and look out a window, a treetop may help you see how fast you are moving relative to the ground.
- If you get up and walk toward the rear of the train, looking at a seat or the floor shows how fast you are walking relative to the train.
- Choosing a meaningful frame of reference allows you to describe motion in a clear and relevant manner.

# Measuring Distance

- How are distance and displacement different?
- Distance is the length of the path between two points. Displacement is the direction from the starting point and the length of a straight line from the starting point to the ending point.

# Measuring Distance

**Distance** is the length of a path between two points. When an object moves in a straight line, the distance is the length of the line connecting the object's starting point and its ending point.

- The SI unit for measuring distance is the meter (m).
- For very large distances, it is more common to make measurements in kilometers (km).
- Distances that are smaller than a meter are measured in centimeters (cm).

# Measuring Displacements

To describe an object's position relative to a given point, you need to know how far away and in what direction the object is from that point. Displacement provides this information.

# Measuring Displacements

Think about the motion of a roller coaster car.

- The length of the path along which the car has traveled is distance.
- Displacement is the direction from the starting point to the car and the length of the straight line between them.
- After completing a trip around the track, the car's displacement is zero.

# Combining Displacements

**How do you add displacements?**

A **vector** is a quantity that has magnitude and direction.

**Add displacements using vector addition.**

# Combining Displacements

Displacement is an example of a vector.

- The magnitude can be size, length, or amount.
- Arrows on a graph or map are used to represent vectors. The length of the arrow shows the magnitude of the vector.
- Vector addition is the combining of vector magnitudes and directions.

# Combining Displacements

## Displacement Along a Straight Line

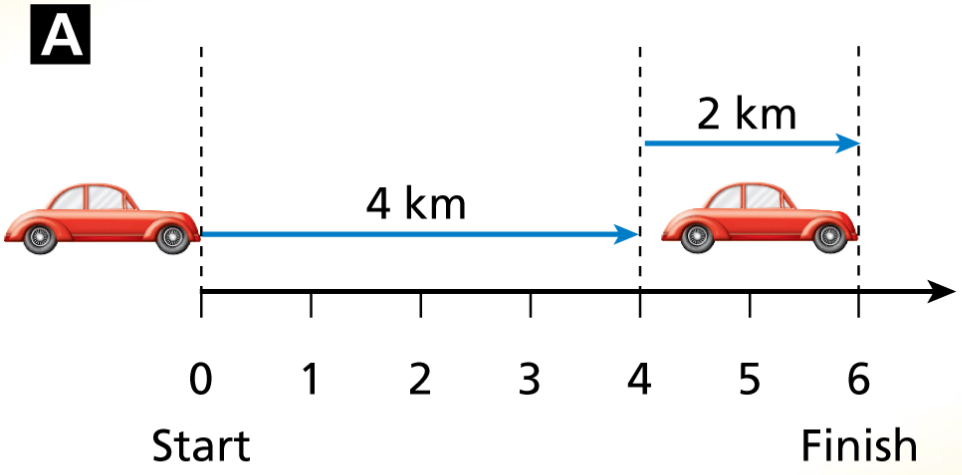
When two displacements, represented by two vectors, have the same direction, you can add their magnitudes.

If two displacements are in opposite directions, the magnitudes subtract from each other.

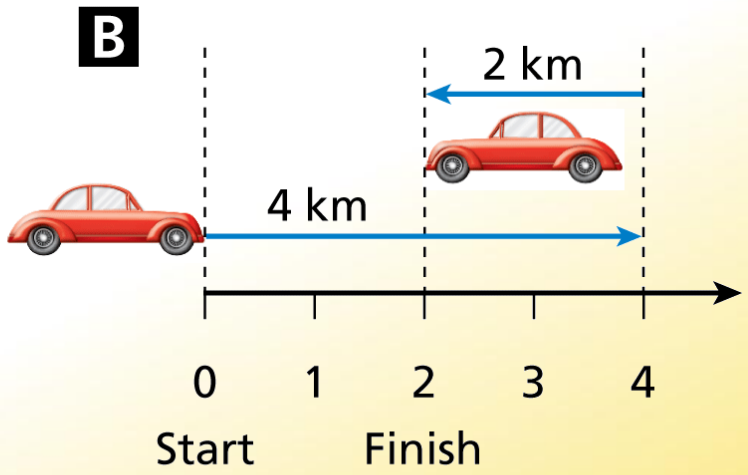
# Combining Displacements

A. Add the magnitudes of two displacement vectors that have the same direction.

B. Two displacement vectors with opposite directions are subtracted from each other.




4 km + 2 km = 6 km




4 km – 2 km = 2 km

# Combining Displacements

## Displacement That Isn't Along a Straight Path

When two or more displacement vectors have different directions, they may be combined by graphing.

# Combining Displacements

Measuring the resultant vector (the diagonal red line) shows that the displacement from the boy's home to his school is two blocks less than the distance he actually traveled.

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# Combining Displacements

The boy walked a total distance of 7 blocks. This is the sum of the magnitudes of each vector along the path.

The vector in red is called the **resultant vector,** which is the vector sum of two or more vectors.

The resultant vector points directly from the starting point to the ending point.

## Assessment Questions

1. A car is driving down the highway. From which frame of reference does it appear to not be moving?
   a. standing at the side of the road
   b. a car driving at the same speed but going the opposite direction
   c. sitting inside the car
   d. an airplane flying overhead

## Assessment Questions

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   a. standing at the side of the road
   b. a car driving at the same speed but going the opposite direction
   c. sitting inside the car
   d. an airplane flying overhead

   ANS: C

## Assessment Questions

2. The SI unit of distance that would be most appropriate for measuring the distance between two cities is the
   a. meter.
   b. centimeter.
   c. kilometer.
   d. mile.

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## Assessment Questions

3. If you walk across town, taking many turns, your displacement is the
   a. total distance that you traveled.
   b. distance and direction of a straight line from your starting point to your ending point.
   c. distance in a straight line from your starting point to your ending point.
   d. direction from your starting point to your ending point.

## Assessment Questions

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   a. total distance that you traveled.
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   c. distance in a straight line from your starting point to your ending point.
   d. direction from your starting point to your ending point.

   ANS: B

## Assessment Questions

4. You travel 30 miles west of your home and then turn around and start going back home. After traveling 10 miles east, what is your displacement from your home?
   a. 20 km
   b. 20 km west
   c. 40 km
   d. 40 km west

## Assessment Questions

4. You travel 30 miles west of your home and then turn around and start going back home. After traveling 10 miles east, what is your displacement from your home?

   a. 20 km
   b. 20 km west
   c. 40 km
   d. 40 km west

   ANS: B