
Methods of Motion

AP Physics B

Displacement

Displacement (x or y) *"Change in position"*

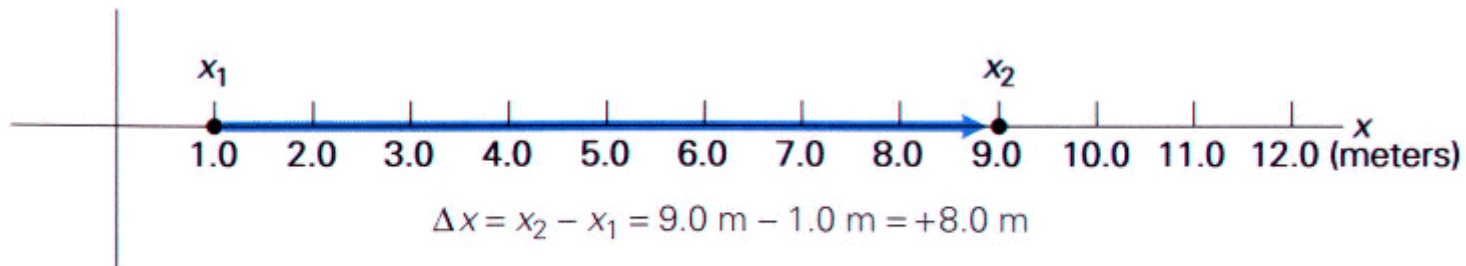
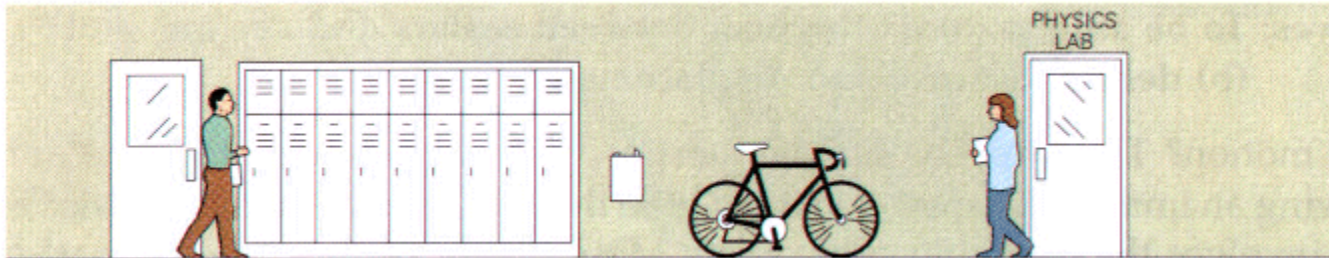
It is not necessarily the total distance traveled. In fact, displacement and distance are entirely different concepts. Displacement is relative to an axis.

- "x" displacement means you are moving horizontally either right or left.
- "y" displacement means you are moving vertically either up or down.
- The word *change* is expressed using the Greek letter **DELTA (Δ)**.
- To find the *change* you ALWAYS subtract your **FINAL - INITIAL** position
- It is therefore expressed as either **$\Delta x = x_f - x_i$ or $\Delta y = y_f - y_i$**

Distance - How far you travel regardless of direction.

Example

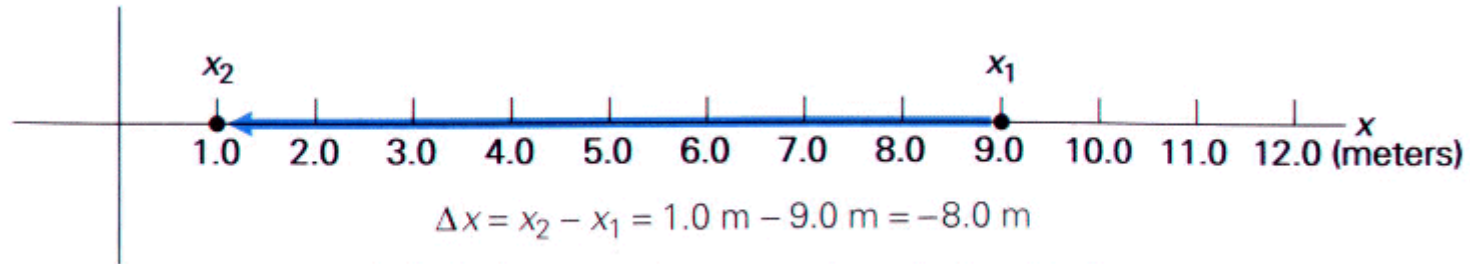
Suppose a person moves in a straight line from the lockers(at a position $x = 1.0$ m) toward the physics lab(at a position $x = 9.0$ m) , as shown below



The answer is positive so the person must have been traveling horizontally to the right.

Example

Suppose the person turns around!



The answer is negative so the person must have been traveling horizontally to the left

What is the **DISPLACEMENT** for the entire trip?

$$\Delta x = x_{final} - x_{initial} = 1.0 - 1.0 = 0 \text{ m}$$

What is the total **DISTANCE** for the entire trip?

$$8 + 8 = 16 \text{ m}$$

Average Velocity

Velocity is defined as: “The **RATE** at which **DISPLACEMENT** changes”.

Rate = ANY quantity divided by **TIME**.

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_{final} - x_{initial}}{t_{final} - t_{initial}}$$

Average **SPEED** is simply the “RATE at which DISTANCE changes”.

$$\bar{s} = \frac{\Delta d}{\Delta t}$$

Example

A quarterback throws a pass to a defender on the other team who intercepts the football. Assume the defender had to run 50 m away from the quarterback to catch the ball, then 15 m towards the quarterback before he is tackled. The entire play took 8 seconds.

Let's look at the defender's average velocity:

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{35m - 0m}{8s - 0s} = 4.38 \text{ m/s}$$

Let's look at the defender's speed:

$$\bar{s} = \frac{d}{t} = \frac{65m}{8s} = 8.125 \text{ m/s}$$

“m/s” is the derived unit for both speed and velocity.

Average Acceleration

Acceleration is the **RATE** at which **VELOCITY** changes.

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_{\text{final}} - v_{\text{initial}}}{t_{\text{final}} - t_{\text{initial}}}$$

A truck accelerates from 10 m/s to 30 m/s in 2.0 seconds. **What is the acceleration?**

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{30\text{ m/s} - 10\text{ m/s}}{2\text{ s} - 0\text{ s}} = \frac{20\text{ m/s}}{2\text{ s}} = 10\text{ m/s/s or m/s}^2$$

Suppose the same truck then slows down to 5 m/s in 4 seconds. **What is the acceleration?**

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{5\text{ m/s} - 30\text{ m/s}}{4\text{ s} - 0\text{ s}} = \frac{-25\text{ m/s}}{2\text{ s}} = -12.5\text{ m/s/s or m/s}^2$$

“m/s/s” or “m/s²” is the derived unit for acceleration.

What do the “signs” (+ or -) mean?

Quantity	Positive	Negative
Displacement	You are traveling north, east, right, or in the +x or +y direction.	You are traveling south, west, left, or in the -x or -y direction.
Velocity	The rate you are traveling north, east, right, or in the +x or +y direction.	The rate you are traveling south, west, left, or in the -x or -y direction.
Acceleration	Your velocity(speed) is increasing in a positive direction or your speed is decreasing in a negative direction.	Your velocity(speed) is decreasing in a positive direction or your speed is increasing in a negative direction.

Beware – the signs can confuse!

Suppose a ball is thrown straight upwards at 40 m/s. It takes 4 seconds to reach its maximum height, then another 4 seconds back down to the point where it was thrown. Assume it is caught with the same speed it was thrown. Calculate the acceleration upwards and downwards.

Upwards

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{0m/s - 40m/s}{4s - 0s} = \frac{-40m/s}{4s} = -10m/s$$

Downwards

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{-40m/s - 0m/s}{4s - 0s} = \frac{-40m/s}{4s} = -10m/s$$

This negative sign came from using the **DELTA**

This negative sign came from the **DIRECTION** of the velocity.

It is no surprise you get a negative answer both ways as gravity acts **DOWNWARDS** no matter if the ball goes up or down. It is **GRAVITY** which changes the ball's velocity.