# Methods of Motion

AP Physics B

# Displacement

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

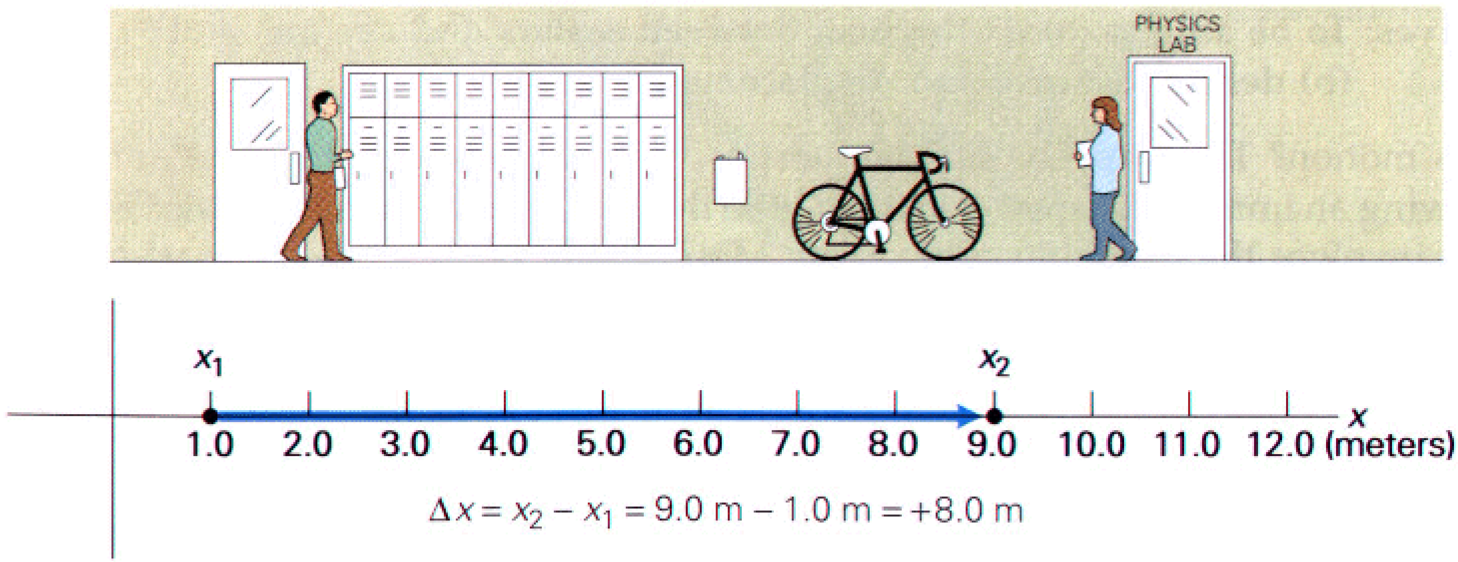
It is not necessarily the total distance traveled. In fact, displacement and distance are entirely different concepts. Displacement is relative to an axis.

- "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

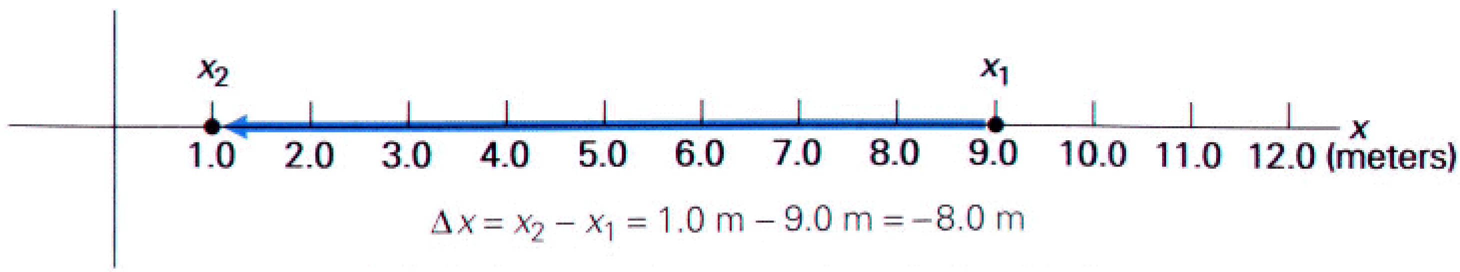
**Suppose a person moves in a straight line from the lockers( at a position x = 1.0 m) toward the physics lab(at a position x = 9.0 m) , as shown below**




**The answer is positive so the person must have been traveling horizontally <u>to the right.</u>**

# Example

**Suppose the person turns around!**




**The answer is negative so the person must have been traveling horizontally <u>to the left</u>**

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

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

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

$$8 + 8 = 16m$$

# Average Velocity

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

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

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

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:**

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

**Let's look at the defender's speed:**

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

"**m/s**" is the derived unit for both speed and velocity.

# Average Acceleration

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

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

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

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

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

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{5m/s - 30m/s}{4s - 0s} = \frac{-25m/s}{4s} = -6.25\ m/s/s\ or\ m/s^2$$

"m/s/s" or "$m/s^2$" 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*

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

*Downwards*

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

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.