#### Speed, Velocity, and Acceleration





#### Goals:

- To investigate what is needed to describe motion completely.
- To compare and contrast speed and velocity.

• To learn about acceleration.



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

An object is in <u>motion</u> if it changes position relative to a reference point.

 Objects that we call stationary—such as a tree, a sign, or a building—make good reference points.





The passenger can use a tree as a reference point to decide if the train is moving. A tree makes a good reference point because it is stationary from the passenger's point of view.

#### **Describing Motion**

Whether or not an object is in motion depends on the reference point you choose.



Relative Motion From the Plane

- The plane does not appear to be moving.
- The skydivers appear to be moving away.
- A point on the ground appears to be moving away.

Relative Motion From the Skydivers

- The plane appears to be moving away.
- The skydivers do not appear to be moving.
- The ground appears to be moving closer.

#### **Relative Motion From the Ground**

- The plane appears to be moving across the sky.
- The skydivers appear to be moving closer.
- The ground does not appear to be moving.

#### <u>Distance</u>

When an object moves, it goes from point A to point B - that is the DISTANCE it traveled. (SI unit is the meter)



#### Displacement

# Knowing how far something moves is not sufficient. You must also know in what direction the object moved.

A quantity that has magnitude and direction is called a...



V E C T O R

#### Speed

Calculating Speed: If you know the distance an object travels in a certain amount of time, you can calculate the speed of the object.



What is instantaneous speed?



Average speed = Total distance/Total time

Speed = Distance/time

# Velocity

# Velocity is a description of an object's speed and direction. It is a vector.



As the sailboat's direction changes, its velocity also changes, even if its speed stays the same. If the sailboat slows down at the same time that it changes direction, how will its velocity be changed?

# Speed v. Velocity

1. How are speed and velocity similar? They both measure how fast something is moving

 How are speed and velocity different?
Velocity includes the direction of motion and speed does not (the car is moving 5mph East)

- 3. Is velocity more like distance or displacement? Why?
- Displacement, because both are vectors which include an amount and a direction.

### Graphing Speed



#### ΤΙΜΕ

# The steepness of a line on a graph is called <u>slope</u>.

- The steeper the slope is, the greater the speed.
- A constant slope represents motion at constant speed.

Using the points shown, the rise is 400 meters and the run is 2 minutes. To find the slope, you divide 400 meters by 2 minutes. The slope is 200 meters per minute.



#### Acceleration

Acceleration is the rate at which velocity changes.

Acceleration can result from a change in speed (increase or decrease), a change in direction (back, forth, up, down left, right), or changes in both. Like velocity, acceleration is a vector.

- The pitcher throws. The ball speeds toward the batter. Off the bat it goes. It's going, going, gone! A home run!
- Before landing, the ball went through several changes in motion. It sped up in the pitcher's hand, and lost speed as it traveled toward the batter. The ball stopped when it hit the bat, changed direction, sped up again, and eventually slowed down. Most examples of motion involve similar changes. In fact, rarely does any object's motion stay the same for very long.



# Understanding Acceleration

1. As the ball falls from the girl's hand, how does its speed change?



2. What happens to the speed of the ball as it rises from the ground back to her hand?

3. At what point does the ball have zero velocity?



**4**. How does the velocity of the ball change when it bounces on the floor?

### You can feel acceleration!



If you're moving at 500mph east without turbulence, there is no acceleration.

But if the plane hits an air pocket and drops 500 feet in 2 seconds, there is a large change in acceleration and you will feel that!

It does not matter whether you speed up or slow down; it is still considered a change in acceleration. In science, acceleration refers to increasing speed, decreasing speed, or changing direction.

• A car that begins to move from a stopped position or speeds up to pass another car is accelerating.





• A car decelerates when it stops at a red light. A water skier decelerates when the boat stops pulling.



• A softball accelerates when it changes direction as it is hit.

### Calculating Acceleration

Acceleration = <u>Change in velocity</u> Total time

Change in velocity = final velocity-initial velocity OR.. = final speed-initial speed

So...Acceleration = (Final speed – Initial speed) Time

# Calculating Acceleration

As a roller-coaster car starts down a slope, its speed is 4 m/s. But 3 seconds later, at the bottom, its speed is 22 m/s. What is its average acceleration?



What information have you been given? Initial speed = 4 m/s Final Speed = 22 m/s Time = 3 s

# Calculating Acceleration

What quantity are you trying to calculate? The average acceleration of the roller-coaster car.

What formula contains the given quantities and the unknown quantity?

Acceleration = (Final speed – Initial speed)/Time Perform the calculation.

Acceleration = (22 m/s - 4 m/s)/3 s = 18 m/s/3 sAcceleration = 6 m/s2

The roller-coaster car's average acceleration is 6 m/s2.

# Graphing acceleration



Time

The slanted, straight line on this speed-versus-time graph tells you that the cyclist is accelerating at a constant rate. The slope of a speedversus-time graph tells you the object's acceleration. **Predicting** How would the slope of the graph change if the cyclist were accelerating at a greater rate? At a lesser rate?



Since the slope is increasing, you can conclude that the speed is also increasing. You are accelerating.



Distance-Versus-Time Graph The curved line on this distance-versus-time graph tells you that the cyclist is accelerating.