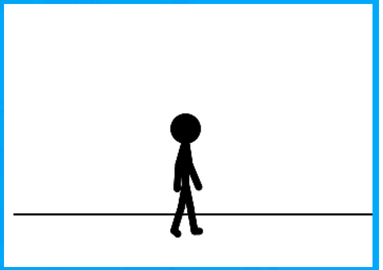
Chapter 9
Motion

Mrs. Valentine

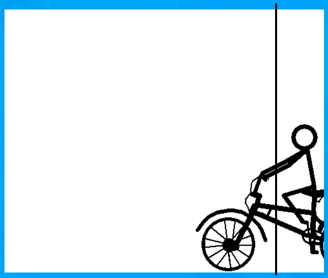
4th and 6th Periods

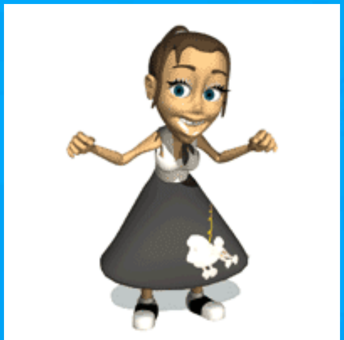
Section 1
Describing and Measuring Motion

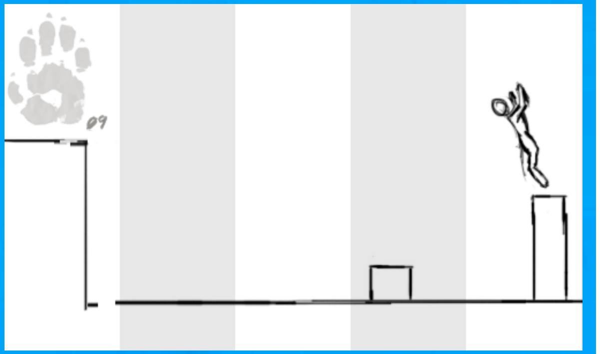
- Motion is everywhere. When you walk to class, change seats, go to lunch, and play at recess, you are in motion.



- **Definition:** Motion – the distance of one object from another is changing.





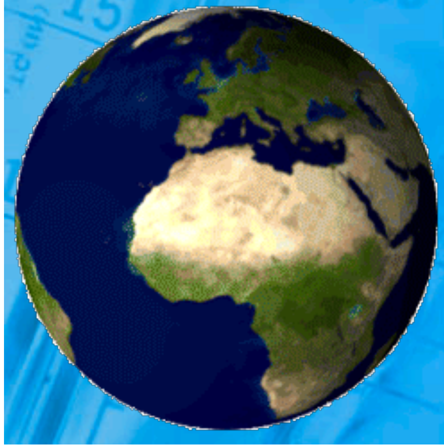


- Since the distance between you and the walls of the room is not changing, you can conclude that you are not in motion.

Recognizing Motion

- However, even though you are staying in your seat, you are still in motion in other ways.

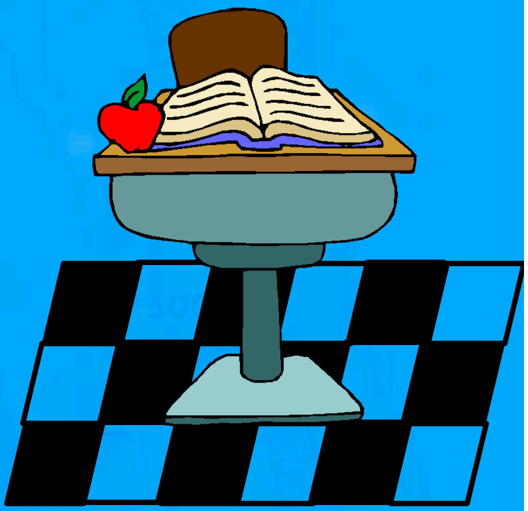
- For example, you are currently moving 30km/s. To give you an idea of how fast this is, if you were to fly a plane this quickly, you could travel from NYC to LA in about 2 minutes.



- You are moving at this rate because the Earth is spinning at this rate, and therefore everything on Earth is moving at this rate.

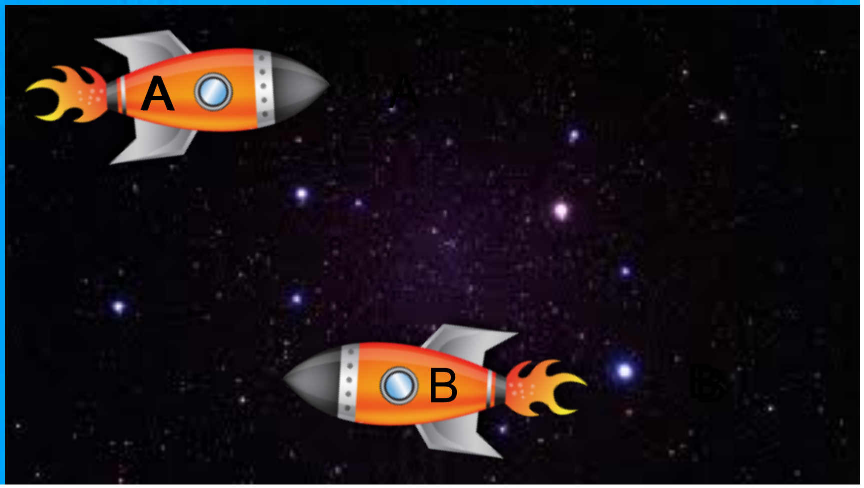
Recognizing Motion

- Motion can be dependent on point of view.



- For example, if you compare a book on your desk to the floor, it may not be in motion.

- Something to think about: Two people are in space, looking out the windows of their ships. The person in ship A sees the person in ship B passing them. Conversely, the person in ship B sees the person in ship A passing them. Who is moving?

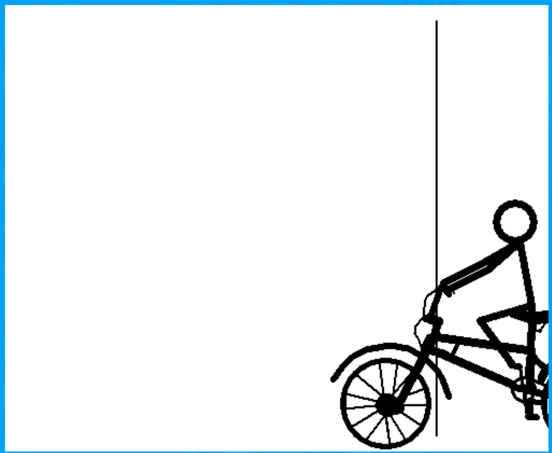


Recognizing Motion

- To answer the question, you need still object to compare the ships to.

- **Definition:** <u>Reference Point</u> – a place or object used for comparison to determine if something is in motion.

- The reference point is assumed to be stationary.

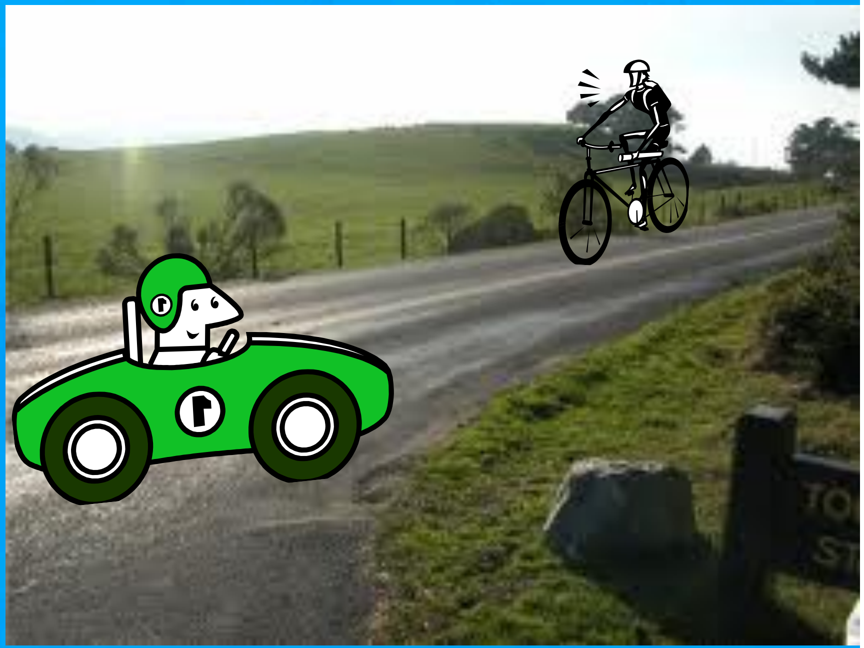


Choosing a Reference Point

- Choosing a reference point can be tricky.

- For example, if you are riding in a car, you would want to pick a reference point that is not moving at the same approximate speed you are.

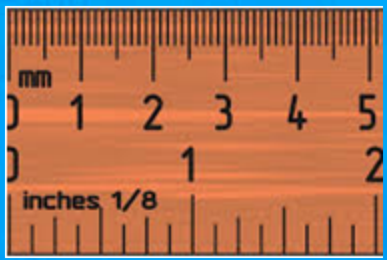
- What would be a good reference point for the car in the picture?



Describing Distance

- When describing distance, a scientist must include units.
- For example, when we measure something small, such as a pen, we use inches, cm, or mm.

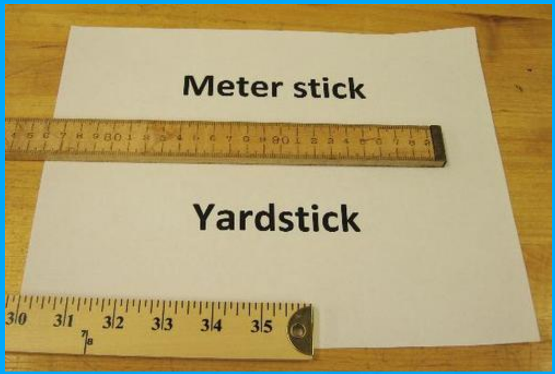
1.0 in, 2.54 cm, 25.4 mm



- REVIEW: Scientists have standardized measurements in the scientific world. We use the International System of Units (SI Units).
- The basic SI unit for length is meter.

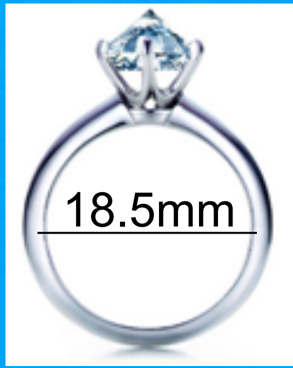
Describing Distance

- A meter is a little bit longer than a yard.



- This is where our SI conversions are really going to start coming in handy.

- Short distances, such as the length of your desk, are measured in centimeters.



- The diameter of a ring might be measured in millimeters.

Calculating Speed

- Speed depends on two things:
    1. The distance the object moves.
    2. How long it takes for the object to move.

- **Definition:** Speed (s or c) – the distance an object travels in one unit of time.

7m

Think of speed as how fast an object is moving.

- This is a type of rate.

Calculating Speed

- To calculate the speed of an object, divide the distance it has traveled in the amount of time it traveled in.

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

- The SI units for speed are meters per second (m/s).

7m

If this runner is moving 7 meters in 2 seconds, she is moving at a speed of 3.5m/s.

Constant Speed

- If the speed of an object does not change, it is said to have constant speed.

- If the object has constant speed, and you know how far it went, you can calculate how long it took.

Constant Speed Practice Problems (p. 1 in packet)

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

- If Jenny is moving with a constant speed of 21 m/s, how long did it take her to travel 17.5 meters?

  s = 21m/s

  d = 17.5 m

  $$21 \text{ m/s} = \frac{17.5\text{m}}{t}$$

  t = 0.83 seconds

- If John is moving with a constant speed of 2 mi/hr, how far was he able to walk in 1.75 hours?

  s = 2mi/hr

  t = 1.75 hr

  $$2 \text{ mi/hr} = \frac{d}{1.75 \text{ hr}}$$

  d= 3.5 miles

Constant Speed Practice Problem (p. 1 in packet)

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

- If Jonah traveled at 30 km/hr for 0.5 hours and at 21.3 km/hr for 1.2 hours, how far did he travel?

s = 30km/hr

t = 0.5 hr

$$30\ km/hr = \frac{d}{0.5hr}$$

(30km/hr) (0.5hr) = d

15 km = d

s = 21.3km/hr

t = 1.2 hr

$$21.3\ km/hr = \frac{d}{1.2hr}$$

(21.3km/hr) (1.2hr) = d

25.56 km = d

15 km + 25.56 km = d

40.56 km = d_{total}

Average Speed

- Most objects do not move at constant speed.

- If an object does not have a constant speed, the average speed can be determined.

- This is done by dividing the total distance by the total time.

$$s_{average} = \frac{d_{total}}{t_{total}}$$

Average Speed Practice Problem (p.2 in packet)

- If Jonah traveled 15 miles during his first half hour of travel, and 25.56 miles during 1.2 hours of travel, what is his average speed?

15 miles + 25.56 miles = d_{total}

40.56 miles = d_{total}

0.5 hours + 1.2 hours = t_{total}

1.7 hours = t_{total}

$$s_{average} = \frac{40.56 \text{ miles}}{1.7 \text{ hours}}$$

$s_{average}$ = 23.86 mi/hr

Average Speed Practice Problems (p.2 in packet)

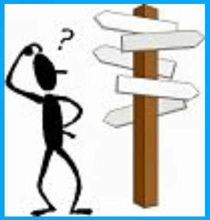
- If Dorothea walked 1.5 miles during her first half hour of travel, and 4.2 miles during 1.25 hours of travel, what is her average speed?

$s_{average}$ = 3.25 mi/hr

- If Henry traveled 34.51 miles during his first forty-five minutes of travel, and 113.5 miles during 1.8 hours of travel, what is his average speed?

$s_{average}$ = 58.04 mi/hr

Describing Velocity



- The speed of an object does not tell you the direction of the object's motion.

- **When you know both the speed and direction of an object's motion, you know the velocity of the object.**

- **Definition:** <u>Velocity (v)</u> – Speed in a given direction.

- When velocity is reported, the direction must be included.

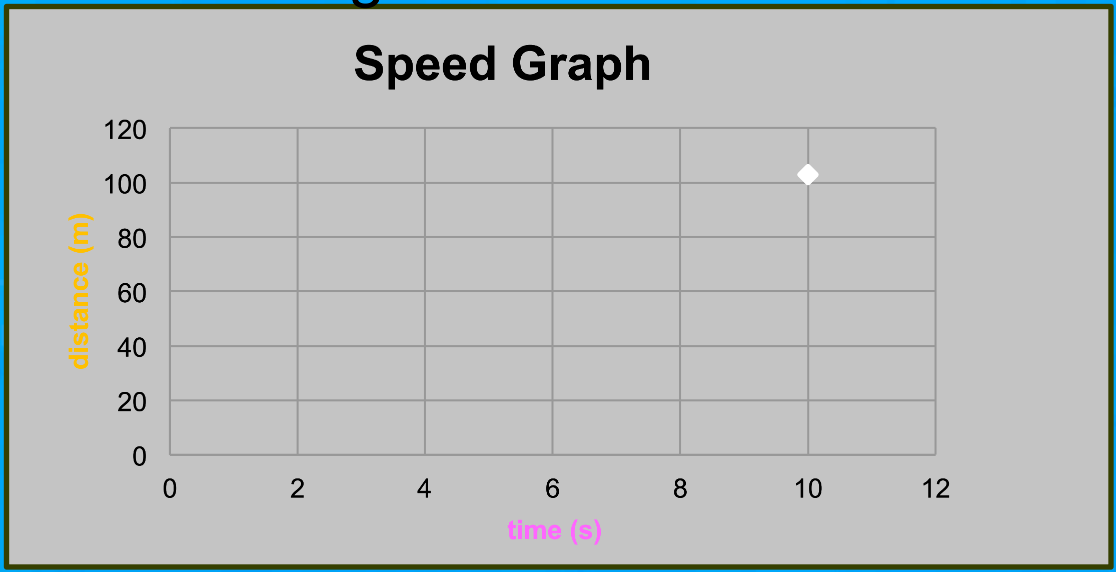
- Velocity is typically reported rather than speed as both speed and direction are important pieces of information to have.

Active Demonstration

- Let the races begin!
- We will be going outside to judge speed and velocity.
- Materials Needed: 2 ropes, 2 blindfolds, 1 timer, 1 tape measure.
- Everyone must run at least one race.
- Which was more challenging: when you were able to determine your direction or not?

Graphing Motion

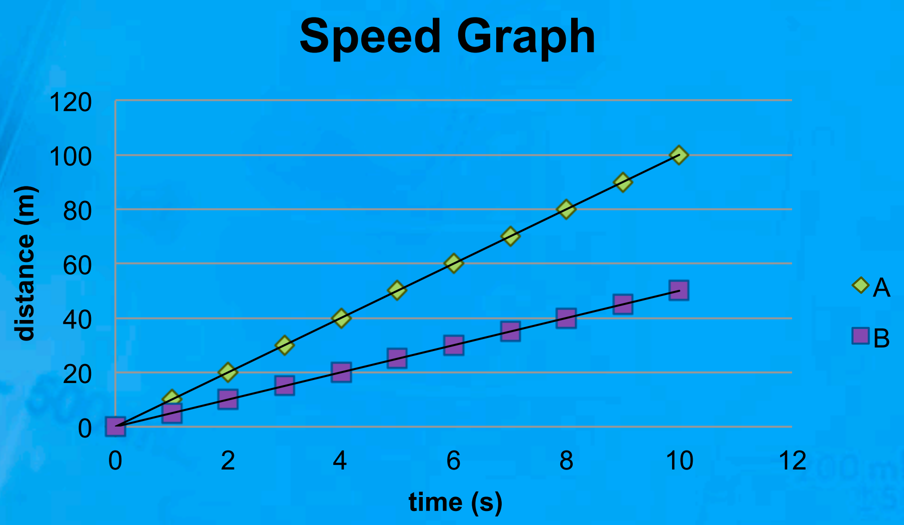
- You can show the motion of an object on a line graph in which you plot distance against time.



- Time will be on the x-axis and distance will be on the y-axis.
- A point on the graph (x,y) will represent the location of an object at a given time.

Graphing Motion

- **Definition:** <u>Slope</u> (m) – the steepness, or slant, of a line on a graph.



A has a larger slope than B because it is a steeper line.

- The slope of the line of the graph will tell you how fast one variable changes in relation to the other.

- Therefore, we can use the slope of the line of a graph depicting motion to determine the speed of the object.

Graphing Motion

- Let’s read the Exploring: Motion Graphs on page 290.

- The first graph shows that the jogger traveled 170m each minute. Therefore, the average speed between any two points is 170m/min.

- Copy the graph and extend the line.

Exploring: Motion Graphs (p. 2 in packet)

- On the second graph, what happened during the sixth through eighth minutes?

  The jogger stopped.

- What effect did the stop have on the jogger's average speed?

  Average speed was lowered. New Avg. Spd.: 119m/min

- What was the difference in the jogger's average speed between the first and the second day?

  51m/min.

- Let's look at the third graph. Compare the slope of the third to the first.

  The slope of the first graph is greater.

- How fast would the jogger be running if the graph was flat?

  0m/min.

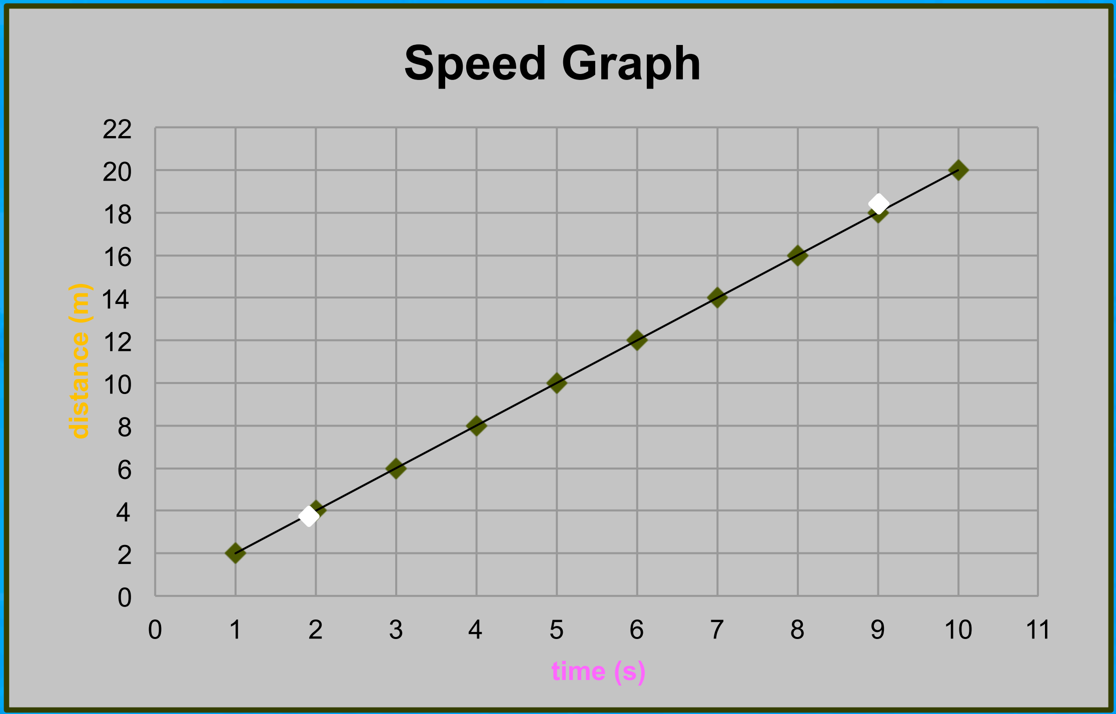
Calculating Slope

- The slope of a line is its rise divided by its run. $m = \frac{rise}{run}$
- Therefore, in order to calculate the slope of a line, two points on the line must be known.
- Typically, it is preferred that these points not be directly beside one another. This is to ensure that the slope is more accurate.
- The rise is the vertical distance between the two points. The run is the horizontal distance between the two points.

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Calculating Slope

- Let's calculate the slope of the following line.



- We can choose the points (2,4) and (9,18) to calculate the slope.

Calculating Slope

$$m = \frac{rise}{run}$$

NOTE: We subtracted the first from the second in both cases. It does not matter which order you do it in, so long as it is the same both times.

[Points (2,4) and (9,18)]

- Remember that the rise is the vertical difference. Therefore, we must subtract the y values.

  18m – 4m = 14m

- The run is the horizontal difference. Therefore, we must subtract the x values.

  9s – 2s = 7s

- We then can divide the rise by the run in order to determine slope.

  $$m = \frac{14m}{7s} = 2m/s$$

- Using the other equation, these steps can be done all at once.

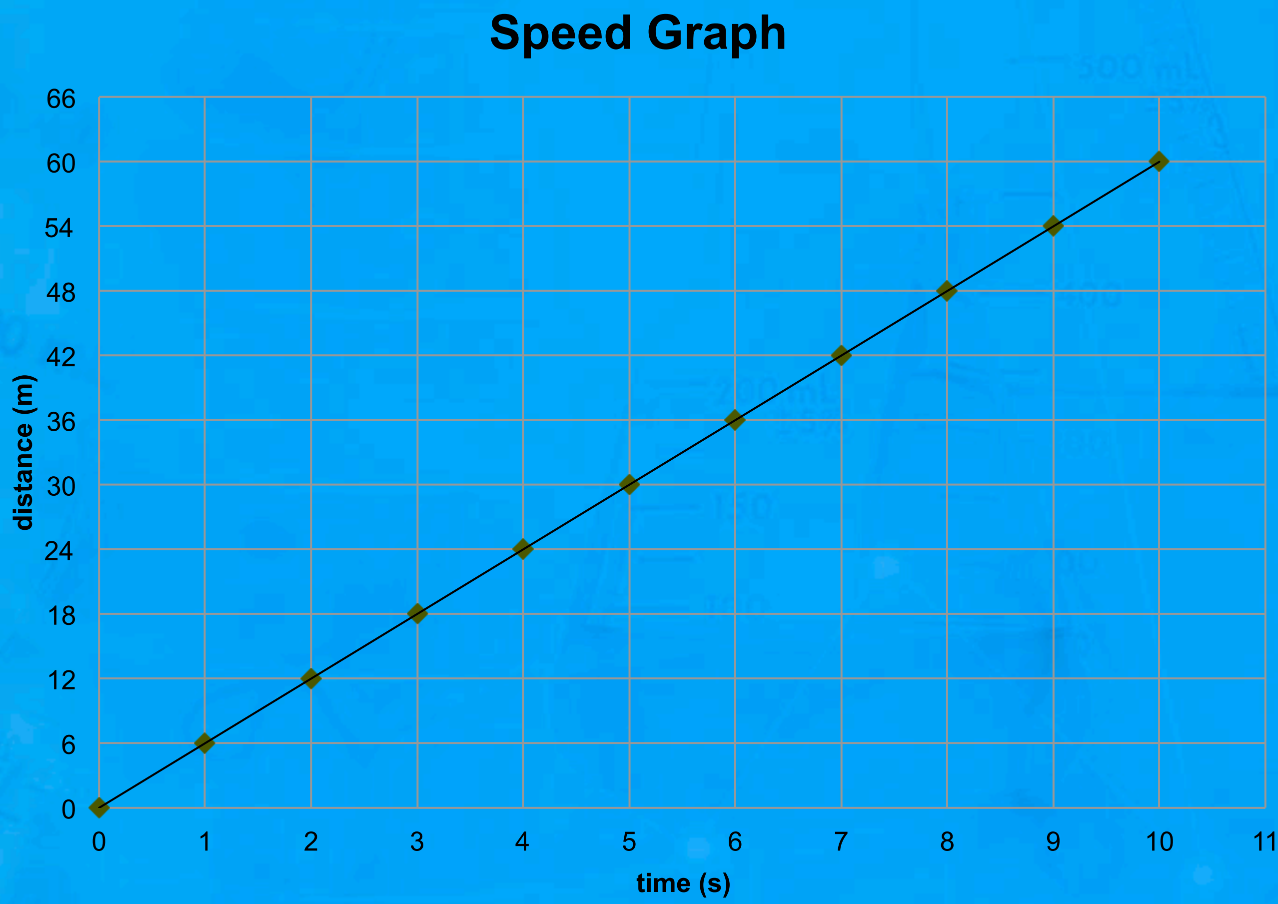
  $$m = \frac{y_2 - y_1}{x_2 - x_1}$$

  $$m = \frac{18 - 4}{9 - 2} = \frac{14m}{7s} = 2m/s$$

Slope Practice Problem (p. 3 in packet)

- Determine the slope of the speed graph below.

m = 6m/s



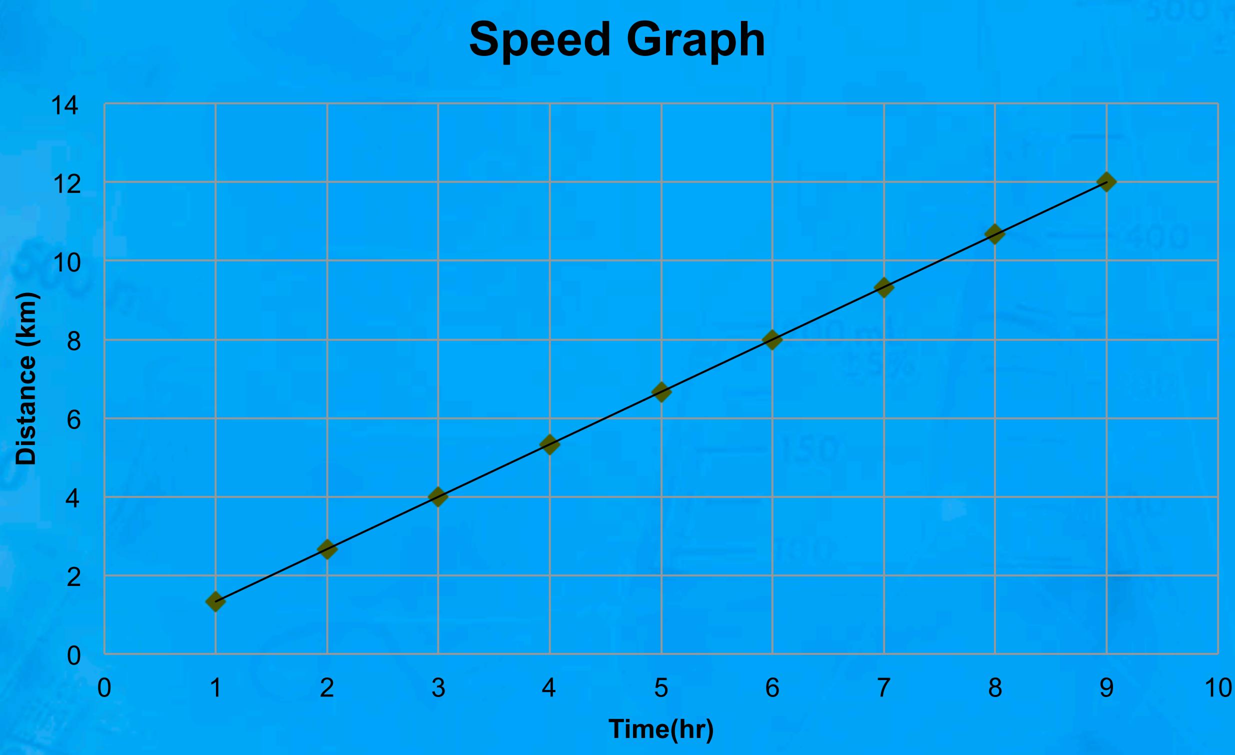
Line Equations

- Once we have the slope, we can use it to determine the equation of the line.
- The equation of a line is y=mx+b where m is the slope and b is the y-intercept.
- In this case, and in the case of all speed graphs, you haven't moved before you start counting time.
- Therefore, the y-intercept is typically (0,0), making the equation for speed graph lines y=mx.
- The equation of our line, therefore, is y=2x

Line Equation Practice Problem (p. 3 of packet)

- Determine the equation of the line in the graph below.

y = 1.33x



Different Slopes

- Note that when an object in motion changes its speed, the slope of the line of the graph representing it changes.
- Let's look at Figure 8 on page 293.
- Each different slope can be seen as a different segment of the same graph, and would have to be calculated separately.
- A horizontal line represents an object that is not in motion, since there is no change in distance.

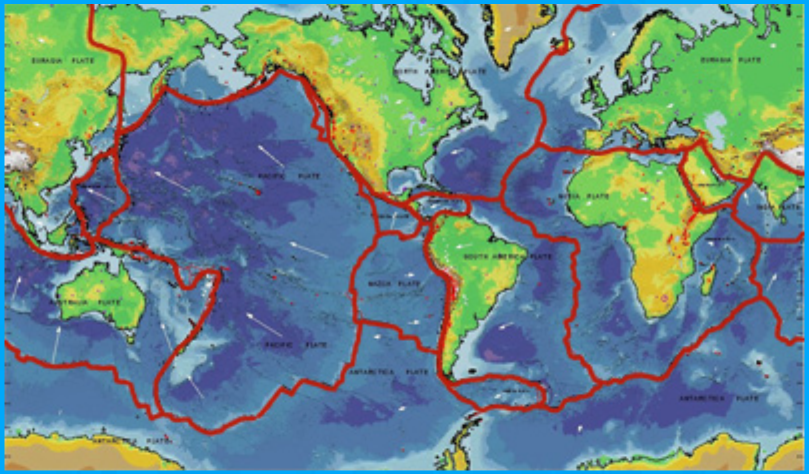
Section 2
Slow Motion on Planet Earth

- Let's have a look at a world map.

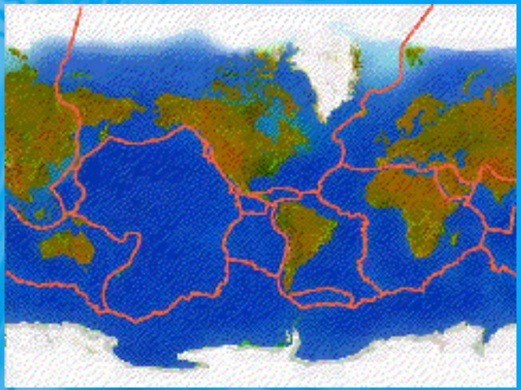
- Notice how the land masses look like a giant puzzle.

What are Earth’s Plates?

- The upper layer of Earth consists of more than a dozen major pieces called plates.



- **According to scientists explanations, known as the theory of plate tectonics, Earth’s plates move ever so slowly in various directions.**

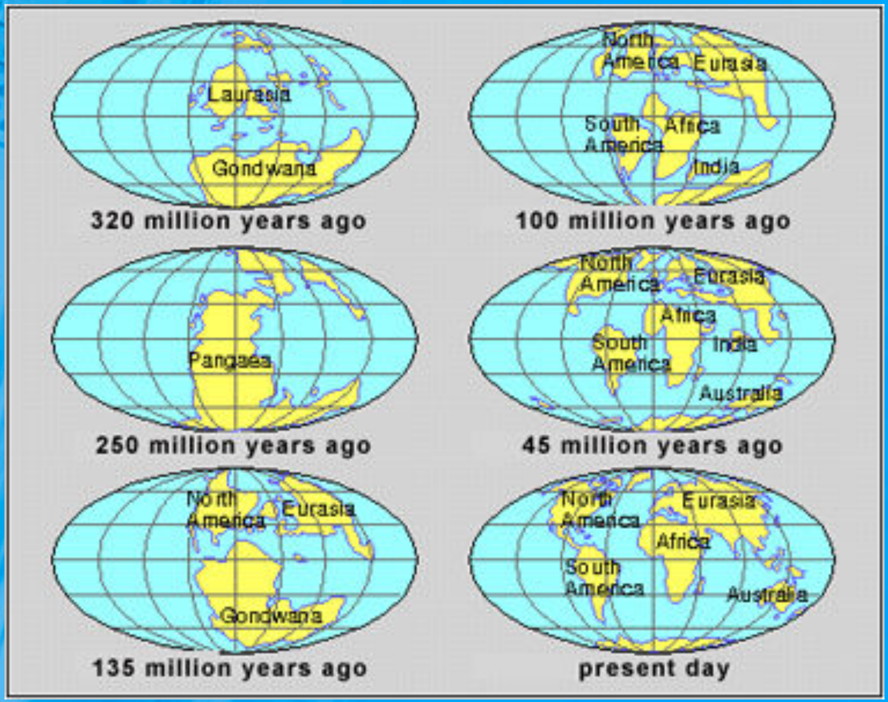


- Some plates will pull away from one another while other plates will come together.

How Fast Do Plates Move?

- Some small plates move as fast as several centimeters per year, while others move only a couple of millimeters per year.

- Let's look at Figure 10 on page 298.



Knowing how fast the plates are moving will allow for scientists to make predictions on what the earth will look like after a set period of time.

Calculating Distance Practice Problem (p. 4 in packet)

- Suppose a plate moves 5 centimeters over the course of a year. It can be said to have a speed of 5cm/yr.
- Try using this speed to determine how far the plate will have moved in 1000 years.

s = 5cm/yr

t = 1000 yr

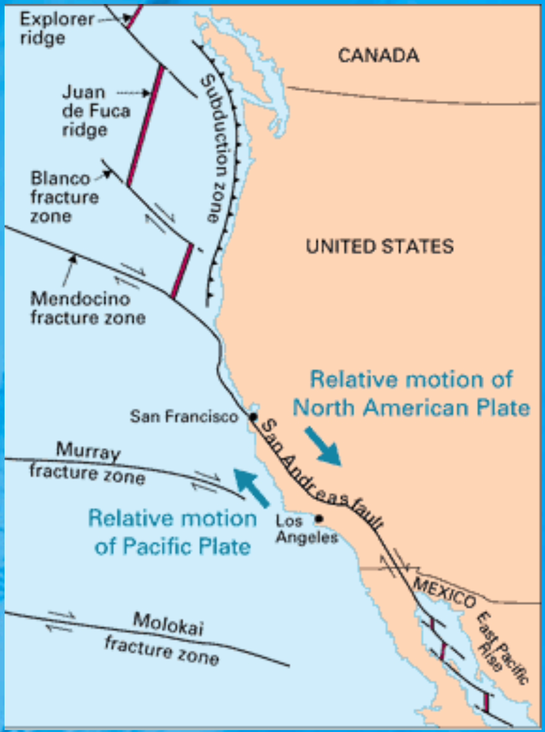
$$s = \frac{d}{t}$$

$$5\text{cm/yr} = \frac{d}{1000\text{ yr}}$$

(5cm/yr) (1000yr) = d

d= 5000cm = 50m

Sharpen Your Skills (pg 297)
(p. 4 in packet)



- LA is on the Pacific plate moving NW. San Francisco is on the North American plate moving SE.
- These cities are moving toward each other at 5cm/yr. If the cities are 554,000m apart, how long will it take for them to reach each other?
- Use the map to the left to locate LA and San Francisco. Where do you think the plate runs?

Demonstration

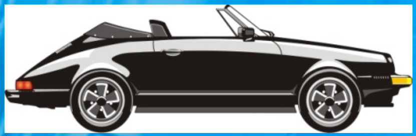
- Measure the length of your step (back toes to front heel) in inches.
- Convert this distance to cm. Recall that 1in = 2.54cm.
- Imagine that you walk 10000 steps in one day on average.
- What is your average speed? Convert this to cm/yr and compare to the average speed of a fast plate.

Section 3
Acceleration

- It is rare for any motion to stay the same for a long time.

- Changes in motion can be described in much the same way that speed and velocity have been described.

- Example – A car, which has been stopped at a red light, gets a green light and begins to move. If the car is in a 35mi/hr zone, when the gas pedal is pushed, does the car instantly go at 35mi/hr?



Acceleration in Science

- The answer to this question is no. The car must accelerate first.

- In everyday language, acceleration means "speeding up."

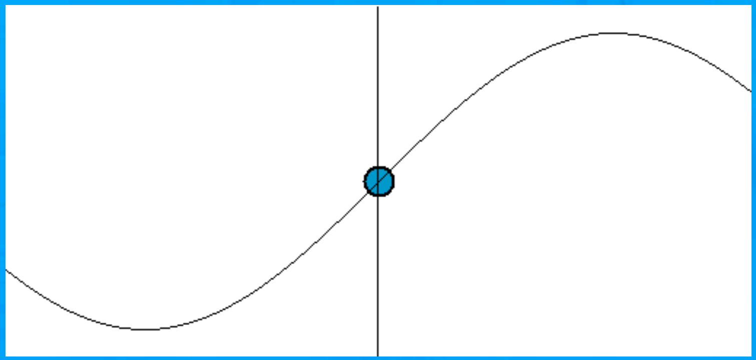
- In science, acceleration has a slightly more specific definition.

- **Definition:** Acceleration (α) – the rate at which velocity changes.

Acceleration

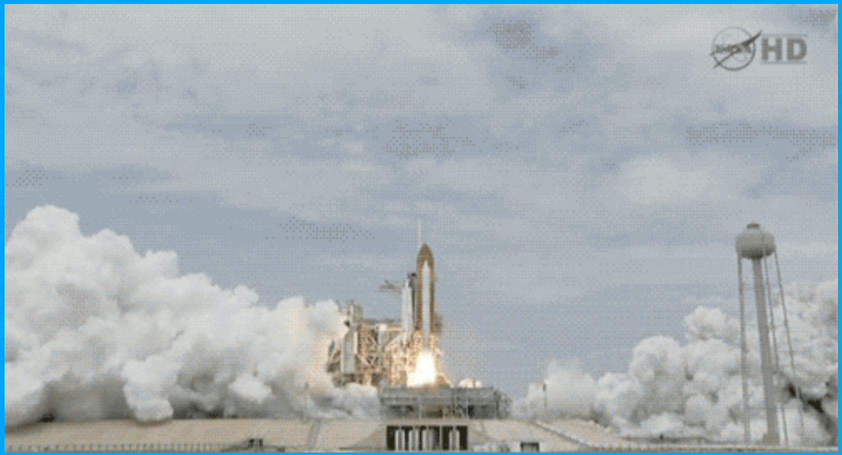
- Remember, velocity has two components: both speed and direction.

- **In science, acceleration refers to increasing speed, decreasing speed, or changing direction.**



- Brief demonstration. Materials – ball on string. How is the ball accelerating?

Increasing Speed



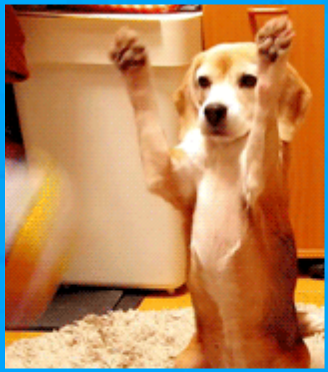
- At any time the speed of an object increases, it is accelerating.

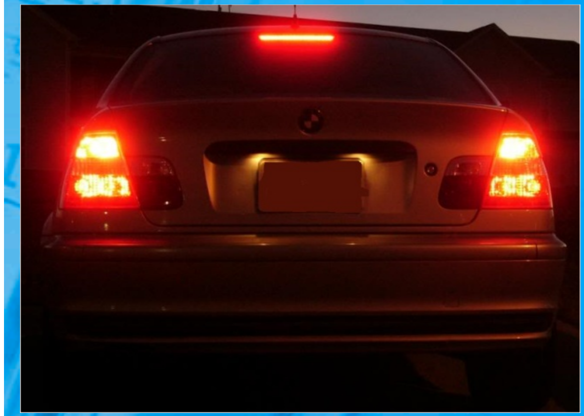
- Examples include:
    1. Throwing a ball
    2. Launching a rocket
    3. Speeding up a car

- People can experience this kind of acceleration as well. When we start running or skating, we accelerate up to the speed we want to be going.

Decreasing Speed

- Decreasing speed is another form of acceleration.
- This process is often referred to as <u>deceleration</u>.
- Examples include:
    1. Stopping a car
    2. A runner slowing to a walk
    3. A ball being caught

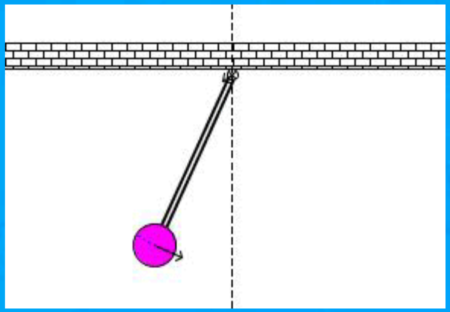


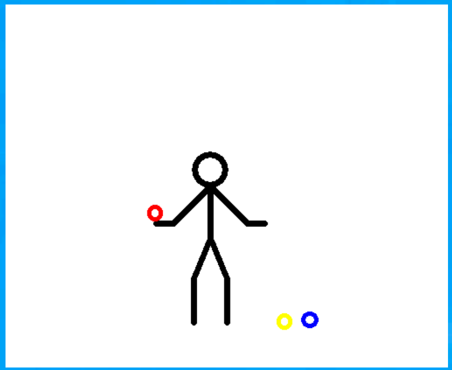


- True or False:
    - When you step on the gas while driving, you are accelerating. True
    - When you step on the brake, you are accelerating. True

Changing Direction

- Acceleration can occur even when speed is constant.
- This happens if the object changes direction.
- Examples include:





Changing Direction

- Many objects are constantly changing direction without changing speed.

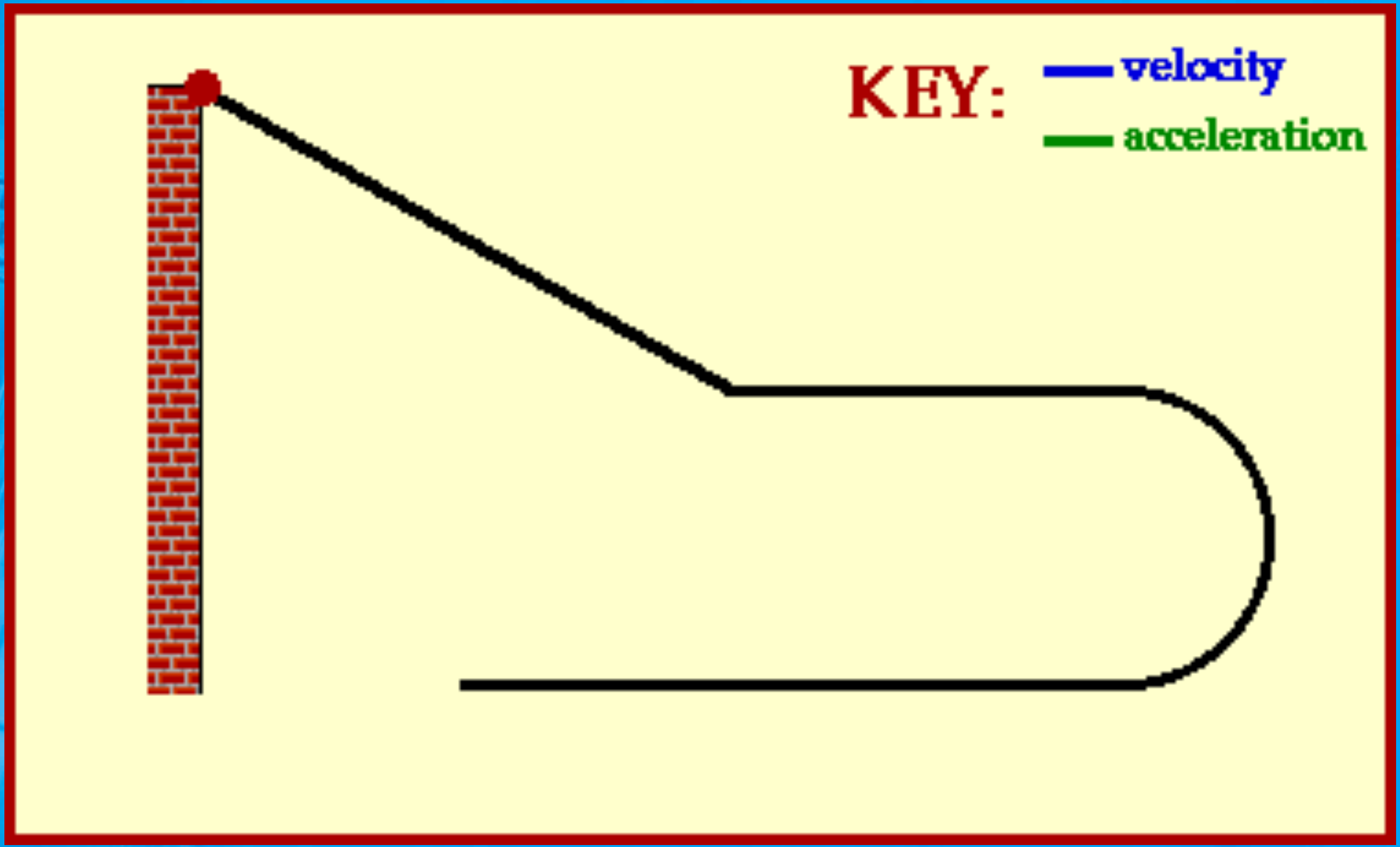
- The simplest form of this kind of acceleration is known as circular motion.

- Examples include:




- Demonstration: Proving that circular motion has a change in direction.   Materials: CD, Arrow, Tape, Marker

Velocity and Acceleration



Calculating Acceleration

- **To determine the acceleration of an object, you must calculate the change in velocity during each unit of time.**

- This can be summarized in the following equation:

$$\alpha = \frac{v_f - v_i}{t}$$

- If velocity is measured in m/s and time is measured in s, then what is acceleration measured in? m/s/s = m/s^2

- If the object's speed changes by the same amount during each unit of time, the acceleration is the same.

- If the acceleration varies, the average acceleration can be described.

Calculating Acceleration Practice Problem (p. 5 in packet)

- A car advertisement states that a certain car can accelerate from rest to 90km/hr in 9 seconds. Find the car's acceleration in mi/hr^2.

v_f = 90km/hr

v_i = 0km/hr

t = 9s = 0.0025hr

$$9s \times \frac{1min}{60s} \times \frac{1hr}{60min} = 0.0025hr$$

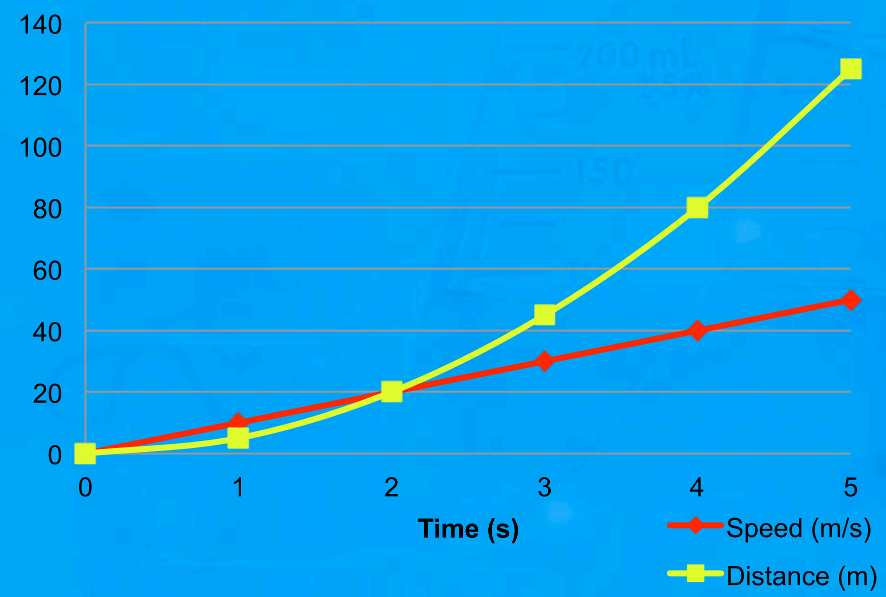
$$\alpha = \frac{90km/hr - 0km/hr}{0.0025hr}$$

= 36000km/hr^2

Graphing Acceleration

- If one graphs speed versus time for constant acceleration, the line will be linear.

- If one graphs distance versus time for constant acceleration, the graph will be nonlinear.



Chapter 9 Review

Answer questions
1-10, 12, 13, 15, 18-19
On pages 308-309

Frank, D. V., Little, J. G., Miller, S., Pasachoff, J. M., & Wainwright, C. L. (2001). *Physical science*. Needham, Mass.: Prentice Hall.