Speed, Velocity, and Acceleration

Major Topic and SOL: Speed, Velocity, and Acceleration
Science SOL PS.1b,d,I PS.10a

Length of Unit: **5 - 90 minute class periods**

Major Understandings:
Students will

- use scientific reasoning, logic, and the nature of science to plan and conduct investigations which will help them develop an understanding of speed, velocity, and acceleration.
- use meter sticks to measure distance, timers to measure time, and use s = d/t to calculate speed.
- graph distance vs. time on a line plot and relate the line slope to motions observed.

Essential Questions

- How can motion be described using the concepts of speed, velocity, and acceleration?
- How can the relationship, s = d/t, be used to determine speed, distance, and time?
- How can quantitative measurements accurately made?

Student Objectives

Students will be able to

- plan and conduct investigations in which length is accurately measured.
- use metric rulers and probeware to gather data.
- construct and analyze line plots.
- investigate and understand speed, velocity, and acceleration.

Bloom's Taxonomy Skills	**21st Century Learning Skills**
• Creating • Evaluating • Analyzing • Understanding • Remembering • Applying	• Critical Thinking • Problem Solving • Creativity & Innovation • Collaboration • Information & Media • Contextual Learning

Assessment Evidence

Performance Tasks

Students will

- measure distances and times, then use these to calculate speed.
- construct line plots for distance/time and compare line slopes to motion observed.
- use the formula s = d/t to solve word problems related to speed.

Other Evidence

- Discussion (written or oral)
- Class Participation
- Teacher Observations
- Laboratory Assignments/Reports
- Group Work
- Quizzes

Technology Computers, Internet Connection, Projector System, Probeware, Laptop, Multimedia, Logger Lite, Internet

Internet Resources:

- Moving Man Simulation: http://phet.colorado.edu/en/simulation/moving-man
- Cheetah Hunt Warhog: http://www.youtube.com/watch?v=sXIpIMRDMGg
- Women's 400m Final: http://www.youtube.com/watch?v=bFp0sRKgBJo
- They Might Be Giants: http://www.youtube.com/watch?v=DRb5PSxJerM
- Graphing Your Motion Lab: http://www.vernier.com/experiments/psv/35/graphing_your_motion/
- Ladybug Simulation: http://phet.colorado.edu/en/simulation/ladybug-motion-2d

Supplies/Materials:

Lesson 1

- Graphing Your Motion Handout
- Motion Detector

Lesson 2

- Speed Challenge handout
- Timers
- Meter sticks

- Calculators
- Graph paper
- Motion Detector
- Colored Pencils

Lesson 3

- Speed and Velocity handout
- Motion Detector

Lesson 4

- Moving Man handout
- computer lab/cart
- Post lab questions for Moving Man

Lesson 1: In Motion (1- 90 minute period)

Engage:

- Students are shown a video of a cheetah and warthog chasing each other (http://www.youtube.com/watch?v=sXIpIMRDMGg).
- After viewing the clip students, are asked the following questions and discuss their answers as a class:
  - What are some examples of motion in the video?
  - How do you describe the motion?
  - How would you measure motion?

Explore:

- As a class, students will complete "Graphing Your Motion" part A, using the link, http://www.vernier.com/experiments/psv/35/graphing_your_motion/.
- Each student will record data on the "Graphing Your Motion" handout.

Explain:

- Individually, students will answer "Processing The Data (Part A)" questions 1-4 (on handout).
- As a class, discuss the answers.

Elaborate:

- Individually, students will answer "Processing the Data (Part A)" question 5 (on handout).
- As a class, discuss the answer.

Evaluate:

- Students will analyze a distance/time graph (on quiz after completion of unit).

Lesson 2: The Need for Speed (2- 90 periods)

Engage:

- Students view the 400 m women final race in the 2012 Olympics (http://www.youtube.com/watch?v=bFp0sRKgBJo).
- Students are then asked who was the fastest and why.

Explore:

- Students will work in groups of 4 – 5 to complete the "Speed Challenge" through collecting data.

Explain:

- Students will work individually to calculate speed from the data collected, using s = d/t (problems 1-3 on handout).

Elaborate:

- Individually, students will prepare a line plot of the data collected.
- Students will plot distance vs. time for the data collected and use the line plots to analyze the different motions observed. Each motion (there are four) will be plotted in a different color on the graph (note: this is explained on the handout).

Evaluate:

- Individually, students will complete the problems on the "Speed Review" worksheet.

Lesson 3: What's the Difference? (1 – 90 minute period)

Engage:

- Students view **They Might Be Giants - Speed and Velocity w/ Marty Beller** (http://www.youtube.com/watch?v=DRb5PSxJerM)
- Students will then explain the difference between speed and velocity.

Explore:

- As a class, students will complete "Graphing Your Motion" part B, using the link, http://www.vernier.com/experiments/psv/35/graphing_your_motion/.
- Each student will record data as the activity is completed.

Explain:

- Individually, students will answer "Processing The Data (Part B)" questions 5-7 (same handout).
- As a class, discuss the answers.

Elaborate:

- Individually, students will answer "Processing The Data (Part B)" question 8 (same handout).
- As a class, we will discuss the answer.

Evaluate:

- Students will complete the Speed and Velocity handout.
- Students will analyze a velocity/time graph (on quiz after completion of unit).

Lesson 4: Move It Man (1- 90 minute period)

Engage:

- As a class, use the "Lady Bug 2D" simulation, using the link, *http://phet.colorado.edu/en/simulation/ladybug-motion-2d*, to compare velocity and acceleration.

Explore:

- Students will complete the "Moving Man" simulation, using the link, http://phet.colorado.edu/en/simulation/moving-man.
- Students will work in pairs to complete the activity.
- Each student will record data on the "Moving Man – Velocity vs. Time Graphs" handout.

Explain:

- In the same pairs, students will explain the difference between the distance/time and velocity/time graphs (on same handout).

Elaborate:

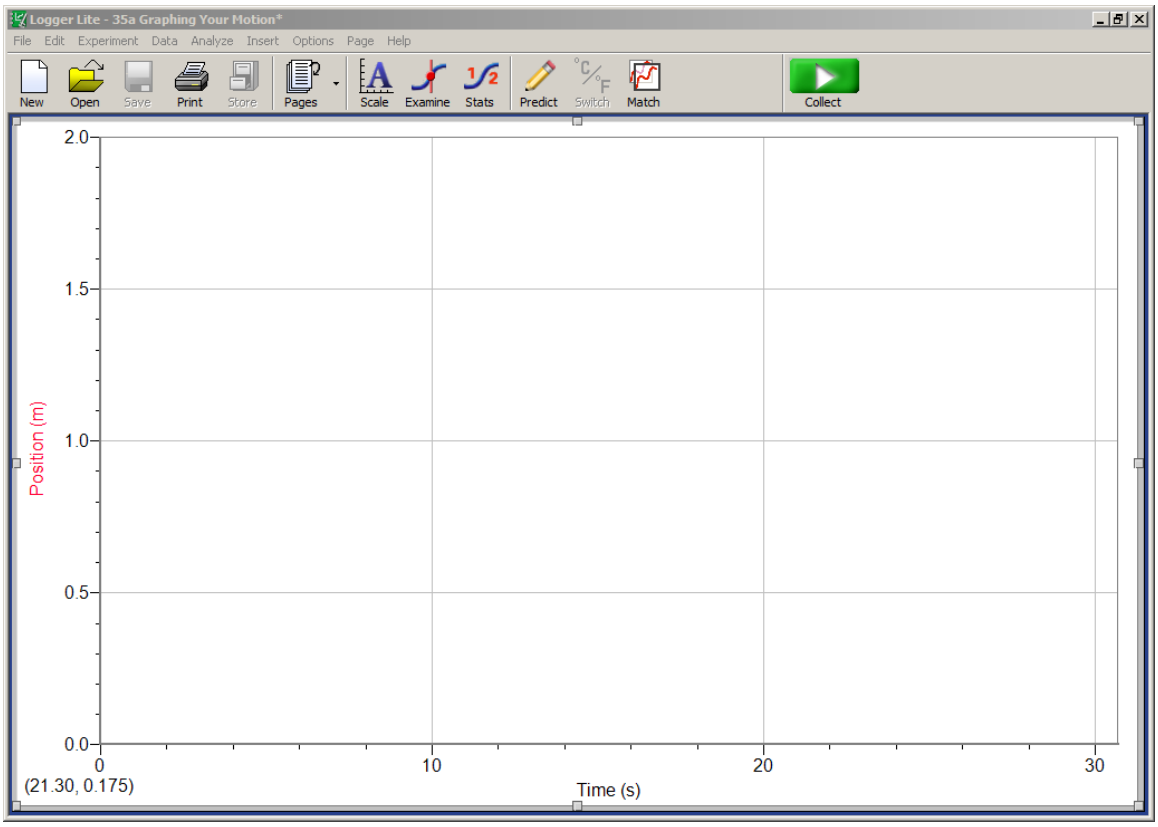
- In the same pairs, students will complete the "Apply what you learned" section of the handout.

Evaluate:

- Individually, students will complete the "Post-lab questions for Moving Man".
- At the end of the unit, students will complete the "Motion" quiz (attached).

Graphing Your Motion (Lesson 1) **Name:**

Date: **Pd:**



Processing the Data

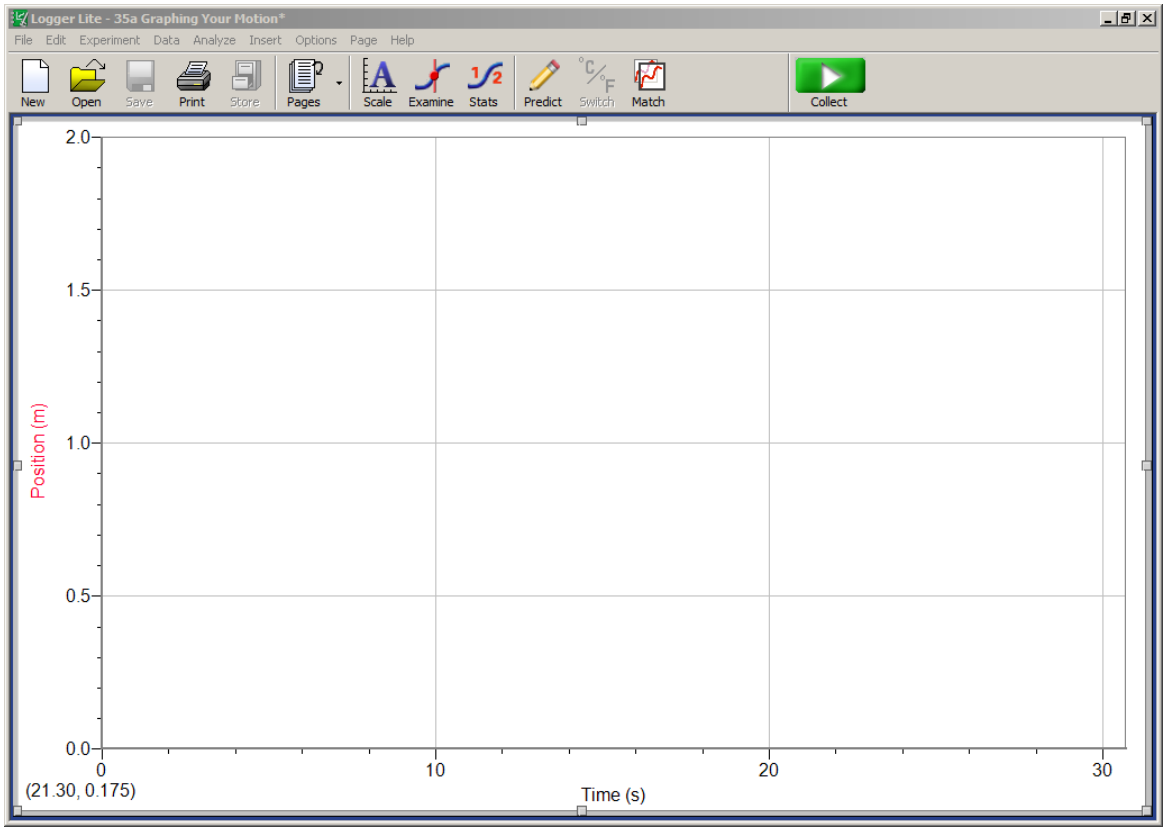
1. Describe the difference between the two lines on your graph made in step 6. Explain why the lines are different.

2. How would the graph change if you walked toward the Motion Detector rather than away from it? Test your answer using the Motion Detector.

3. Describe the line slope when you are not moving.

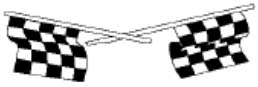
4. What did you have to do to match the graph you were given in Step 7?

5. Sketch a position vs. time graph for a car that starts slowly, moves down the street, stops at a stop sign, and then starts slowly again.



Name _____

Speed Machines



FORMULA : SPEED = Distance ÷ Time

Round answers to the nearest tenth (one decimal place)!

1. NASCAR fans love race day when they get a chance to cheer on their favorite team! If a driver was able to travel 600 miles in 3 hours, what was his average speed?

2. The fastest car on Earth, a British-made *Thrust SSC*, would win every NASCAR race in America. If it takes 0.5 hours (30 minutes) to travel 380 miles, what is its speed?

3. The fastest train on Earth, the *TGV* from France, can travel at faster speeds than trains in the United States. During a speed test, the train traveled 800 miles in 2.5 hours. What is its speed?

4. *Spirit of Australia*, a hydroplane boat, made speed records by traveling 239 miles in 0.75 hours (45 minutes). What is its record-breaking speed?

5. The fastest plane ever made, the *Lockheed SR71*, was able to travel 2200 miles per hour. Based on this speed, how far could it travel in:

a. 2 hours? b. 3 hours? c. 5 hours?

Challenge:
Which machine on this page is the fastest? _____

6. Fill in the boxes and use a calculator to determine how long it would take each machine to get to travel 60 miles. Use the speeds you calculated in miles per hour on the front of this worksheet. Round answers to the nearest tenth (one decimal place)!

60 miles	÷		=		X	60 minutes	=	
		↑ Speed (mph)						

A. Jeff Gordon's Car = _____ minutes

B. *Thrust SSC* Car = _____ minutes

C. *TGV* Train = _____ minutes

D. *Spirit of Australia* Boat = _____ minutes

E. *Lockheed SR71* Airplane = _____ minutes

Speed Machine Answers:

1. 600 ÷ 3 = 200 mph

2. 380 ÷ .5 = 760 mph

3. 800 ÷ 2.5 = 320 mph

4. 239 ÷ .75 = 318.67 mph

5. a. 2200 x 2 = 4400 miles, b. 2200 x 3 = 6600 miles, c. 2200 x 5 = 11,000 miles

Challenge: Lockheed SR71

6. A. 18 minutes, B. 4.7 minutes, C. 11.3 minutes, D. 11.3 minutes, E. 1.6 minutes

Speed Challenge (Lesson 2) **Name:**

Date: **Pd:**

During this activity, you will move through a distance and measure/record times at various intervals. You will use the data collected to prepare a distance/time graph and calculate speeds using the formula:

Speed = Distance/Time

For the activity, you may choose your method of motion (walk, run, etc). Make sure to use the same method of motion for each trial. You will move through a total distance of 25 meters; members of your group will measure the time that it takes for you to move through each 5 meter interval. Follow the directions specified in the chart and use the chart to record your times. Times should be recorded to the nearest second.

Distance	Time			
	MOTION 1 Move at a slow steady pace from 0 to 25 meter mark	MOTION 2 Move at a faster steady pace from 0 to 25 meter mark	MOTION 3 Move at a slow steady pace backwards from 25 to 0 meter mark	MOTION 4 Start at the 0 mark, move slowly to the 15 meter mark, stop briefly, then move quickly to the 25 meter mark
5 m				
10 m				
15 m				
20 m				
25 m				

Use the data collected to prepare a distance/time graph. Label the horizontal axis "time" and the vertical axis "distance". Be sure to include your units with the labels. Examine your times to determine an appropriate scale for the horizontal axis. Plot your data points for each type of motion using a different color for each line (you should have 4 lines on the graph). Be sure to make a key for the graph.

Calculate your speed at the following points:

1. Motion 1 at the 15 meter mark:

2. Motion 2 at the 10 meter mark:

3. Motion 4 at the 25 meter mark:

Speed and Velocity (Lesson 3) **Name:**

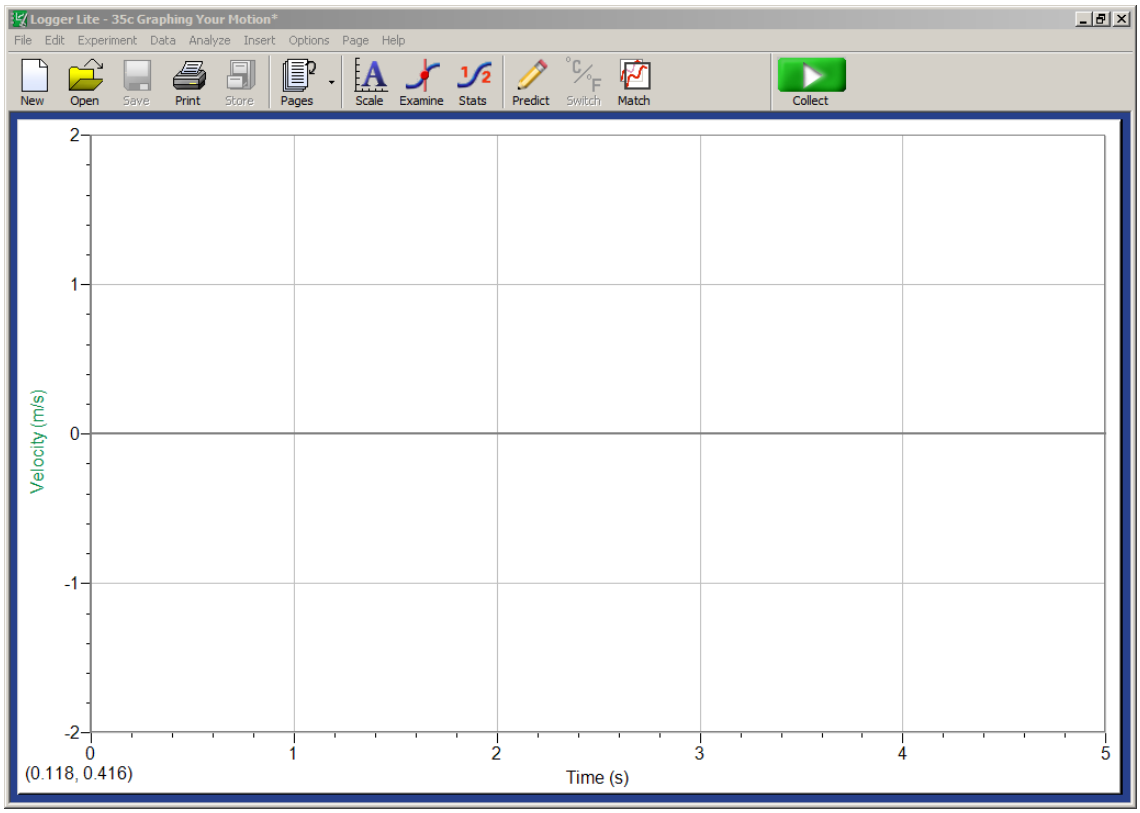
Date: **Pd:**

Watch the short video clip, "Speed and Velocity"…..then answer the following questions.

1. **What is the difference between speed and velocity?**

2. **How are speed and velocity similar?**

In the graph grid below, sketch the two lines made during the activity.



Processing the Data

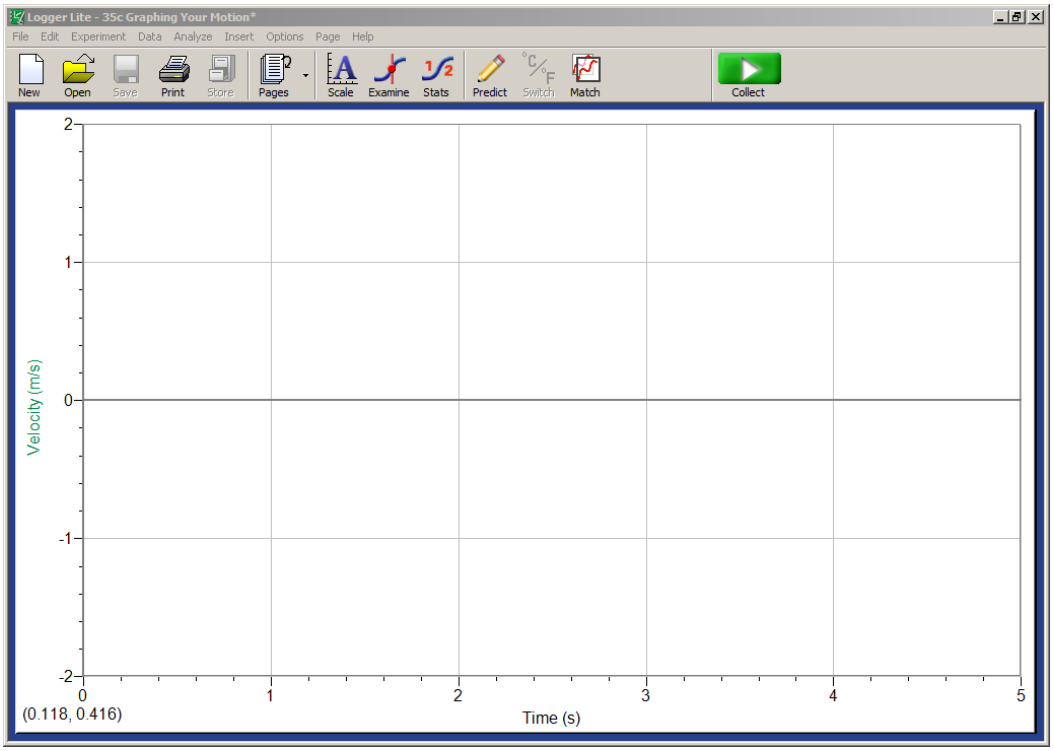
1. **Describe the difference between the two lines on the graph. Explain why the lines are different.**

2. **Describe the line slope when velocity increases.**

3. **Describe the line slope when velocity stays the same (is constant).**

4. **Describe the line slope when velocity decreases.**

5. Sketch a velocity vs. time graph for a person who walks, stops for a few seconds, and then starts to run.



Moving Man - Velocity vs. Time Graphs (Lesson 4)

Teacher Pages

Prior Knowledge – The students should know:

- How to make a line graph
- The basic unit of measure for distance is the meter and for speed it is meters per second.
- What is meant by the term “slope of a line”.

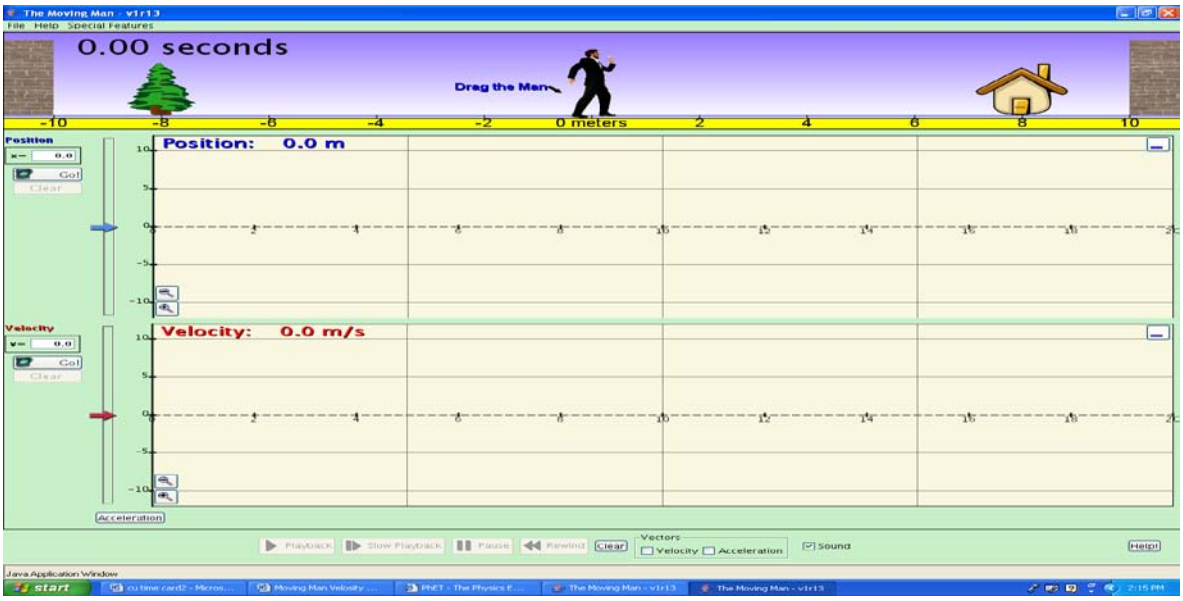
Activity & Simulation Instructions-

- This assignment is intended as an assignment the students will complete outside of class either at home or in a library.
- That the 0m point where the moving man is located is an arbitrary point and all distance measurements will be made from that point.
- That the positive and negative values on the position graph represent the direction the man moves from the 0m point.
- To close the acceleration graphs the students need to click on this symbol, located in the upper right hand corner of the acceleration graph
- Give the students a descriptive vocabulary to use in their description of a graph. For example;

Description of	Samples of descriptive phrases		
Direction	Moving from ____ to ___	Moving away from observer	Moving towards observer
Speed	Standing still	Moving slow	Moving fast

Learning Goals – The students will:

- Develop a general knowledge of “Velocity vs. Time” graphs and “Distance vs. Time” graphs
  - What graphs of a person standing still would look like
  - What graphs of a person moving away from an observer at a constant speed would look like.
  - What graphs of a person moving towards an observer at a constant speed would look like.
  - How differences in speed appear on the graphs



Moving Man - Velocity vs. Time Graphs (Lesson 4)

Student Pages

Background – Remember graphs are not just an evil thing your teacher makes you create, they are a means of communication. Graphs are a way of communicating by using pictures and since a picture is worth a thousand words knowing how to make and interpret graphs will save you a lot of writing.

Learning Goals – The students will:

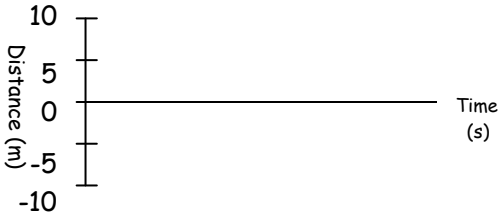
- Develop a general knowledge of "Velocity vs. Time" graphs and "Distance vs. Time" graphs
  - What graphs of a person standing still would look like
  - What graphs of a person moving away from an observer at a constant speed would look like.
  - What graphs of a person moving towards an observer at a constant speed would look like.
  - How differences in speed appear on the graphs

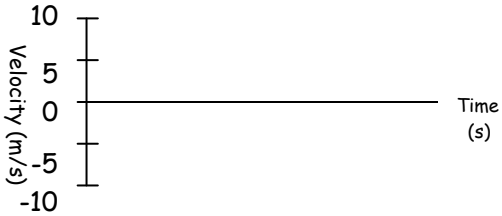
Screen 1

Procedure – Do the following activity using this web site
http://www.colorado.edu/physics/phet/simulations-base.html
Then click on "The Moving Man"

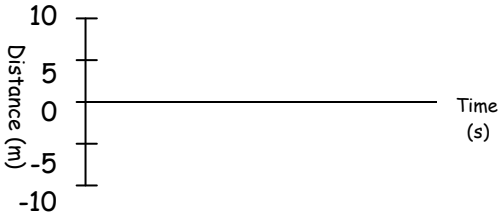
1. **Getting started.** After "The Moving Man" is open leave the position graph and the velocity graph open but close the acceleration graph. Your screen should look like screen 1.
2. **Making observations.** By either clicking on the man or the slider cause the man to move back and forth and observe what shows up on the graphs. Using the axis provided below make sketches of Distance vs. Time and Velocity vs. Time graphs for the actions described next to each axis.

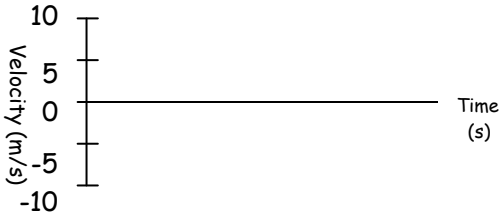
A man moving from 0 to 10 at a slow steady pace.



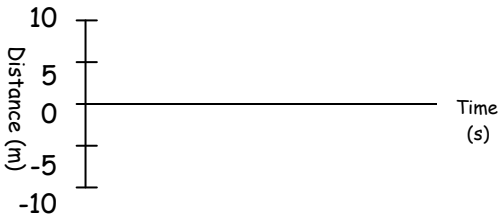


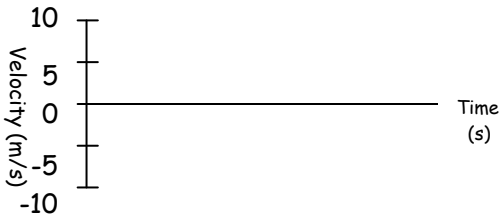
A man moving from 0 to 10 at a fast pace.





A man standing still at 4 m

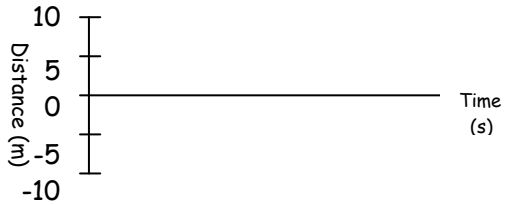


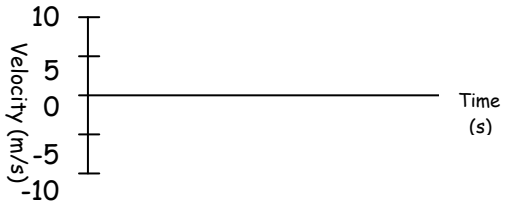


Moving Man - Velocity vs. Time Graphs (Lesson 4)

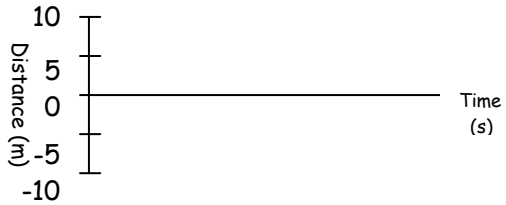
A man moving from 0 to 10 at a fast pace the moving back to 0 at a slow pace.

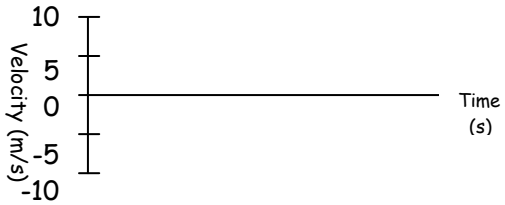
A man moving from 0 to -10 at a fast pace the moving back to 0 at a slow pace.



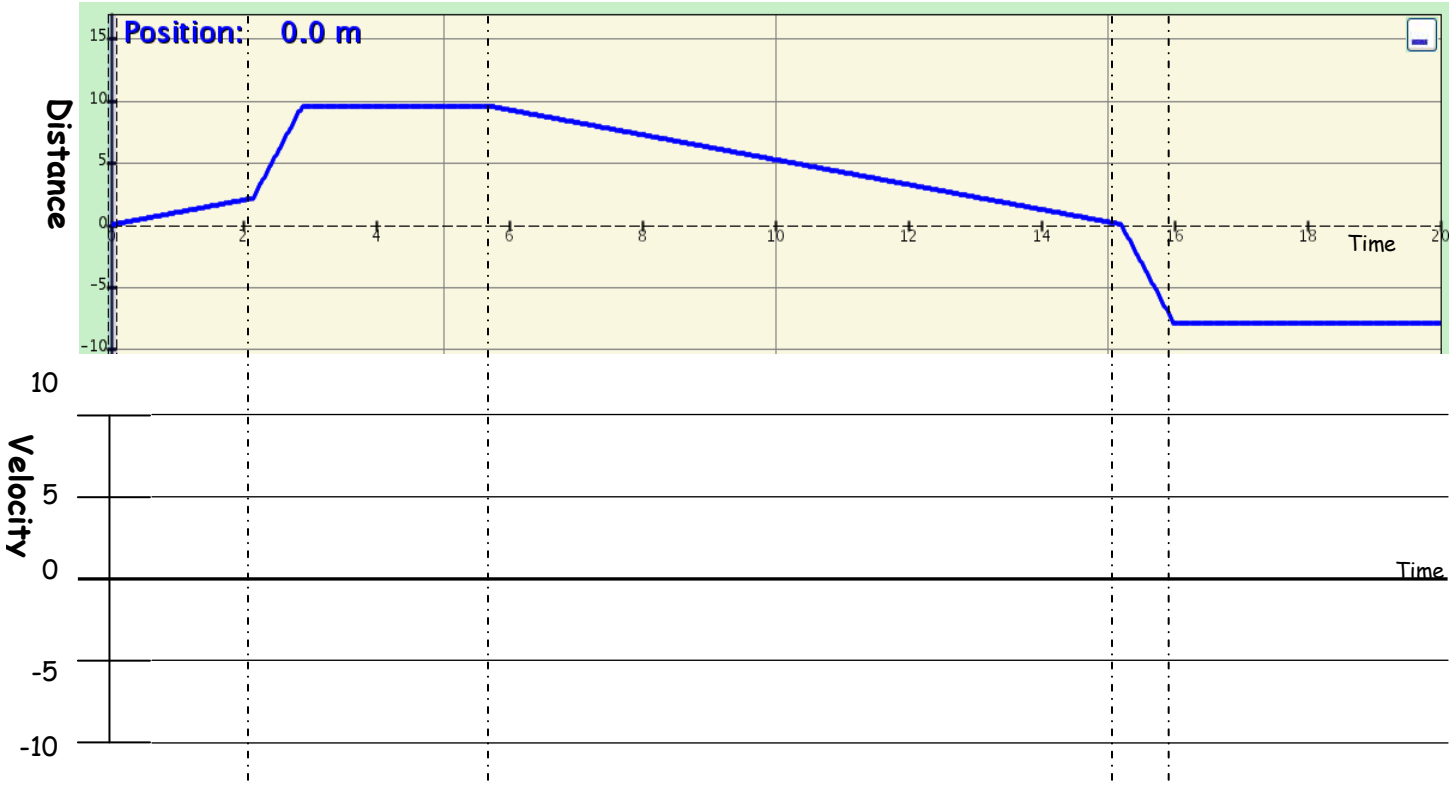


A man moving from 10 to 0 at a fast pace.



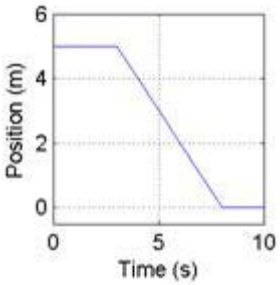


Apply what you learned. Look at the Distance vs. Time graph below and for the different parts of the graph that are marked by the dotted lines make the corresponding Velocity vs. Time graph directly below each part.



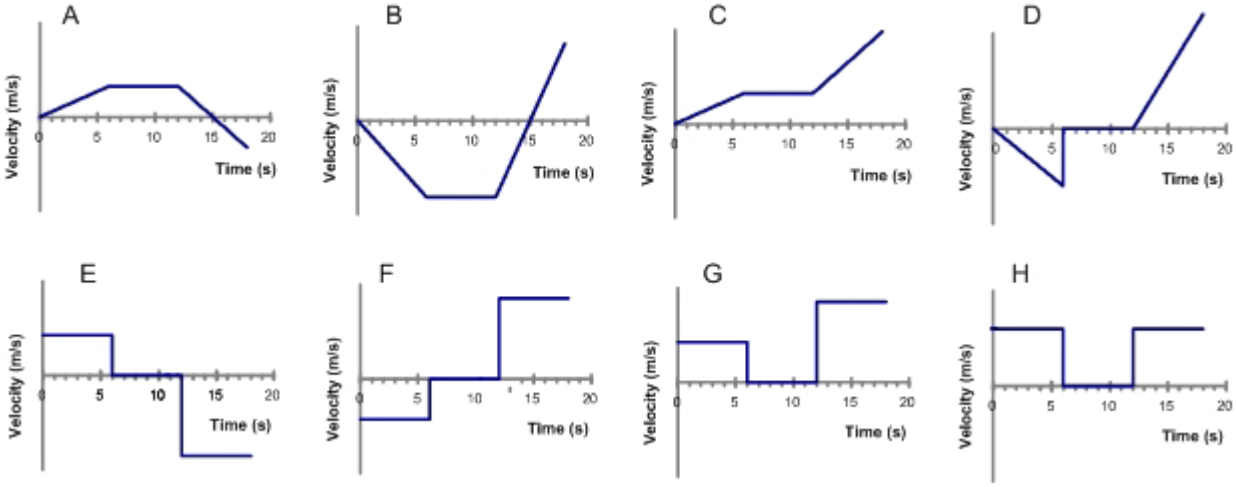
Prelab and Postlab questions for Moving Man (Lesson 4)

1. Below is a graph of a balls motion. Which of the following gives the best interpretation of the ball's motion?

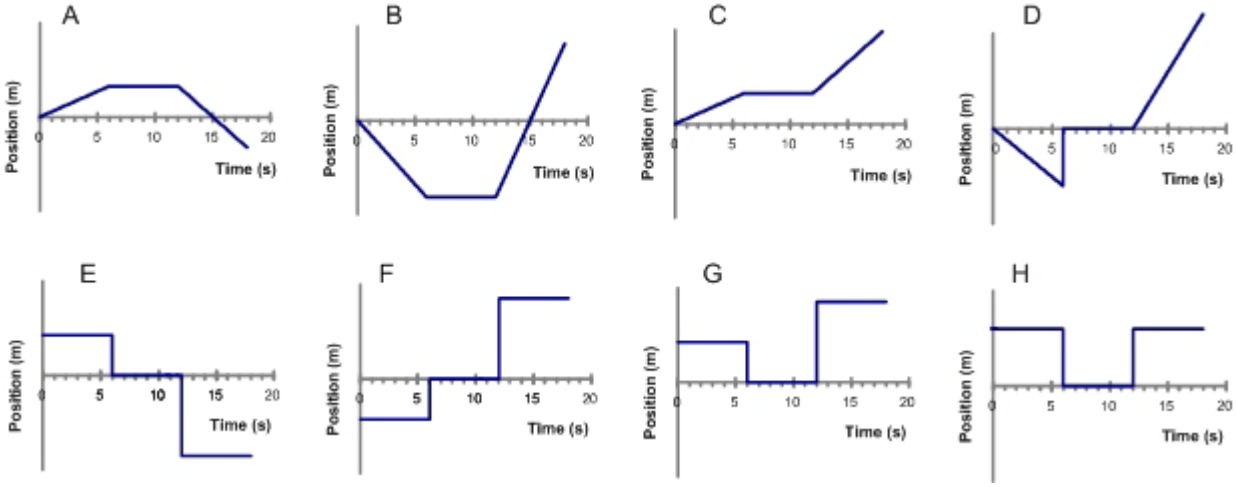


   a. The ball moves along a flat surface. Then it moves forward down a hill, and then finally stops.
   b. The ball doesn't move at first. Then it moves forward down a hill and finally stops.
   c. The ball is moving at constant velocity. Then it slows down and stops.
   d. The ball doesn't move at first. Then it moves backwards and then finally stops.
   e. The ball moves along a flat area, moves backwards down a hill and then it keeps moving.

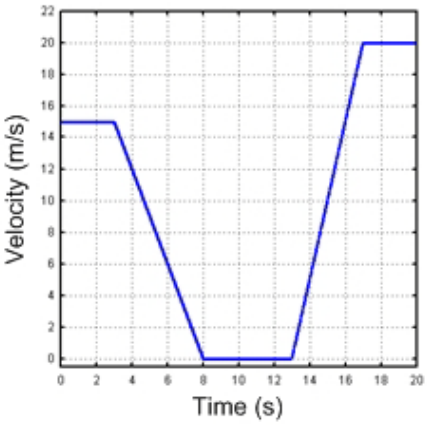
2. Which graph would best depict the following scenario? A man starts at the origin, walks back slowly and steadily for 6 seconds. Then he stands still for 6 seconds, then walks forward steadily about twice as fast for 6 seconds. Note that these are ***velocity-time*** graphs.



3. For the same scenario as # 2, which ***position-time*** graph best depicts the motion?



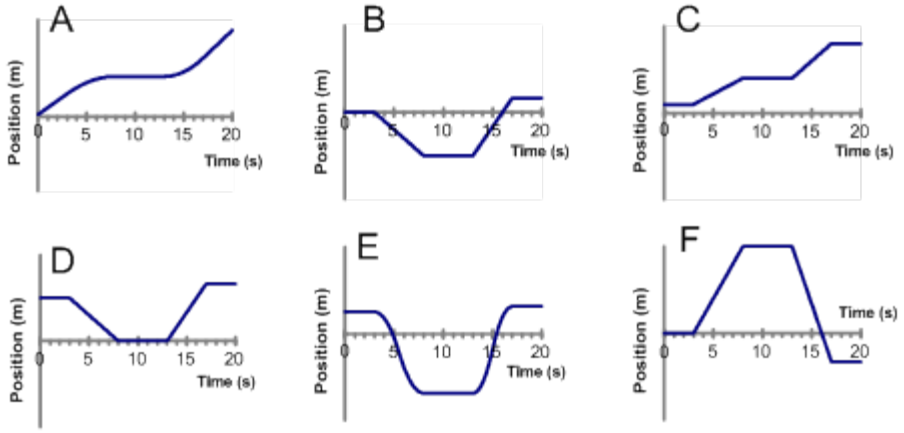
4. A car is traveling along a road. Its velocity is recorded as a function of time and is shown in the graph below.



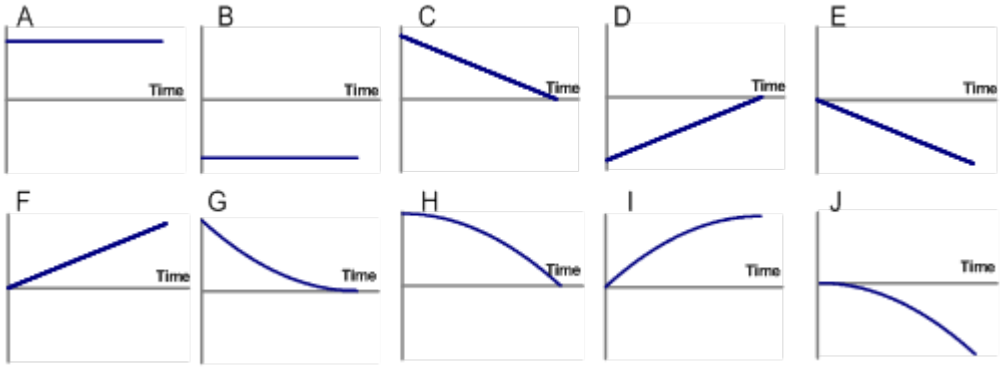
During which intervals is the car accelerating? Choose all the answers that apply.

a. between 0 and 3 seconds
b. for a brief instant at 3,8,13 and 17 seconds
c. between 3 and 8 seconds
d. between 8 and 13 seconds
e. between 13 and 17 seconds
f. between 17 and 20 seconds

5. Which of the following ***position-time*** graphs would be consistent with the motion of the car in question #4?



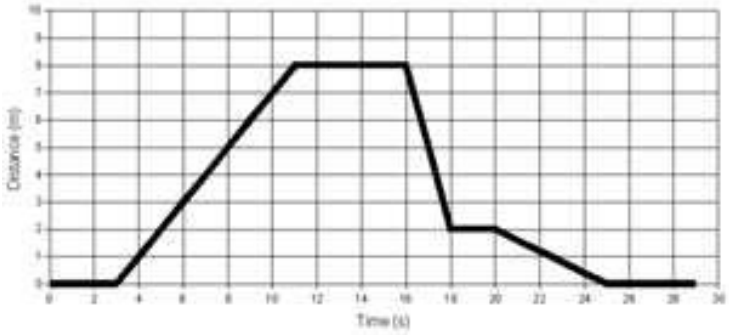
6. A car is moving forward and applying the break. Which ***position-time*** graph best depicts this motion?



Quiz: Motion (Lesson 4) **Name:**

PART 1: Use the distance vs. time graph below to answer questions 1 – 5:

Motion of a toy car



1. **How far did the toy car travel in 10 seconds?**
2. **Describe the motion of the toy car between 3 and 11 seconds (relative speed and direction).**
3. **Describe the toy car's motion between 18 and 20 seconds.**
4. **Using the formula, speed = distance/time, calculate the toy car's speed at 6 seconds.**
5. **Describe the relative speed and direction of the toy car between 20 and 25 seconds.**

PART 2: Short Answer/Word Problems – SHOW YOUR WORK, include correct UNITS:

6. **A runner moves a distance of 50 meters in 10 seconds. What is his average speed?**

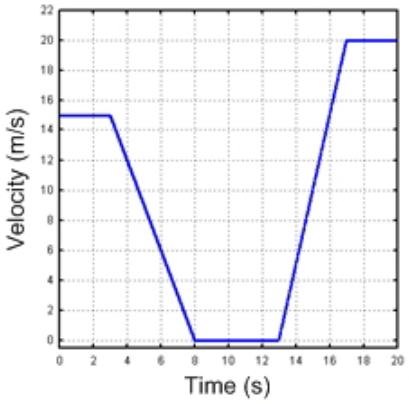
7. **Karen lives 10 km from school. If it takes 45 minutes for Karen to ride her bike to school, what is her average speed?**

8. **The fastest train on Earth, the *TGV* from France, can travel at an average speed of 320 miles per hour. How far will the train travel in 2.5 hours? (Distance = speed x time)**

9. **An airplane flies from California to Virginia at an average speed of 640 km/hr. A second plane flies from Virginia to California at an average speed of 640 km/hr. Compare/contrast the speeds and velocities of the two planes.**

10. **A horse trots around a track at a constant speed of 5 m/s. Is the horse accelerating? Explain your answer.**

PART 3: Use the velocity vs. time graph below to answer questions 11 – 15. The graph represents a 20 second portion of a bicycle trip. During this portion of the trip, the bicyclist was travelling south.



11. **What was the bicyclist's velocity at 6 seconds?**

12. **When did the bicyclist reach a speed of 20 m/s?**

13. **During which time interval did the bicyclist slow down?**

14. **During which time interval did the bicyclist speed up?**

15. **During which time interval did the bicyclist stop?**