3.1 Position, Speed, and Velocity

How are position, speed, and velocity related?

Knowing an object's position and measuring how fast or slow it is moving can be helpful, but not always precise enough for science. Sometimes it is important to also know in what direction an object is moving.

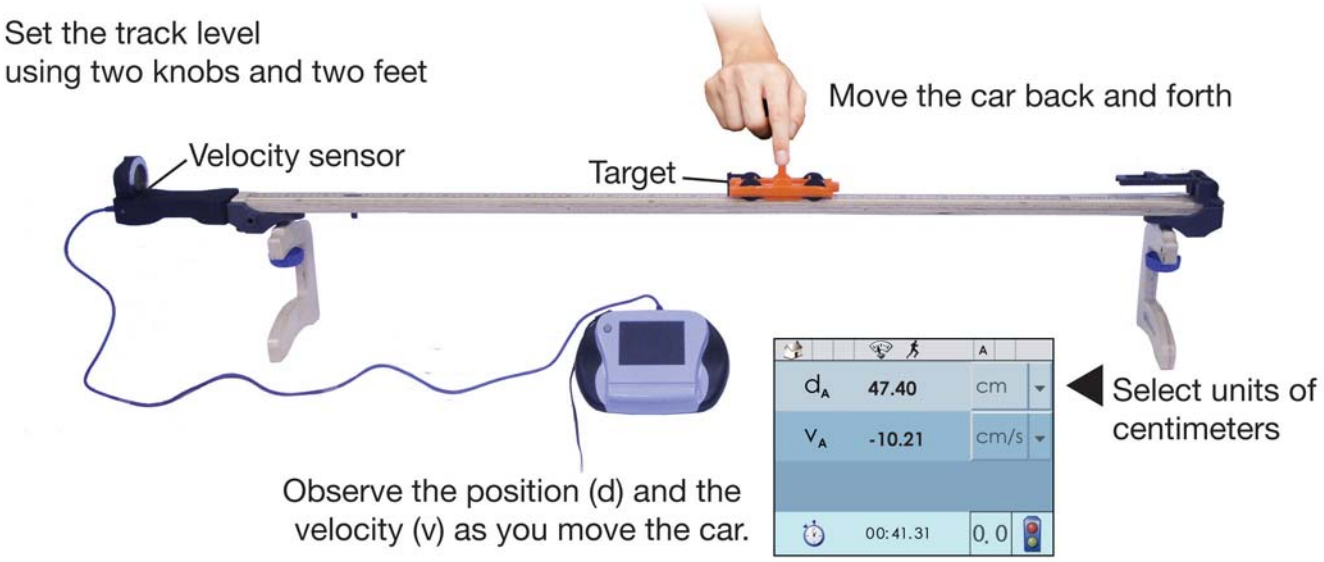
In this investigation, you will:

- measure increases and decreases in positions values.
- measure positive and negative velocity.
- compare speed and velocity.

Materials List

- DataCollector
- SmartTrack
- Energy Car
- Physics Stand
- Graph paper
- Bubble level
- Distance-Velocity sensor

1 Position



1. Attach the Distance-Velocity sensor to the track, then attach the communication cable so that one end is plugged into the sensor and the other is plugged into the A slot of the DataCollector.
2. Set up the SmartTrack so it is approximately level using the bubble level. You may need to slide a few sheets of paper under one end of the track to make it level.
3. Set the DataCollector to Meter mode. The units will default to centimeters for position, or distance, (d) and centimeters/second for velocity (v).
4. Attach the target to the car and place the car at the center of the track so the target is positioned near the 50cm mark, initially leaving the car at rest.
5. Move the car backward toward the sensor and forward away from the sensor along the track. Observe the values of position and velocity. Answer the questions below using this set up.

2 Thinking about what you observed

a. Did you observe both increasing and decreasing positions? If so, describe when the position increaseds positive and when it decreased.

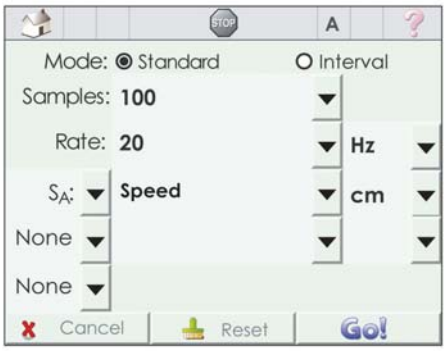
b. Did your position value change sign? What do you think it would take to see a negative position?

c. The default zero position is at the 0 centimeter mark on the SmartTrack. If the zero were at the center of the track, would you expect see a sign change when you run this same experiment?

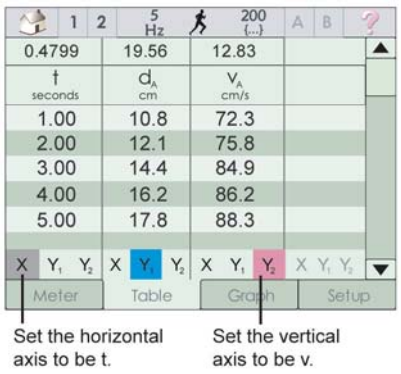
d. What is velocity? What determines when the velocity value changes sign?

3 Speed and velocity

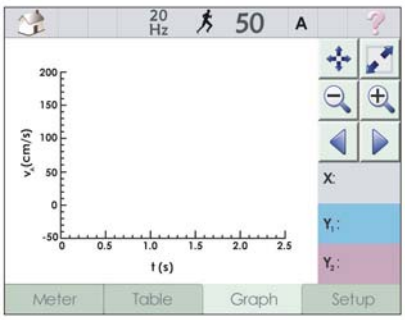
1. Use the same set up of the EnergyCar and SmartTrack as you did for part 1 of this investigation.
2. Start a new experiment by going to the home screen and tapping data collection.



3. Tap setup on the menu bar at the bottom of the screen. Set the samples to 100 and the rate to 20 Hz. This will give you five seconds to move the car back and forth on the track.
4. Select Speed and cm/s as your measurement input. The other two inputs should be set to None.
5. Once again, you will begin the experiment with the car at the center of the track, but instead of moving the car back and forth randomly, create a plan with your group on how you are going to move the car for the entire five seconds. Decide in which direction and how fast or slow you will move the car. Make at least three changes in direction, come to a complete stop at least once, move the car fast at least once, and slow at least once. Write out your plan using words and arrows indicating direction and speed. Use a step-by-step approach and describe what should be done during each step. Each step should describe some kind of change.
6. Hit the go button to start the experiment.
7. In order to watch the velocity change in real time on a graph when you move your car on the track, switch to the Graph tab.
8. Move your car according to your plan and watch the graph it makes.



9. Take careful note of what the graph does as you move your car. Write these notes next to each instruction on your list. You will need to be able to make a connection between what is being displayed on the graph and how the car is moving.
10. To repeat the experiment with the current setup, tap Setup tab and hit Repeat.



4 Analyzing the data

a. Describe the graph you see. Make a careful sketch of the graph on a piece of graph paper and label the axes.

b. When is the velocity positive? When is it negative?

c. Velocity is a change in position divided by a change in time. Speed is a change in distance divided by a change in time. What is the difference between a change in position and a change in distance?

d. Look at your sketch of the velocity vs. time graph. If you were to use this graph to make a speed vs. time graph, how would the two graphs be different? How would the two graphs be similar?

e. Use your sketch of the velocity vs. time graph to make a sketch of a speed vs. time graph. Do you think you could make an accurate velocity vs. time graph from a speed vs. time graph? Why or why not?

f. Look at your sketch of your velocity vs. time graph. Match up the steps from your plan with the places on the graph where they occur. Describe what each step created on your graph. Be descriptive, and state what the shape of the graph looks like at each step; if it created a straight line, a curve, whether it is sloping up or down, and whether it is in the positive or negative region of your graph.

g. Set up the experiment as you did for section 3. Instead of the written steps, use the sketch you made from part 3 as your guide, and try to match the DataCollector's graph to the sketch as you move the car. Describe how well your group was able to match the graph, what you found difficult, and what you found easy. Keep trying until you get a good match.

h. *Challenge*: Set up the experiment again. Trade sketches with another group. See if you can match their sketch with your DataCollector's graph as you move the car using their sketch as your guide. Trade sketches with as many groups as time permits. Describe your successes and challenges as you match their graphs. Make a speed vs. time sketch based on each velocity vs. time sketch you try to match.