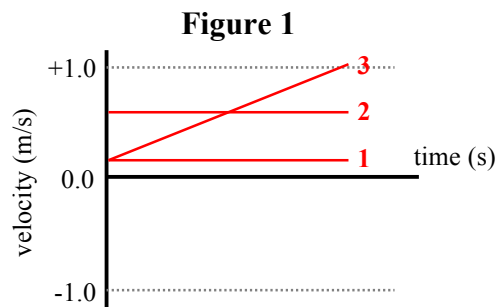


Velocity versus Time Graphs

A moving object can be described by its velocity. **Velocity** refers to how fast an object is moving (known as **speed**) AND in what direction. A plus (+) or minus (-) sign is often used as an indicator of direction. So an object with a velocity of -34 m/s is moving with a speed of 34 m/s in the - direction. A group of students conduct an investigation of how a velocity vs. time graph can be used to describe motion. Using a motion detector connected to a computer, they move in a variety of ways and observe the corresponding plots of velocity vs. time on the monitor.

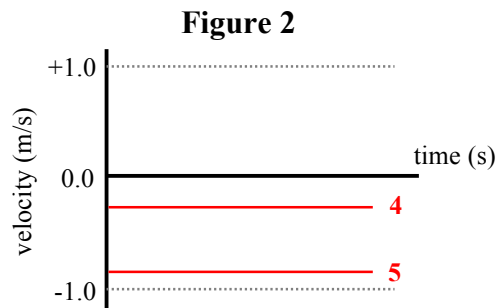
Experiment 1:

The students move away from the detector in three separate trials. In trial 1, they move slowly at a constant speed. In trial 2, they move fast at a constant speed. In trial 3, they change their speed from slow (initially) to fast (finally). The plots for the three trials are shown in **Figure 1**.



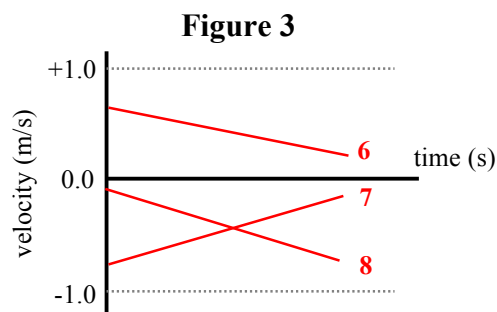
Experiment 2:

The students conduct two constant speed trials. In trial 4, they move towards the detector slowly. In trial 5, they move towards the detector, but with a faster speed than in trial 4. The plots for the two trials are shown in **Figure 2**.



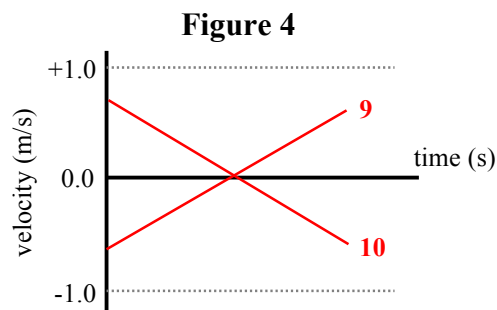
Experiment 3:

The students conduct three changing speed trials. In trial 6, they walk away from the detector from fast to slow. In trial 7, they walk towards the detector from fast to slow. In trial 8, they walk towards the detector from slow to fast. The plots for the three trials are shown in **Figure 3**.



Experiment 4:

The students finally constructed a ramp and obtained a cart that rolled along the ramp. The cart was given a push from the bottom of the ramp. The cart decreased its speed as it rolled up the ramp, it turned around, and it increased its speed as it rolled down the ramp. They performed Trial 9 with the motion detector at the top of the ramp. In trial 10, the motion detector was at the bottom of the ramp. See **Figure 4**.

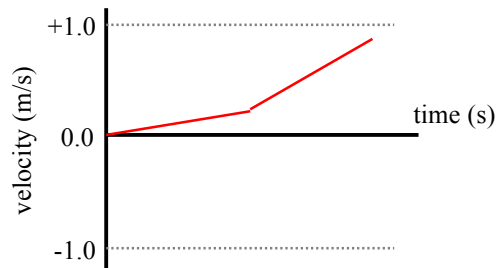


Questions:

1. How do the lines on the velocity-time graph differ for moving towards the motion detector compared to moving away from the motion detector?
 - a. When moving towards the detector, the line slopes upward; when moving away from the detector, the line slopes downward.
 - b. When moving towards the detector, the line slopes downward; when moving away from the detector, the line slopes upward.
 - c. When moving towards the detector, the line is above the axis; when moving away from the detector, the line is below the axis.
 - d. When moving towards the detector, the line is below the axis; when moving away from the detector, the line is above the axis.
2. After completing **Experiment 1**, students concluded that a fast object is represented by a line that is higher on the graph. How must this conclusion be modified (if at all) in order to be consistent with the results from **Experiment 2**?
 - a. A fast object is represented by a line that is far above or far below the time axis.
 - b. A fast object is represented by a line that is diagonal and finishes high on the graph.
 - c. There is no need to modify the conclusion since it is consistent with both experiments.
 - d. Nonsense! The students were wrong from the beginning. A fast object has a large slope.
3. What information is provided by the observations in Experiment 2 that was not provided by observations in Experiment 1?
 - a. **Experiment 2** shows what the velocity-time plots look like when objects slow down.
 - b. **Experiment 2** shows what the velocity-time plots look like when objects move fast.
 - c. **Experiment 2** shows what the velocity-time plots look like for constant speed motion.
 - d. **Experiment 2** shows what the velocity-time plots look like when objects move towards the detector.
4. Based on the plotted velocity values in **Experiment 4**, how is the negative (-) direction defined?
 - a. The negative direction is up the hill.
 - b. The negative direction is down the hill.
 - c. The negative direction is towards the motion detector.
 - d. The negative direction is away from the motion detector.
5. What vital information is provided by the observations in **Experiment 4** that were not provided by observations in the other three experiments?
 - a. **Experiment 4** reveals how the graph looks when objects are at rest.
 - b. **Experiment 4** reveals how the graph looks when objects slow down.
 - c. **Experiment 4** reveals how the graph looks when objects change their direction.
 - d. **Experiment 4** reveals how the graph looks when objects other than people move.

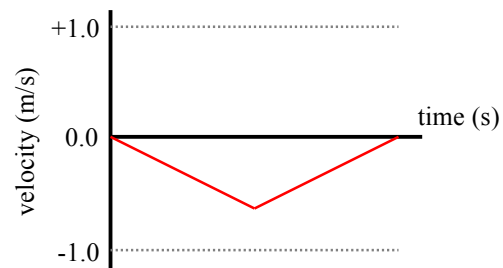
6. Which statement below describes the line on a velocity-time graph for any object that is slowing down?
- The line is diagonal and sloping downward.
 - The line is diagonal and located in the negative (-) velocity region.
 - The line is diagonal and sloping downward and located in the negative (-) velocity region.
 - The line is diagonal and in either + or - velocity region, but sloping towards the time axis.
7. Based on **Experiment 4**, what conclusion can be made regarding the line on a velocity-time graph for an object that is changing direction?
- The line has an upward slope and then a downward slope, or vice versa.
 - The line begins above the axis and later is below the axis, or vice versa.
 - The line begins as a diagonal line and changes to a curved line, or vice versa.
 - The line begins as a horizontal line and changes to a diagonal line, or vice versa.

8. As the group of students continued to experiment, they produced a variety of different graphs. One of them looked like the graph at the right. Which statement describes how they moved to create the velocity-time graph at the right?



- They moved slowly; then changed directions and moved fast.
- They moved away from the detector slowly at a constant speed; then they moved much faster in the same direction.
- They moved away from the detector slowly at a constant speed; then they moved much faster, but in a different direction than before.
- Starting from rest, they moved away from the detector while speeding up; they then continued speeding up but at a more rapid rate.

9. As the group of students continued to experiment, they produced a variety of different graphs. One of them looked like the graph at the right. Which statement describes how they moved to create the velocity-time graph at the right?



- They moved away from the detector at a constant speed; then they moved towards the detector at a constant speed.
- They moved towards the detector at a constant speed; then they moved away from the detector at a constant speed.
- They moved from slow to fast in one direction; then they moved from fast to slow in the opposite direction.
- They moved towards the detector while speeding up; then they moved towards the detector while slowing down.