3.2.4: Instantaneous Velocity

Figure 2.3.1

In a footrace such as the one shown here, the initial velocity of a runner is zero. The runner increases his velocity out of the starting blocks and his velocity continues to increase as the race proceeds. For the well-trained athlete, his highest velocity is maintained through the finish line.

Instantaneous Velocity

The **instantaneous velocity** of an object is the velocity of the object at a given moment. If the object is moving with constant velocity, then the instantaneous velocity at every moment, the average velocity, and the constant velocity are all the same.

Position vs Time Graphs

Consider a position versus time graph for an object starting at t=0 and x=0 that has a constant velocity of 80. m/s.

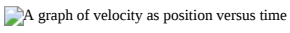

Figure 2.3.2

The velocity of an object can be found from a position vs time graph. On a position vs time graph, the displacement is the vertical separation between two points and the time interval is the horizontal separation. The ratio of displacement to time interval is the average velocity. This ratio is also the slope of the line. Therefore, the slope of the straight line is the average velocity. For the motion pictured above,

$$\text{slope} = \text{rise}/\text{run} = \Delta d/\Delta t = 400.\text{m}/5.0\text{s} = 80.\text{m/s}$$

For accelerated motion (the velocity is constantly changing), the position vs time graph will be a curved line. The slope of the curved line at any point is the instantaneous velocity at that time. If we were using calculus, the slope of a curved line could be calculated. Without calculus, we approximate the instantaneous velocity at a particular point by laying a straight edge along the curved line and estimating the slope.

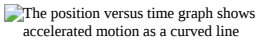

Figure 2.3.3

In the image above, the red line is the position vs time graph and the blue line is an approximated slope for the line at t=2.5 seconds. The rise for this slope is approximately 170 m and the time interval (run) is 4.0 seconds. Therefore, the approximated slope is 43 m/s.

Swimming is another sport in which the velocity of the swimmer is constantly changing over time. In simulation below, adjust the sliders to change the swimmer's expertise in the Butterfly Stroke. Then, try to derive the instantaneous velocity of the swimmer at various points in the race using the position-time graph:

Summary

- The slope of a position versus time graph is the velocity.
- For constant velocity motion, the slope gives the constant velocity, the average velocity, and the instantaneous velocity at every point.

- For constant acceleration motion, the slope of the position versus time curve at a particular point gives the instantaneous velocity at that point.

Review

Draw a velocity versus time graph for an object whose constant velocity is 15 m/s and whose position starts at x=0 when t=0. Graph the motion for the first 5.0 seconds.

Use the graph below to answer the following questions:

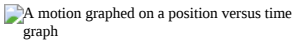

Figure 2.3.4

1. For the motion graphed in the position versus time graph shown above, what is the average velocity in the time interval 1 to 3 seconds?
2. For the motion graphed in the position versus time graph shown above, what is the average velocity in the time interval 3 to 4 seconds?
3. For the motion graphed in the position versus time graph shown above, what is the average velocity in the time interval 5 to 6 seconds?

Explore More

Use this resource to answer the questions that follow.

1. In the graph on the video, what is graphed on the vertical axis?
2. What is graphed on the horizontal axis?
3. What does the slope of this graph represent?

Additional Resources

PLIX: Play, Learn, Interact, eXplore: Changing Speeds

Real World Application: The Reality of Speeding

Video:

Study Guide: Motion Study Guide
