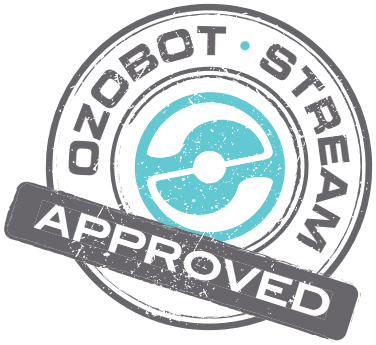

Ozobot Bit Classroom Application:

Velocity as Slope of Position vs. Time Graphs

Created by

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Topics

Mathematics, Science, Physics

Ages

Grades 7-12

Duration

40-50 minutes

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Introduction

The study of the motion of an object, without regard to the object's mass and forces causing the motion, is known as ***kinematics***. Graphs of position, velocity, and acceleration versus time are commonly used to aid in visualization of kinematics. For example, if we begin with a position vs. time graph of an object moving along a straight line, then the *slope* tells us the *velocity* of the object. Unlike ***speed***, which tells us only how fast an object is moving, ***velocity*** tells us how fast *and* in what direction the object is moving. Consider an object moving along a straight line, similar to the real number line, with positive number positions on the right and negative number positions on the left. If the object is moving to the right, then its velocity would be positive. If the object is moving to the left, then its velocity would be negative.

Figure 1 shows a possible position (x) vs. time (t) graph for such an object. From time 0 to t_1 the object is moving to the right—velocity and slope are positive. From time t_1 to t_2 the object is at rest, since its position is constant—velocity and slope are zero. From time t_2 to t_3 the object is moving to the left, since it position is decreasing—velocity and slope are negative. The object's *speed* is greater from time 0 to t_1 than it is from time t_2 to t_3 since the slope is steeper from time 0 to t_1.

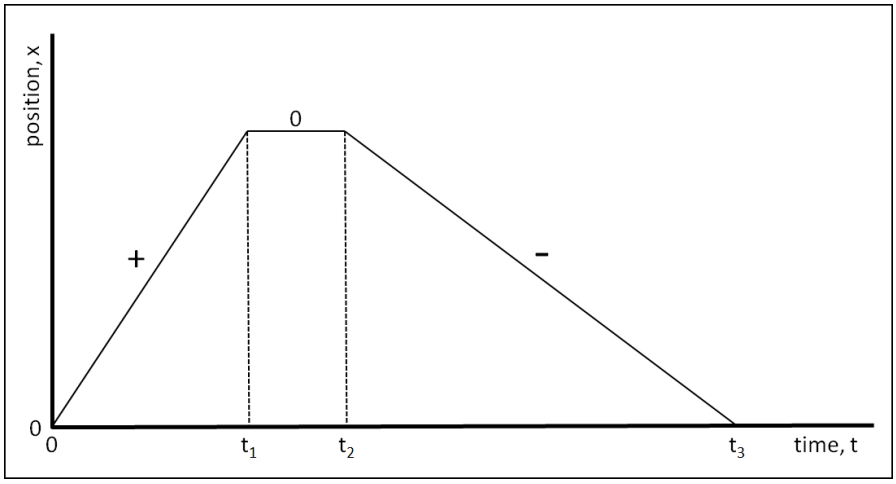


Figure 1

By using the provided OzoBlockly program and an OzoMap drawn on a 1.5 meter piece of adding machine tape, your students will make a position vs. time graph for Ozobot Bit and compute velocity from the slope of the graph. Each lab group will need a meter stick and a stop watch or stop watch app on a cell phone in addition to an Ozobot Bit loaded with the OzoBlockly program *kinematics.ozocode*.

The OzoMap for this Classroom Application

Student lab groups will be creating the OzoMap for this classroom application on a piece of adding machine tape that is about 1.5 meters long. The OzoMap should appear similar to that shown in Figure 2. Using Ozobot Washable Markers or other similar markers, a line is drawn down the center of the length of adding machine tape. Any of the marker colors black, red, green, or blue will do. Again, using markers, four short lines (A, B, C, and D) perpendicular to the long line are drawn. There should be about 2 inches of the black line to the left of marker A and to the right of marker D. Markers B and C can be placed anywhere between markers A and D—they need not be in the same locations as shown in Figure 2. The four markers divide the long line into three segments AB, BC, and CD. Lab groups should place markers B and C in such a way that none of the three segments is shorter than approximately a foot. If any of the three segments is quite short, then time measurements for that segment may be quite short, leading to greater percentage error in timing that segment. Each of the three segments should be of somewhat different lengths—there is no need for them to be equal in length.

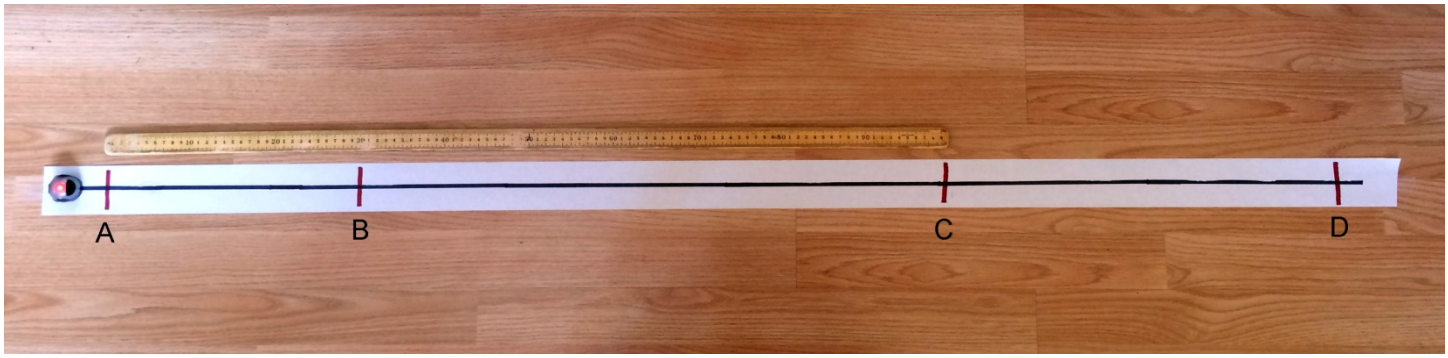
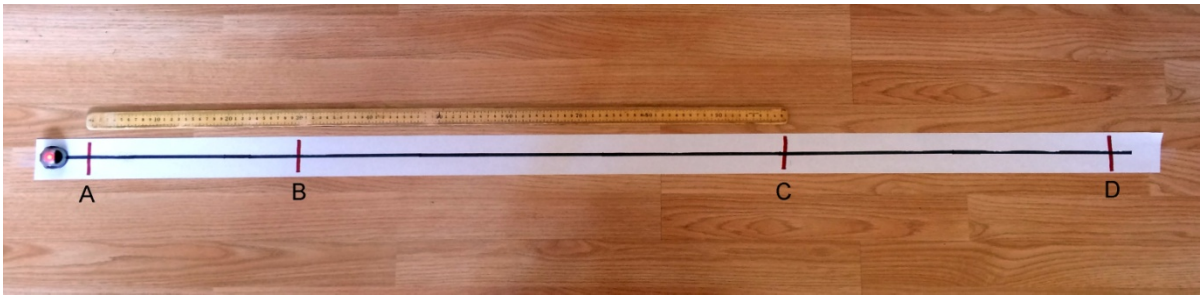


Figure 2

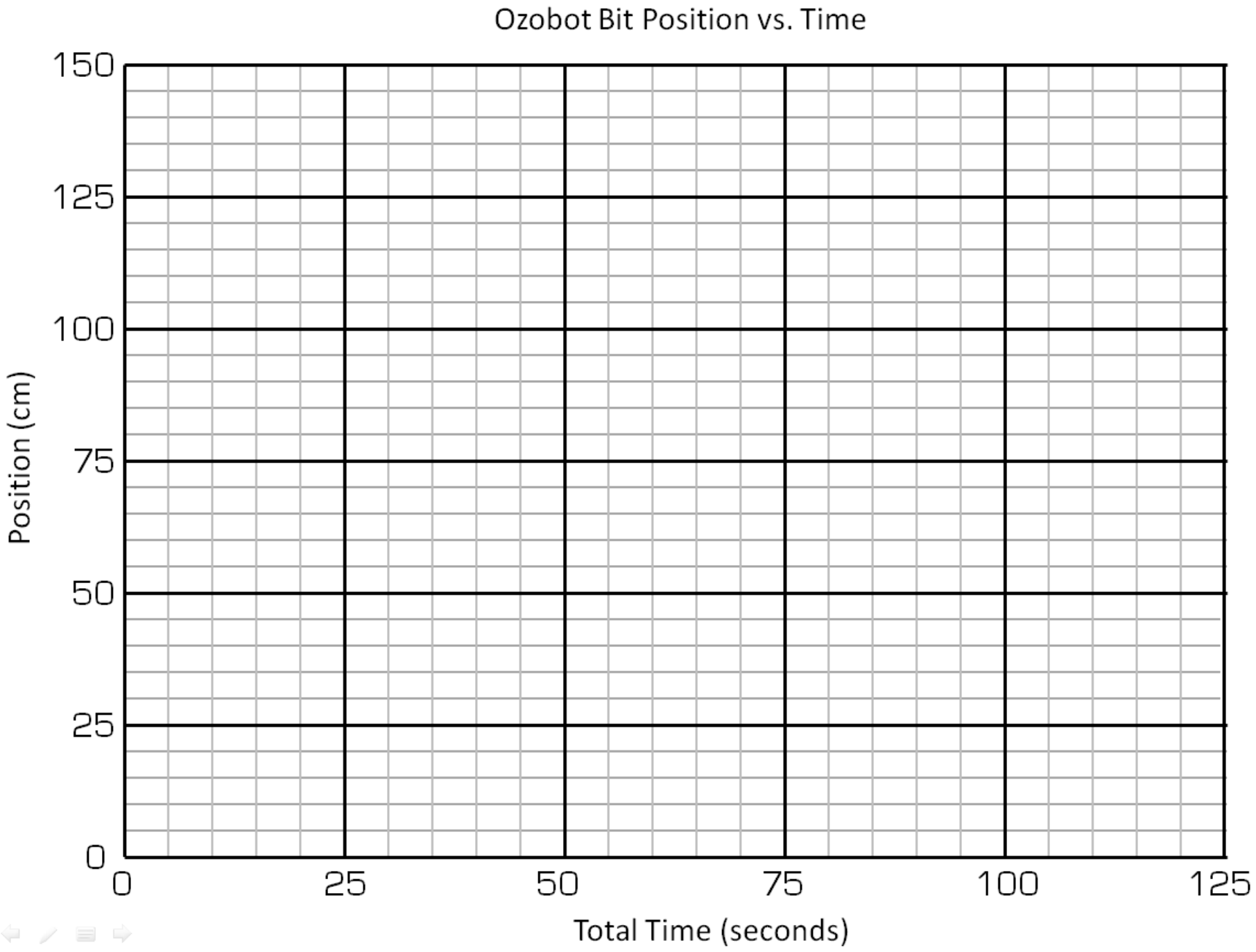
The OzoBlockly program *kinematics.ozocode* that is loaded into Ozobot Bit will cause Ozobot Bit to make a roundtrip on the tape, from A to B, B to C, C to D, D to C, C to B, and B to A. Ozobot will travel at different constant speeds in each of these six portions of the round trip. With Ozobot Bit located at the far left end of the tape, he should be started by double-pressing the start button. He will then display a red LED for the entire trip. Students should start their stop watch or cell phone stop watch app when Ozobot Bit's leading edge meets marker A. Total travel time should then be recorded when Ozobot Bit reaches markers B, C, D, C, B, and A during the round trip. If it is easier with their stop watch or stop watch app to get "lap" times for each of the six segments, then total times can be obtained by adding successive lap times together.

Students also need to record the position of each of the markers in cm, with position zero at marker A. Note that the left end of the meter stick is placed at marker A as the zero point for position. Data on position and total times can be recorded in the data table shown on page 3 of this document. Then data from the data table can be used to prepare a position vs. time plot on the graph on page 4. Student groups can then obtain the slope ($\Delta y/\Delta x$) of each of the six regions of the position vs. time graph in order to determine Ozobot Bit's velocity in each of the six regions. Students should find it interesting to compare their six velocities with the actual speed settings used in the OzoBlockly program: 45 mm/s, 25 mm/s, 75 mm/s, 15 mm/s, 50 mm/s, and 35 mm/s, respectively. Note that OzoBlockly uses *mm/s*, whereas the students' unit of velocity is *cm/s*.

Data Table for Ozobot Bit Kinematics Experiment



Point	Lap Time (s)	Total Time (s)	Position (cm)
A			
B			
C			
D			
C			
B			
A			

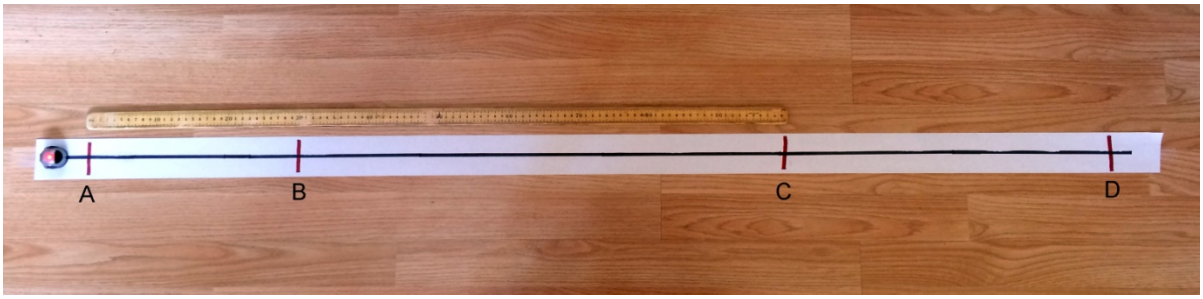

Ozobot Bit Position vs. Time
150
125
100
75
50
25
0
Position (cm)
0
25
50
75
100
125
Total Time (seconds)

Preparation for the Lesson

1. Make a copy of pages 3 and 4 for each lab group.
2. You must use Ozobot Bits.
3. Load each of the Ozobot Bits with the OzoBlockly program *kinematics.ozocode*.
4. Make sure that the Ozobots are fully charged, calibrated for paper, have clean wheels, and the motors are tuned.
5. The students should start their Ozobots by double-pressing the start button, with Ozobot Bit at the left end of the tape and facing to the right.

For the Teacher: Typical Results

Data Table for Ozobot Bit Kinematics Experiment



Point	Lap Time (s)	Total Time (s)	Position (cm)
A	0	0	0
B	6.45	6.45	29.5
C	27.17	33.62	98.9
D	6.54	40.16	144.8
C	35.25	75.41	98.9
B	14.63	90.04	29.5
A	8.22	98.26	0

Note: *Data will vary from lab group to lab group, as the positions for points B, C, and D will be different for each lab group.*

For the Teacher: Example Ozobot Bit Position vs. Time Graph