I. Objectives

1. Collect, graph, and analyze real-world data.
2. Calculate velocity and acceleration from a graph.
3. Use one-dimensional kinematic equations.

II. Introduction

This lab involves outdoor activities. You must wear closed-toed shoes during this entire lab.

This lab consists of two parts. In the first, a walker will attempt to walk with constant velocity. To determine whether he or she was successful, distance will be plotted against time, and a straight line will indicate that the student was able to maintain a constant velocity. In the second, the walker will try to move with constant acceleration, and change in velocity will be plotted against time. Again, a straight line will indicate that the student was successful in maintaining constant acceleration.

Students will time the walker as he or she passes pre-measured points along a line. The data will be analyzed and displayed as a graph, and conclusions made about the walker's ability to perform as intended.

III. Calculations

Part 1 Constant Velocity

We will utilize the concepts of velocity, which is change in distance divided by change in time:

$$v = \frac{\Delta x}{\Delta t}$$

Thinking about this mathematically, it is the same as calculating the slope of a line:

$$m = \frac{\Delta y}{\Delta x}$$

In this case the distance x is the vertical axis coordinate and the time t is the horizontal axis coordinate.

To compute the average velocity:

$$\bar{v}_n = \frac{x_n - x_{n-1}}{t_n - t_{n-1}}$$

Part 2 Constant Acceleration

In the second part, the goal for the walker is to maintain a constant acceleration. Acceleration is defined as instantaneous velocity divided by time. We don't have a means for measuring instantaneous velocity, but can use the average velocity between each pair of points and timers.

To compute the average acceleration:

$$\bar{a}_n = \frac{\bar{v}_n - \bar{v}_{n-1}}{t_n - t_{n-1}}$$

IV. Equipment and Materials

Meter tape, stop watches, calculator

V. Procedure

Part 1 Constant Velocity

1. One timer will stand at the starting point of the meter tape, and others with stopwatches will be arranged along the line at appropriate distances. When the walker passes the timer at the starting point indicates that the trial has begun, all timers must start their stopwatches, then stop them as the walker passes.

2. Record the walker's times for the two trials in Table 1.

3. Compute the average velocities using adjacent pairs of values. For example, $\bar{v}_1 = \frac{x_1 - x_0}{t_1 - t_0}$.

4. For Trial 1, graph time *t*, the horizontal axis coordinate value, and distance *x*, the vertical axis coordinate value. You must include a line generated by the spreadsheet program, not a hand drawn line, connecting each point for this trial to the adjacent point. This line may not be straight overall, but will be straight, not curved, between each set of adjacent points.

5. On the same graph, graph the data for Trial 2. You must include a line generated by the spreadsheet program, not a hand drawn line, connecting each point for this trial to the adjacent point. This line may not be straight overall, but will be straight, not curved, between each set of adjacent points. Staple the graph to the lab.

Part 2 Constant Acceleration

6. This part of the lab will be completed using the same method as used in Part 1, but the walker will attempt to walk with a constant acceleration.

7. Record the walker's times for the two trials in Table 2.

8. Compute the average velocities using the same method used to calculate those in Table 1.

9. Compute the average accelerations using adjacent pairs of values. For example, $\bar{a}_1 = \dfrac{\bar{v}_1 - \bar{v}_0}{t_1 - t_0}$

10. Begin a new graph for this part of the lab. For Trial 1, graph time *t*, the horizontal axis coordinate value, and average velocity $\bar{v}$, the vertical axis coordinate value. You must include a line generated by the spreadsheet program, not a hand drawn line, connecting each point for this trial to the adjacent point. This line may not be straight overall, but will be straight, not curved, between each set of adjacent points.

11. On the same graph, graph the data for Trial 2. You must include a line generated by the spreadsheet program, not a hand drawn line, connecting each point for this trial to the adjacent point. This line may not be straight overall, but will be straight, not curved, between each set of adjacent points. Staple the graph to the lab.

VI. Data

Table 1 Times, Distances, and Average Velocities for Constant Velocity Walker

A	B	C	D	E	F	G	H
		Trial 1			Trial 2		
Data point number	Data point	Time t in s	Distance x in m	Average velocity $\bar{v}$ in m/s	Time t in s	Distance x in m	Average velocity $\bar{v}$ in m/s
0	(t_0, x_0)	0.0	0.0	0.0	0.0	0.0	0.0
1	(t_1, x_1)		10.0			10.0	
2	(t_2, x_2)		20.0			20.0	
3	(t_3, x_3)		30.0			30.0	
4	(t_4, x_4)		40.0			40.0	
5	(t_5, x_5)		50.0			50.0	
6	(t_6, x_6)		60.0			60.0	
7	(t_7, x_7)		70.0			70.0	
8	(t_8, x_8)		80.0			80.0	
9	(t_9, x_9)		90.0			90.0	
10	(t_{10}, x_{10})		100.0			100.0	

Table 2 Times, Distances, Average Velocities, and Average Accelerations for Constant Acceleration Walker

A	B	C	D	E	F	G	H	I	J
		Trial 1				Trial 2			
Data point number	Data point	Time t in s	Distance x in m	Average velocity $\bar{v}$ in m/s	Average acceler-ation $\bar{a}$ in m/s^2	Time t in s	Distance x in m	Average velocity $\bar{v}$ in m/s	Average acceler-ation $\bar{a}$ in m/s^2
0	(t_0, $\bar{v}_0$)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	(t_1, $\bar{v}_1$)		10.0				10.0		
2	(t_2, $\bar{v}_2$)		20.0				20.0		
3	(t_3, $\bar{v}_3$)		30.0				30.0		
4	(t_4, $\bar{v}_4$)		40.0				40.0		
5	(t_5, $\bar{v}_5$)		50.0				50.0		
6	(t_6, $\bar{v}_6$)		60.0				60.0		
7	(t_7, $\bar{v}_7$)		70.0				70.0		
8	(t_8, $\bar{v}_8$)		80.0				80.0		
9	(t_9, $\bar{v}_9$)		90.0				90.0		
10	(t_{10}, $\bar{v}_{10}$)		100.0				100.0		

VII. Discussion Questions

Part 1 Constant Velocity

1. Was the walker able to walk at a constant velocity? Explain how you used the data on your graph to answer this question.

2. Were his or her velocities different for the two trials? What could account for any differences? Explain how you used the data on your graph to answer this question.

Part 2 Constant Acceleration

3. Was the walker able to walk with constant acceleration? Explain how you used the data on your graph to answer this question.

4. Were his or her accelerations different for the two trials? What could account for any differences? Explain how you used the data on your graph to answer this question.

5. Which of the two parts of this lab were more difficult for the walker? Why?

6. Describe a specific method that we could use to improve the data collection method and why the method you describe would be an improvement.