I. Objectives

1. Demonstrate an understanding of how to graph the motion of objects with constant, increasing, and decreasing velocities and constant, increasing, and decreasing accelerations.

II. Introduction

The goal of kinematics is to develop models to describe and explain the motion of real-world objects using words, diagrams, numbers, graphs, and equations. Using these models we can make predictions about the behavior of moving objects in relation to other objects to help us understand the laws of physics and apply them to real-world situations.

Linear kinematics usually begins by studying the linear motion of an object. We can graph the object's velocity using the *x*-axis to represent time, and the *y*-axis to represent distance, and its acceleration using the *x*-axis to represent time, and the *y*-axis to represent velocity.

III. Calculations

The equation for velocity is:

$$v = \frac{x - x_0}{t - t_0} = \frac{\Delta x}{\Delta t}$$

The equation for acceleration is:

$$a = \frac{v - v_0}{t - t_0} = \frac{\Delta v}{\Delta t}$$

A displacement versus time graph, where time is plotted on the x-axis and displacement is plotted on the y-axis, describes velocity. The slope of the line at a particular displacement and at a particular time provides the velocity at that instant, and some information about the motion of the object:

- If the line on the graph is horizontal and linear, meaning that its slope is zero, then the object's displacement is not changing and its velocity is zero. This does not, however, imply that its displacement is zero, just that the object is at a particular location and is staying at that location as time passes.
- If the line on the graph is not horizontal but is linear, meaning that its slope is constant and not zero, then the object's displacement is changing as time passes, but its velocity is constant.

- As the *magnitude* (the absolute value) of the slope increases, *not* necessarily the actual *value* of the slope, meaning that the line becomes more slanted either upwards or downwards, the *change* in velocity increases.
- As the *magnitude* of the slope decreases, *not* necessarily the actual *value* of the slope, meaning that the line becomes more flattened, the *change* in velocity decreases.
- If the line on the graph is vertical and linear, we have a situation that violates the laws of physics!

A velocity versus time graph, where time is plotted on the x-axis and velocity is plotted on the y-axis, describes acceleration. The slope of the line at a particular velocity and at a particular time provides the acceleration at that instant, and some information about the motion of the object:

- If the line on the graph is horizontal and linear, meaning that its slope is zero, then the object's velocity is not changing and its acceleration is zero. This does not, however, imply that its velocity is zero, just that the object is not speeding up, slowing down, or changing direction as time passes.
- If the line on the graph is not horizontal but is linear, meaning that its slope is constant and not zero, then the object's velocity is changing as time passes, but its acceleration is constant.
- As the *magnitude* (absolute value) of the slope increases, *not* necessarily the actual *value* of the slope, meaning that the line becomes more slanted either upwards or downwards, the *change* in acceleration increases.
- As the *magnitude* of the slope decreases, *not* necessarily the actual *value* of the slope, meaning that the line becomes more flattened, the *change* in acceleration decreases.
- If the line on the graph is vertical and linear, we again have a situation that violates the laws of physics!

Additional assumptions about representing the motion of objects on distance versus time and velocity versus time graphs:

- Negative time values are not included unless specifically included in a problem.

IV. Equipment and Materials

Graph paper, calculator

V. Procedure

1. Work with your lab partner to answer the following questions.

VI. Discussion Questions

1. Draw an example of a distance versus time graph for an object with constant, non-zero velocity. **Label the axes and include the correct units for each axis.**

2. What does the slope of the line on this graph represent? Does the slope change? Why or why not?

3. If an object has zero velocity what does its distance versus time graph look like? Why?

4. Draw an example of a distance versus time graph for an object whose change in velocity magnitude is increasing. **Label the axes and include the correct units for each axis.**

5. What does the slope of the line on this graph represent? Does the slope change? Why or why not? How does the slope change with time?

6. Draw an example of a distance versus time graph for an object whose change in velocity magnitude is decreasing. **Label the axes and include the correct units for each axis.**

7. What does the slope of the line on this graph represent? Does the slope change? Why or why not? How does the slope change with time?

8. Draw an example of a velocity versus time graph for an object with a constant, non-zero acceleration. **Label the axes and include the correct units for each axis.**

9. What does the slope of the line on this graph represent? Does the slope change? Why or why not?

10. If an object has zero acceleration what does its velocity versus time graph look like? Why?

11. Draw an example of a velocity versus time graph for an object whose change in acceleration magnitude is increasing. **Label the axes and include the correct units for each axis.**

12. What does the slope of the line on the graph represent? Does the slope change? Why or why not? How does the slope change with time?

13. Draw an example of a velocity versus time graph for an object whose change in acceleration magnitude is decreasing. **Label the axes and include the correct units for each axis.**

14. What does the slope of the line on this graph represent? Does the slope change? Why or why not? How does the slope change with time?

15. Based on the assumptions listed above, why is it not likely that points on a displacement versus time graph or velocity versus time graph will appear to the left of the y-axis?

16. Why can the motion of an object on a distance versus time graph never be represented by a vertical line? What would that imply about the object? What law of physics would this situation violate?