INSTANTANEOUS VERSUS AVERAGE VELOCITY
PHYSICS 221: CLASSICAL PHYSICS I

Name: ____

Lab Date: ___________________________ Due Date: ______________________________

Lab Partner(s): ____

Introduction

An *average velocity* can be a useful value. If you know that you will average 50 miles per hour on a 200 mile trip, it is very easy to determine how long the trip will take: four hours. On the other hand, the highway patrolman following you does not care about your average speed over 200 miles. He wants to know how fast you are driving at the instant his radar strikes your car, so he can determine whether or not to give you a ticket. He wants to know your *instantaneous velocity*.

In this experiment you will investigate the relationship between instantaneous and average velocities, and see how a series of average velocities can be used to deduce an instantaneous velocity.

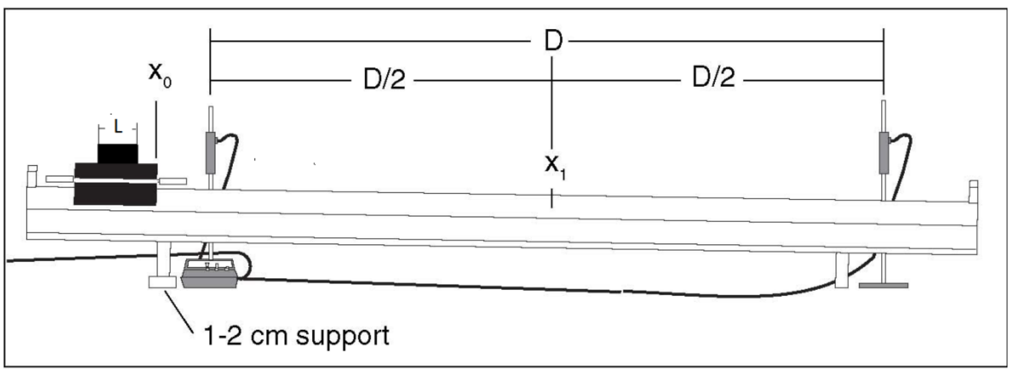

Figure 1.1: Setting Up the Equipment

Procedure

1. Set up the air track as shown in Fig.1.1, elevating one end of the track with a 1-2 cm support.
2. Choose a point $\mathbf{x_1}$ near the center of the track. Measure the position of $\mathbf{x_1}$ on the air track metric scale, and record this value in Table I.

3. Choose a starting point $\mathbf{x_0}$ for the glider, near the upper end of the track. With a pencil, carefully mark this spot on the air track so you can always start the glider from the same point.
4. Place the Photogate Timer and Accessory Photogate at points equidistant from $\mathbf{x_1}$, as shown in the figure. Record the distance between the photogates as **D** in Table I.
5. Set the slide switch on the Photogate Timer to PULSE.
6. Press the RESET button.
7. Hold the glider steady at $\mathbf{x_0}$, then release it. Record time $\mathbf{t_1}$, the time displayed after the glider has passed through both photogates.
8. Repeat steps 6 and 7 at least four more times, recording the times as $\mathbf{t_2}$ through $\mathbf{t_5}$.
9. Now repeat steps 4 through 9, decreasing **D** by approximately 10 centimeters.
10. Continue decreasing **D** in 10 centimeter increments. At each value of **D**, repeat steps 4 through 8.
11. You can continue using smaller and smaller distances for **D** by changing your timing technique. Use just one photogate and place it at $\mathbf{x_1}$.
12. Set the timer to GATE. Now **D** is the length of the flag that is attached to the glider. Measure the length of the flag.
13. Start the glider from $\mathbf{x_0}$ as before, and make the measurement of the time it takes for the flag of the glider to pass through the photogate.
14. Repeat the measurement at least four more times.

Data and Calculations

1. For each value of **D**, calculate the average of $\mathbf{t_1}$ through $\mathbf{t_5}$. Record this value as $\mathbf{t_{avg}}$.
2. Calculate $\mathbf{v_{avg}} = \mathbf{D}/\mathbf{t_{avg}}$. This is the average velocity of the glider in going between the two photogates.
3. Plot a graph of $\mathbf{v_{avg}}$ versus **D** with **D** on the x-axis.

Questions

1. Which of the average velocities that you measure do you think gives the closest approximation to the instantaneous velocity of the glider as it passes through point $\mathbf{x_1}$**?**
2. Can you extrapolate your collected data to determine an even closer approximation to the instantaneous velocity of the glider through point $\mathbf{x_1}$? From your collected data, estimate the maximum error you expect in your estimated value.
3. In trying to determine an instantaneous velocity, what factors (timer accuracy, object being timed, type of motion) influence the accuracy of the measurement? Discuss briefly how each factor influences the result.
4. Can you think of one or more ways to measure instantaneous velocity directly, or is an instantaneous velocity always a value that must be inferred from average velocity measurements?

Table I. Data and Calculations

x_1=____________________________________

D (cm)	t_1 (s)	t_2 (s)	t_3 (s)	t_4 (s)	t_5 (s)	t_{avg} (s)	v_{avg} (cm/s)

Turn in

(a) This sheet of instructions with data and calculations.
(b) The graph of $\mathbf{v_{avg}}$ versus **D.**
(c) The answers to the questions.