## Lab 4 Motion in One-Dimension Part 2: Position, Velocity and Acceleration Graphically and Statistically (pre-requisite Lab3)

## Objectives:

- To obtain an understanding of position, velocity, and acceleration for one-dimensional motion
- To understand how graphs can be used to describe changes in position, velocity and acceleration of an object moving along a straight line
- To be able to interpret and produce graphs of position, velocity and acceleration
- To understand and be able to use graphical and statistical methods to determine the average velocity from both position and velocity graphs
- To understand and be able to use graphical and statistical methods to determine the average acceleration from both velocity and acceleration graphs
- To understand the sign of the acceleration and velocity for different parts of motion


## Equipment

- Computer
- LabPro computer interface
- Motion detector
- Real-Time physics mechanics experiment configuration files (software)
- White board
- Cart
- Fan to attach to cart
- Track
- Ball


## Exploration 5 Graphing position, velocity and acceleration graphs

Exploration 5.1 Predict the position vs. time, velocity vs. time, and acceleration vs. time graphs for the following motions:

- Start 0.2 m from the motion detector, and move away from the motion detector slowly and steadily.
- Start 0.2 m from the motion detector, and move away from the motion detector speeding up at a constant rate.
- Start 0.2 m from the motion detector, and move away from the motion detector slowing down at a constant rate.
- Start 2.0 m from the motion detector, and move toward the motion detector speeding up at a constant rate.

Sketch your predictions in the graphs below.


Start 0.2 m from the motion detector, and move away from the motion detector slowly and steadily.


Start 0.2 m from the motion detector, and move away from the motion detector speeding up at a constant rate.


Start 0.2 m from the motion detector, and move away from the motion detector slowing down at a constant rate.


Start 2.0 m from the motion detector, and move toward the motion detector speeding up at a constant rate.

Exploration 5.2 Open the experiment file "Position, Velocity, and Acceleration Graphs (L01AX-X)" to set up the axes.

Walk in front of the motion detector to create position vs. time, velocity vs. time, and acceleration vs. time graphs you predicted in Exploration 5.1.

Save the graphs using the store command. Compare the graphs to your predictions.

## Investigation 2 Average acceleration

Investigation 2.1 Calculate the average acceleration two ways from the velocity vs. time graphs for the last two motions in Exploration 5.1.

First record the two methods:

Method 1 $\qquad$

Method 2 $\qquad$

Graph 1 moving away slowly:

Average acceleration Method 1 $\qquad$

Average acceleration Method 2 $\qquad$

Graph 2 moving toward, speeding up:

Average acceleration Method 1 $\qquad$

Average acceleration Method 2 $\qquad$

Investigation 2.2 Calculate the average acceleration two ways from the acceleration vs. time graphs for the last two motions in Exploration 5.1.

Record the two methods:

Method 1 $\qquad$

Method 2

Graph 1 moving away slowly:

Average acceleration Method 1 $\qquad$

Average acceleration Method 2 $\qquad$

Graph 2 moving toward, speeding up:

Average acceleration Method 1 $\qquad$

Average acceleration Method 2 $\qquad$

Investigation 2.3 Do the values found in parts Investigation 2.1and Investigation 2.2 agree? Explain.

## Exploration 6. Constant acceleration

Exploration 6.1 At your table is a cart, a fan to attach to the cart and a track. Attach the fan to the cart. Set up the motion detector at one end of the track. Place the fan-cart on the track about the middle of the track. Turn on the fan and observe the motion. Which way does the fan need to point to accelerate towards the detector? To accelerate away? Catch the cart before it falls off the track or hits the motion detector.

Set the fan-cart up close to the detector so that if you start the fan and then give it a small push away from the detector, the fan will slow the cart down as it moves. Set it up so that the cart after the initial push slows down, stops and moves in the other direction. Adjust your push so that you can observe this motion one or two times. Do not turn on the motion detector yet. Catch the cart before it falls off the track or hits the motion detector!

Without turning on the motion detector, sketch graphs of position vs. time, velocity vs. time and acceleration vs. time below. (These are predictions.)


Exploration 6.2 Now open the experiment file "Position, Velocity, and Acceleration Graphs (L01AX-X)" to set up the axes, turn on the motion detector and take data for position vs. time, velocity vs. time and acceleration vs. time.

Save the graphs using the store command. Compare the graphs to your predictions.

## Exploration 7 Sign of velocity and acceleration

Exploration 7.1 For the motion in Exploration 6, fill out the following table with the sign of the velocity and acceleration at different parts of the motion. For each box, write,+- or 0 to indicate if the velocity or acceleration are positive, negative or zero during that part of the motion.

|  | Moving away | At the turning point | Moving toward |
| :--- | :--- | :--- | :--- |
| Velocity |  |  |  |
| Acceleration |  |  |  |

Are your answers in agreement with your graphs in Exploration 6? If not, discuss and settle the disagreement.

Exploration 7.2 Throw a ball up in the air and catch it. Sketch a graph the position, velocity and acceleration vs. time on the graphs below.


Exploration 7.3 For the motion in Exploration 7.2, fill out the following table with the sign of the velocity and acceleration at different parts of the motion. For each box, write,+- or 0 to indicate if the velocity or acceleration are positive, negative or zero during that part of the motion.

|  | Moving away | At the turning point | Moving toward |
| :--- | :--- | :--- | :--- |
| Velocity |  |  |  |
| Acceleration |  |  |  |

Are your answers in agreement with your graphs in Exploration 7.2? If not, discuss and settle the disagreement.

How is this motion similar to that of the cart in Exploration 6? Explain.

