Physics 103 Laboratory
Fall 2011

Lab #2: *Position, Velocity and Acceleration*

Introduction

In this lab, we will study one-dimensional motion looking at position (x), velocity (v) and acceleration (a) which can apply to many situations, e.g., driving a car, launching a rocket and flying a plane. Which car will win in a drag race: the car with the greater top speed or the car with the greater acceleration? Well, that's a trick question because it depends upon the circumstances, but after today's lab you will be able to make this kind of calculation.

POSITION

The *position of an object (x)* describes where the object is in the context of a reference frame, which for us will be a coordinate system. The MKS unit for position is ***meter*** (m).

DISPLACEMENT

The distance an object travels is called its *displacement (x final - x initial)* The MKS unit for displacement is again ***meters***.

VELOCITY

The *velocity* (*v*) of an object is its displacement per unit time (*t).* The MKS units for velocity are ***meters per second(m/s)***

Displacement can be written as a continuous function of time, *x(t)*; and then we can compute the average velocity,

$$\bar{v} = \frac{x - x_0}{t - t_0} \tag{2.1}$$

and instantaneous velocity,

$$v = \frac{dx}{dt} = \dot{x} \tag{2.2}$$

Note that the equation for (instantaneous) velocity is obtained by considering average velocity over infinitesimal time intervals. If you were to plot the position of our object with respect to time, the *slope* of the tangent line to the curve at any point $x(t_a)$ would be the (instantaneous) velocity of the object, $\dot{x}(t_a)$ or $v(t_a)$ at that time.

ACCELERATION

The relationship between acceleration and velocity-parallel that of velocity and position. The acceleration is the time rate of change of velocity. The MKS units for acceleration are ***meters per second squared (m/s^2).***

That is to say, if my velocity is changing, I am accelerating. If this is the case, and velocity **can be written as a continuous function of time, v(t), then we can compute the average** acceleration,

$$\bar{a} = \frac{v - v_0}{t - t_0}, \tag{2.3}$$

and instantaneous acceleration,

$$a = \frac{dv}{dt} = \dot{v} = \frac{d^2x}{dt^2} = \ddot{x} \tag{2.4}$$

If you were to plot the velocity of an object versus time, the *slope* of the tangent line to the curve at any point would be the (instantaneous) acceleration of the object at that time.

Experiment

Turn on your computer and the Science Workshop 750 Interface. Open the Data Studio software. Choose "Create Experiment." An image of the 750 interface should appear on the screen. Under "Sensors," scroll down to and double click on "Motion Sensor." It will show a yellow plug to port 1 and a black plug to port 2. Make this connection for your motion sensor.

Set the sensor on one end of the track in front of the magnetic bumper aimed to take data along the track. Double click on "Graph" under "Displays" to the left side of the screen. Select "Position, Ch 1&2 (m); Velocity, Ch 1&2 (m/s); and Acceleration, Ch 1&2 (m/s^2)." Expand the graph and scale for time measurements from zero to 10 s and position measurements of 2.0 m or less. You're now ready to take data.

CONSTANT VELOCITY

Put a track car on the track. While watching the velocity graph, move the cart down the length of the track at a constant velocity. Each one of you should do this a couple of times to get a feel for this motion. Pick out the one with the steadiest velocity and perform the following analysis:

1. Pick two points on the position graph where the curve is very linear and compute the slope. Sketch the position vs. time graph and record your computed slope.
   Slope____________________
2. Sketch the velocity curve.
3. What is the value of the velocity during the same time period as in (1)?
   Velocity_____________
4. How does this compare to the slope of position vs. time during the same interval?
   ____
5. Sketch the acceleration curve. What is the average acceleration during the same time period as in (1)? **Acceleration______________** Does this make sense? Yes___No_____

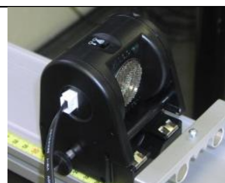
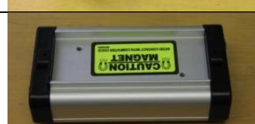
INCREASING VELOCITY

Again, put a track car on the track. While watching the velocity graph, move the cart down the length of the track at a steadily increasing velocity. Each one of you should do this a couple of times to get a feel for this motion. Pick out the one which has the most linear velocity plot and perform the following analysis:

6. Display and sketch the graphs for position, velocity and acceleration vs. time. Pick two points on the velocity graph where the curve is very linear and compute the slope.
7. What is the value of acceleration over the same interval? **Acceleration**_______________How does this compare to the slope of velocity vs. time for that period?_______________
8. What is the shape of the position curve? _________

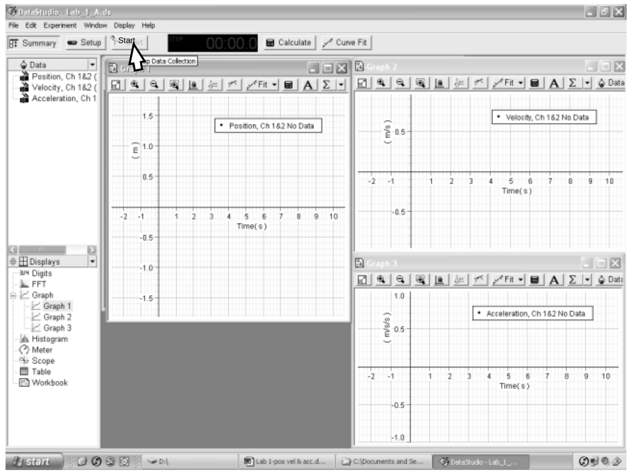
Lab Report **a)** answer to question above; **b**) sketch of lab set up **c)**; sketch of (Pos/Vel/Accel) graphs for
1) Constant velocity
2) Increasing velocity

Equipment:

Motion Sensor	
Force Sensor	
Dynamics Cart	
Track	

PASCO 750 interface


Set motion sensor to narrow beam



Display of position/velocity/acceleration vs time