# Physics 122 - Lab 1

**Goal:** To understand the relationship between position, velocity and acceleration for 1-D motion.

**Equipment:** Motion Detector, Computer Interface, Computers, Spheres/balls.

## Procedure

1. With the motion detector mounted above the benchtop, drop each of the spheres to the floor from a point 15 cm below and directly under the detector. Gather data for each of the sphere's position, velocity and acceleration as a function of time.

2. Repeat (1) for each of the spheres but this time toss the spheres up to the motion detectors from a point directly below the detectors. Make sure that the spheres do not approach the detectors any closer than 15 cm. Attempt to keep the motion of the spheres along a straight line. It's probably a good idea to practice your tosses several times before gathering data.

3. Gather and discuss about your observation. Predict what you would observe if you drop a heavy ball from a point and let it bounce a couple of times under the detector. Repeat (1) for the ball and compare with your prediction.

4. Gather and predict what you would observe if you drop a beach ball from a point. Repeat (1) for the beach ball, and compare the result with your prediction.

## Analysis

1. Plot graphs of position, velocity and acceleration as a function of time using the data you acquired during each of the 4 experiments.

2. Choose one group of data, and use the position vs. time data to determine the velocity vs. time graph by 'differentiating' the position data using the mathematical definition of the derivative. Use several t values to explore the effect of taking the limit as $\Delta t$ approaches zero.

3. Repeat (2), but this time operate on the velocity vs. time data to get the acceleration vs. time plot.

## Questions

1. Discuss the relationships between the signs of the position, velocity and acceleration for the second experiment.

2. Compare the v(t) and a(t) graphs you obtained directly from the motion detectors with those you obtained by differentiating the x(t) and v(t) curves. Discuss why (or why not) the curves you obtained by 'hand differentiation' look more like those the motion detectors measured as t gets smaller.

3. Discuss the differences and similarities between the x, v and a vs. t curves for the two spheres, and the beach ball. Why do you think that there are differences?

4. Compare the x(t) and v(t) curves for all 4 experiments with those that constant acceleration kinematics would predict. Discuss any similarities or differences between 'theory' and 'experiment'.

**<u>What you need to turn in</u>**

1. x(t), v(t) and a(t) graphs for each of the 4 experiments obtained from the motion detectors.

2. v(t) and a(t) graphs obtained by 'hand differentiation' of the x(t) and v(t) curves for 3 different values of t.

3. Your answers to all 4 questions. Including your graphs and the lab report cover page, your report should not be more than 7 pages long.

**<u>Important information</u>**

The motion detectors use the transit time of an ultra sound pulse to measure the distance between an object and the detector. The resolution of the timing circuitry is insufficient to measure distances smaller than about 15 cm. i.e., the time for the pulse to 'bounce back' to the detector is too short for the detector to measure. So, the motion detectors measure the distance to the first object in the 15° cone they detect. Keep this in mind if your data looks funny.

**<u>Definitions</u>** :

$v(t) = dx/dt, a(t) = dv/dt$, if a is constant, these expressions can be integrated to get : $v(t) = v_0 + at, x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

Mathematical definition of a derivative :

$$\frac{dy(x)}{dx} = \lim_{\Delta x \to 0} \frac{y(x + \Delta x) - y(x)}{\Delta x}$$