

## Lab 4

### Kinematics 2D

#### *Examining Kinematic Equations in Two Dimensions*

##### **Abstract**

In this lab we will experimentally uncover the equations that govern motion during constant acceleration. The objective of the experiment is to see the immediate connection between the act of investigating a phenomenon by experimentation (in this case, the occurrence of motion undergoing constant acceleration) and the construction of a mathematical model describing the particular phenomenon.

##### **Background**

The motion of objects undergoing constant acceleration is very common. Anything flying through the air or rolling or sliding downhill is motion undergoing constant acceleration. This is because the force of gravity produces a uniform acceleration down, of  $9.8 \text{ m/s}^2$ . What we want to determine is the mathematical nature of this motion. In other words, we want to come up with a set of equations that will predict the motion of objects undergoing constant accelerations.

##### **Materials**

Ball  
Meter stick  
Finepix Camera  
Computer with logger pro software  
Ball launcher with bucket

##### **Procedures**

For each experiment plot the x-position and y-position vs time on a graph and the x-velocity and y-velocity on a graph and then use the fitting tools to get the best fit for the lines of motion. Save or print the graphs including the best fit data. Have one set of graphs for each group. Write equations to predict location and velocity of the ball using the data generated from your video analysis. Compare your experimental numbers with what you know about constant acceleration motion and what they should be. Differences between experimental results and ideal conditions should be discussed in the discussion section of your lab report.

Use the supplied USB cable and connect the camera to the computer. You will need to move the movies from the camera to the computer. To do this, press the “Start” button → “My Computer” and click. A window should open showing the hard drive, CDROM/DVD, and Finepix camera. Click on the Finepix camera until you find the movie files then move the movie files to the desktop. The video analysis setup procedures are listed at the end of the experiment descriptions.

There is only one ball launcher so groups will have to rotate through the different experiments staggering the experiment each team begins with. The video analysis is similar to the 1-D lab we did previously. Remember to include a meter stick or other measuring device in the video for creating the scale.

### Experiment 1:

Record one team member tossing a ball vertically up and then catching it. Analyze the video plotting position vs time and velocity vs time using a curve fit for the line to find acceleration. You might need to do more than one to get a good graph to find acceleration.

### Experiment 2:

Record the motion of the ball being tossed being tossed between two team members. You might need to do this more than once to get a good graph. Remember you need to hold the camera steady so that all the projectile motion is captured with the camera.

### Experiment 3:

*There is only one ball launcher, so teams will need to take turns recording the motion from the ball launcher.*

The velocity of the steel ball from the ball launcher is about 3.38 m/s (using the strongest setting on the launcher). At what angle and time will the steel ball land in the bucket placed 1.5 meters away on the ground from the ball launcher? Make a prediction based on what you know about projectile motion and the motion equations. After making your prediction, launch your ball using your angle and see if you were right. If not, move the bucket (recording the distance from the launcher) so the ball will land in the bucket. When you make the target, video the motion and use the information from the video analysis to refine the terms of your equation. Yes, that means figuring out the initial velocity using the video analysis.

### Video initialization process:

Open LoggerPro 3.5

Insert → Movie, choose the video you saved to the computer.



Click this button to open the options on the right side of video screen.



Set the pixel scale. Click the scale button and then draw a line from one end to the other end of a known object. When asked enter the length of the object chosen as the scale.



Sink the video time to the time on the graph:

Move the movie slider to the point where the projectile motion begins (*after* it has left your hand or the ball launcher)

Click the “sink video time”

Movie synchronization window pops up; set graph = 0



Plot data by “adding points.” Press the add point button and then select a point on the object. Always add points to the **same location** on the object each time. Continue to add data points until you have reached the end.

Additional graphs can be added by going to insert → Graph and then right-clicking on the graph → options and choose the data source as a video time series.