In this lab session you will conduct three experiments to study and analyse different types of motion. Find a lab partner,and then do each experiment in turn. If you start with experiment 1, move to 2 then 3. If you start with 2, move to 3 then to 1. If you start with experiment 3, move to 1 then 2.

Paste these instructions in appropriate sections of your lab notebook. Record your data in organized labelled tables. Print out graphs and paste them into your lab notebook. Answer questions and make observations in your lab notebook.

Experiment 1: Motion on an Inclined Plane

Equipment:
Low Friction Track with stopper and stand and cart
Stop watch
Small bricks or markers
Ruler

Introduction
In this experiment you will model Galileo's inclined plane experiment to quantify the motion of an accelerating object. Galileo showed that if an object is accelerating uniformly and it moves a distance of one unit in the first second, it should move 3 units in the second second and 5 units in the third second, and so on.

Procedure
Set up the low friction track with a stopper at one end and elevate the other end with a stand. Place the low friction cart at the high end and time how long it takes to descend. Adjust the height so that it takes more than 5 seconds, but less than 10 seconds to roll down the ramp.

Now place the low friction cart at the high end of the ramp again and hold it stationary with a ruler placed across the front of the cart. Place a small marker or brick at the location of the front of the cart. Now watch your watch and tap the table once each second and on cue (ready set go) count zero, one two, three, four, five etc. On zero you should release the cart, as the cart descends your partner should place a marker at the location of the front of the cart when you say one, another when you say two, another when you say three and so on.

Repeat this several times until you are confident that you have the placement of the markers approximately right.

1. Record the distances between each of the markers in a table in your lab notebook. Divide each of those distances by the distance you measured between the first two markers. You should now have a list of numbers showing the distance between each of the markers measured in terms of the first distance.

2. How close does this pattern of numbers fit to the expected sequences1,3,5,7,9 … ? Is the motion uniformly accelerated? If not how does it differ, and why do you think that is? Is it some error in accuracy of measuring, or is the acceleration non-uniform in some way?

Experiment 2: Free Fall Motion

Equipment:
Measuring Tape
Masking Tape
6-8 inch bouncing balls or large CAL balls
Motion Detectors and Lab Quest with logger pro

Introduction
In this experiment you will conduct a quantitative analysis of a ball that falls under the influence of gravity and then bounces several times. In particular you will measure quantities such as the acceleration, the time between bounces and the height of each bounce.

Procedure
The main instrument we will use for studying the motion of the ball is a motion detector connected to a Lab quest. This instrument detects the position of an object as a function of time using sonar and can be used to obtain graphs of position vs. time and velocity vs. time. The slope of the velocity time graph is the best way to determine the acceleration due to gravity. Tape the motion detector to the ceiling and release the ball from about 0.5 m below the motion detector.

Graphical Analysis
Your assignment is to complete the following tasks and answer all the questions carefully and in a quantitative way. Answer the questions in your lab notebook. It will be helpful to consider what direction the motion detector takes as the positive direction and what location corresponds to the zero position?

1. Drop a ball below the motion detector and obtain position and velocity vs. time graphs which are reasonably clean of anomalous spikes and which show several bounces of the ball. Describe the form of each graph. (eg parabolic, linear etc), On each graph indicate when the bounces occur and when the ball reaches its maximum height.

2. From the slope of the velocity vs. time graph obtain the value of the acceleration of the ball. Compare this value to the accepted value for the acceleration due to gravity (9.81 m/s^2). What is the percent error?

3. From the position vs. time graph record the maximum heights of each bounce. Include the initial height of the ball in your list. In certain situations we might expect this sequence of numbers to follow an exponential decay pattern. Find the ratio between each height and the next? Is it approximately constant?

4. From the position vs. time graph make a list of time intervals between each successive bounce. In certain situations we might expect this sequence of numbers to decrease in a linear way. Find the difference between each time interval. Are the differences approximately constant?

Experiment 3: Motion in Two Dimensions

Equipment
Lab Quest with webcam and video capture software
Meter stick
Halogen Lamps, Paper for backdrop and tape.

Procedure:

1. Download the video file balltossproj from the handouts section of the program space; save it to your folder.

2. Launch LoggerPro and Use Insert:Movie to open up balltossproj.

3. Reproduce the analysis you saw your instructor do, including setting the scale, setting the origin, plotting just X vs. Time on the graph, inserting a second graph with just Y vs. Time, and fitting linear functions and quadratic functions as appropriate.

4. Determine the x-component of the velocity from the X vs. Time graph and your linear fit. Also use this to determine the x-component of the acceleration.

5. Determine the y-component of the acceleration from the Y vs. Time graph and your quadratic fit. Remember the ½ in $Y=\frac{1}{2}\,a\,t^2 + \ldots$ in the constant acceleration formula.

6. Given the kind of motion this is, what value do you expect for the y-component of the acceleration? Is your experimental result reasonably consistent with your expectation?

7. Obtain a web-cam, two halogen lights, and paper to use as a backdrop. Tape up the backdrop and illuminate brightly with the lights. Make sure to put something in the field of view of the camera that can serve to set the scale.

8. Disconnect the LabQuest from the computer; turn it off. Exit LoggerPro. Hook up the web-cam. Launch LoggerPro.

9. From Insert:Video Capture, you'll get a window showing the video from the web-cam.

10. Blow up and tie off a balloon. Tape just enough washers/weights to the balloon so that you can throw it in an arc.

11. Toss the balloon through an arc so that the washers spin around the balloon as it moves and record a video. Make sure it moves in a plane parallel to the backdrop and so that a good portion of its motion can be captured by the webcam. Save this file as balloonArc.

12. Return the web-cam, light, and materials so that another group can use them.

13. Analyze the motion of the center of the balloon as you did the ball toss video. Does the balloon follow a parabolic path? Is the x-velocity constant and is the y-velocity uniformly accelerated?

14. Analyze the motion of the washers as you did the ball toss video. Does the balloon follow a parabolic path? Is the x-velocity constant and is the y-velocity uniformly accelerated?