Procedure

1. Download the file ball_drop.mov from http://jmh.nbed.nb.ca/teacher/mr-macdonald and load it into the Tracker program.

2. Once loaded in to the Tracker program click on the film settings icon, ▦ and change the start frame, step size, end frame and frame rate to match the following:
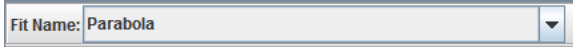
Clip Settings ✕

Frames
Start frame: 7
Step size: 7
End frame: 623

Frame Times
Start time: 0.000 s
Frame rate: 500.00 /s
Frame dt: 2.00E-3 s

OK   Cancel

3. Forward the video so the ball has dropped enough to be clear of the hand. Click on the calibration icon and insert a calibration stick. Stretch the calibration stick across the diameter of the ball and set its value to 0.026. Zoom in on the ball to set the stick as accurately as possible across the ball.

4. Insert a coordinate system and place the origin near the bottom left – the x-axis should cut through the middle of the wooden board.

5. Click on the create icon – then point mass (rename and edit colours of the track if you want). Track the ball as in bounces to the ending frame.

Analysis (to be answered in WORD)

1. Click on the vertical axis label (probably says "x") and select the letter y. Insert that graph into your report. Remember, this is a graph of the ball's position or how high the ball was with time (not the actual path of the ball through the air).
   a. Other than the start, at what times did the velocity of the ball reach zero and the ball changed direction? (Note: you can click on a data point and its value will appear in a yellow box.)

   b. Based on this graph, how can you tell if the ball is accelerating?

   c. From this graph calculate the total distance traveled by the ball as accurately as you can.

2. Analyzing the y(t) functions. Right-click on the y-t graph and select analyze from the drop-down list.
   a. Fit each parabola with a parabolic curve: Fit Name: Parabola ▼

   b. Write down the three separate equations for y(t) in the form $y_1 = At^2 + Bt + C$, keeping two significant digits.

   c. Remember, these are equations for the position of an accelerating object; from each equation find the acceleration and initial velocity of the ball.

3. Go back to your main Tracker page with the video. Click on the vertical axis label and select *vy*. Insert it into your report. This is a graph of the ball's vertical velocity with time. Right-click and select *Analyze*. You may still see the graphs of the parabolae, to remove them right click on the column heading that says "y" and select "cut columns".

    a. Use a line of best fit to determine the equations of $v_y(t)$ for the three times it was freely moving through the air. Call them v_{y1}, v_{y2} and v_{y3}, write them in the form $v_{y1} = At + B$ but only keep two significant digits.

    b. Take the average of the three accelerations from the results in (a) to calculate the acceleration of gravity acting on the ball and compare that value to the accepted value of -9.8 m/s^2.

    c. Use a line of best fit to determine the acceleration of the ball during the bounces (the nearly vertical lines); again keeping two significant digits.

    d. Consider your answers in (c), do you think a human could survive such an acceleration? Take your answers from (c) and divide them by -9.8; that will tell you how many "g-s" the ball experienced. So many "g-s" is a multiple of Earth's acceleration of gravity and is commonly used by fighter and stunt pilots as the talk about the strength of g-forces.

    e. Near the top left of the analysis window click on the work "Measure" and check off "Area". You should see some shaded triangles and two dark vertical lines near the edges of the graph – these lines must be dragged so that they go through a data point for the program to calculate an area. Use this analysis to calculate the total of the all areas (the top-bottom result is displayed in a yellow window near the bottom-right of the graph). Compare this result with your calculations in question 1(c) – are the results in reasonable agreement?

4. On a separate sheet of paper write down your three equations for y(t) across the page and directly below them write the three equations for $v_y(t)$. In your report answer the questions below:
    a. How can we mathematically get the $v_y(t)$ equations by only having the y(t) equations. Look for connections in the numerical values. Using our regular equations from class may help.

5. List at least three sources of error that could have lead you to get slightly inaccurate results or results that differ from your classmates (think of the experiment as a whole and not just the analysis you were asked to do). Is it possible to get exact results in an experiment?