**Purpose**

To learn how to perform a statistically relevant error analysis when tracking a video. This will be accomplished as you attempt to determine the acceleration of gravity of a ball as it bounces up and down. The acceleration will be analysed when the ball is moving freely through the air.   The error analysis consists of calculating the % error when comparing the air-acceleration with that of gravity, -9.81 m/s^2, and the standard deviation.

For simplicity, you will record your results in the WORD file called *Physics 112 Bouncing Ball Analysis* and use the EXCEL file *Averages and Error Analysis* both found on my teacher page (note: the EXCEL file will open with DIV/0 in some of the cells, do not worry, they will go away as you enter values).

Tracking Procedure

1. Download (right-click and select *save link as* or *save file as*) the file **ball_drop.mov** from my teacher page and load it into the Tracker program or load the video from the memory stick.

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:
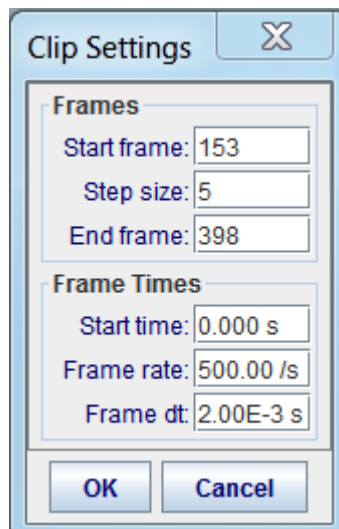
3. Click on the calibration icon and insert a calibration stick. Stretch the calibration stick across the diameter of the ball and set its value to 0.026 (the unit is meters). Zoom in on the ball to set the stick as accurately as possible across the ball.

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: Repeat the tracking steps a total of four times. (Use the tables provided WORD and Excel files)

1. **Determining the position-time equation.** Click on the vertical axis label (probably says "*x*") and select the letter *y*. Remember, this is a graph of the ball's position or how high the ball was with time and not the actual path of the ball through the air. **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 remember to select only the points where the ball is in the air and not the bounces.
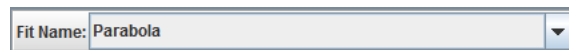
    b. In the table record the equations for y(t) in the form $y_1 = At^2 + Bt + C$, keeping two significant digits (because that is all the significant digits used for the calibration stick).

    c.   Remember, these are equations for the position of the ball as a function of time for an accelerating object; from each equation find the acceleration of the ball by doubling the coefficient of the t^2 term; acceleration = 2A.

2. **Determining the Velocity – Time Equation.** From your graph (that is next to your video) change the vertical axis to v_y. This is the vertical velocity of the ball and the change in this velocity is the acceleration. Analyze this graph by fitting it with a linear relation. The slope of the line (the parameter A in the equation) is the acceleration of the ball – which should theoretically be -9.81 m/s^2. Record these values in the supplied WORD file.

3. **Error Analysis**. Input the accelerations from the four velocity – time analysis videos into the EXCEL file. It will automatically calculate an average for the accelerations, % error and a standard deviation.

Relating this to your Physics Projects

Your project needs and requires a numerical error analysis. It must include a percent error analysis (compared to the acceleration due to gravity or a known theoretical value of your investigation) and a standard deviation.

The mathematics behind those calculations are not overly complex (if you take Foundations of Math 120 you will learn such calculations) but for the sake of time for your projects adapt the EXCEL file used for this lab. Your projects require a minimum of four analyses for each video. Take your individual video results and place them into this EXCEL file (or modify it if need be). The standard deviation is a measure of how much your results varied.