ME 2302 Computer Simulation Project # 1
Due Tuesday July 25, 2017 In class

Read Chapters 6 and 7 of the book. Study the examples. This is group work. No sharing of files with other groups is allowed. Everything should be documented in a Mathematica notebook with good formatting of sections, etc.

The notebooks indicated are found on the commercial book website indicated in the syllabus; follow the link Mathfiles/math3/...

Part 1

1) Use the notebook traject.nb in the same location specified above. Using reasonable numbers for the drag and mass of the tennis ball simulate the ball being thrown from some initial height on the order of 1-20 ball diameters. Plot this curve on the same graph as the curve that is produced from the same problem when no drag is present. You will need to derive the no drag situation or use the solver with drag set to zero. Repeat the procedure with the drag chosen increased then decreased by 25% and 50%. Comment on what is observed, note deviations from the ideal solutions of no drag. **Pay attention to the constant used in the drag formula. Make sure you adjust the constant to match the definition indicated in the book in the section of Chapter 4 where drag force is discussed.**

2) Study the problem formulation in the book for the trajectory simulation. Modify the simulation to allow for a horizontal head-wind, a tail-wind and a cross-wind. Plot at least three cases each of various magnitude winds verses the case for still air. Makes sure the relative velocity is used in the drag function. Comment on what is observed.

3) For the most general simulation you create above generate a nested manipulate and animate function, similar to the ones for earlier quiz projects assigned this semester, to allow a person to change the wind parameters so that they can see all the effects the wind has on the ball.

Part 2

Acquire a tape measure and tennis ball for use below. The tape measure can be the 25 ft variety. You will run two experiments as indicated in the figure below. Document the experiments with photos.

Experiment 1: Hold the tape measure against the wall with about 5 or 6 ft of tape unreeled. Put the end of the tape against the ground and hold the reel against the wall on the high end. Using the stop watch on a smart phone. Release the ball from rest at H = 4 ft. Simultaneously start the watch timer. Count the number of bounces until the ball bounce essentially ceases. Simultaneously stop the timer. Record H, the number of bounces and the total time. Repeat The experiment several times until the bounce
count and time is consistent. Average the bounces and time as the result for this stage of the experiment. Repeat the entire process for \( H = 3 \) ft and \( H = 2 \) ft. In the end you will have the average bounce count and average total times for 3 different values of \( H \).

Experiment 2: Build a ramp system shown in the figure. Measure the geometry as indicated in parameters \((L, H, h)\). A table or board will suffice for the ramp. Lay the tape measure out along the floor so that the bounce distance \( D \) can be measured. You will need two stop watches. Upon release of the ball from rest at the top of the ramp start both timers. Stop one timer as the ball leaves the ramp. Count the number of bounces until the ball essentially stops bouncing. Simultaneously have a person mark the stop bouncing distance \( D \) with their foot while the second timer is stopped, all the while someone is counting the bounces. Record this data in a table and repeat the experiment at least 4 times to get good average data.

Part 3

Use the \texttt{pbounce.nb} Mathematica notebook found on the book website; follow the link \texttt{Mathfiles/math3/...} for the following analysis.

Analysis 1: Get initial estimates for the coefficient of restitution for the ball against the concrete floor and estimates for the coefficient of drag \( Cd \) from a table or the web. Using the initial conditions for the straight drop experiment, Exp 1, fine tune the estimates of the coefficient of restitution for the ball and coefficients of air drag that you find using fluid drag equations, so that your simulation ball bounces as long as the experiment with the same number of bounces. \textbf{Note that the constant in the function defined in the notebook is a combined constant, use it appropriately…pay attention to this detail.}

Analysis 2: Assuming the ball slides with no friction as a particle on the table, derive a set of equations to predict the speed of the ball as it leaves the table. Using the time, length, and angle data from the experiment, estimate the velocity vector of the ball as it leaves the table.
Analysis 3: Using the end height of the inclined table and your estimated velocity vector, run simulations of the ball bouncing down range for the length indicated in the data. Adjust your drag and restitution parameters from Analysis 1 so that this simulation matches the experimental data.

Write a brief report (not more than three pages) detailing your simulation/experiment matching efforts. Use plots and equation development to justify your conclusions. Use the notebook as your report format using the built in type setting capabilities of Mathematica. Hide the simulation cells in any report filed or put them in an appendix. Clearly indicate the experimental values and how they correspond to the simulation data.

**Note:** Be sure to use consistent units in the simulation, English or Metric units are fine. Make sure each teammate does their fair share. Provide one cell in the notebook where the group grades its members. Make sure each member's name is in the title section. Submit a clean PDF copy of your work, do not print extraneous cells that are not showing your work, close them for printing. If we have questions on veracity of calculations you will be required to submit the live notebook for computational verification. This is to be a professional report, impress us.

Get your group its own tennis ball to use for all trebuchet work for the class.