Catapult Project v.1

December 4, 2015

Summary. The purpose of the final project is to integrate the ideas we have been exploring throughout the semester: data acquisition, modeling change, model fitting.

(a) Assuming that your catapult launches its ping-pong ball in a direction perpendicular to the frame, devise a means of launching the catapult at a specified angle. Use trigonometry, and your imagination.

(b) Collect data on the travel distance of your catapult – as measured from the point where the bottom of the catapult touches the ground – as a function of launch angle. I would recommend collecting data at the increments $\theta \in \{10, 20, 30, 40, 50, 60, 70, 80\}$, and I would recommend collecting at least 10 measurements per angle, to obtain means and standard deviations.

(c) Construct an empirical fit to your data. Try simple functions such as polynomials $D = A + B\theta + C\theta^2$. How many terms to you need to get a good fit?

(d) Now build an ODE model for the trajectory, including initial position of the ball as calculated input (use trigonometry), and the launch speed and the drag coefficients as parameters. Write a Matlab function file that accepts this information, and returns the RHS of the ODEs.

(e) Estimate the value of your model coefficients using physical observations (for launch speed) or research (for drag coefficients). Then fit the values using a weighted least squares approach. Are you able to get a good fit to the data? Are both drag coefficients needed?

(f) Finally, develop an approach for selecting a launch angle θ, given your model $m(\theta)$ and a target distance D. You can resort to printing out a picture of your graphs if needed, or employ a root-finding approach automatically.

(g) Summarize these efforts to create a calibrated catapult in a written report, including diagrams illustrating your launch setup, plots of your data and fits, and a description of your aiming strategy. The final exam time will consist of trying to launch ping-pong balls into buckets placed in the room. You are expected at least to come close to some of them.