Physics 200 Name (s): _____

24-25 Water Rocket Modeling, Part 2

Using Models To Estimate Real Values

Overview: At this point, you may have good data from your video analysis, and you may have bad data (due to camera frame rate malfunctions, human error, etc.). The goal in this stage is to find what you think are the most reasonable (closest to realistic) values for your rocket's acceleration, thrust, height, etc. You have two models to work with. One is your trajectory spreadsheet, into which you can insert your data from the video analysis. Another source is Clifford Heath's water rocket simulator. To find all of the information that you need, you may need both models. You could, for instance, use many of Clifford's numbers, but you won't find specific values of drag in his simulator. You will need your model for that.

1. **Set Up Your Model (trajectory spreadsheet):** Enter your rocket launch data into **your trajectory spreadsheet** (the one you used for homework problems):
    a. initial Y velocity (the max velocity from the thrust phase) – from #14 from your part 1 worksheet.
    b. initial X velocity (enter zero)
    c. rocket's dry mass, in kilograms
    d. estimated cross-sectional area (Clifford Heath used $0.013m^2$)
    e. estimated drag coefficient – whatever you want to use for your first guess (0.1 is very low, 0.5 is very high)
    f. initial y position (height at the end of thrust)
    g. air density (use 1.28kg/m^3 – it was a cold morning).
2. Now adjust some values until the flight time matches your rocket's actual flight time. Adjust whatever values make the most sense to you. You can adjust the initial velocity, the cross-sectional area, drag coefficient… whatever. ***If your rocket behaved differently on the way up and the way down, see me for a special version of the spreadsheet**.*
3. **Set up Clifford Heath's Model** (see link on my website)**.** Enter data from your rocket launch into Clifford's model. Make sure that you enter the pressure as "100p." Water = 0.6L. Dry Mass = your rocket's dry mass, in grams. Choose a drag coefficient that makes sense. Click "submit simulation," and look at the results.
    a. Look at Clifford's actual apogee and total flight time and then look at your spreadsheet "max height" and time aloft.
    b. Look at your acceleration and thrust calculations and look at Clifford's graphs. He provides a lot of information.
4. Look at both models. Change your numbers as you see fit to try to arrive at the most realistic model.
5. **Enter your Data in Google Classroom:** Use all of the information at your disposal (your video data, your spreadsheet, Clifford Heath's simulator) to populate the 2nd spreadsheet in Google Classroom (Rocket Spreadsheet #2: Water Rocket Graph Data)
6. **Create an Acceleration vs Time Graph:**
    a. Draw a graph of acceleration vs time. The time should stretch from 1 second before the launch to 1 second after the landing. Adjust your y axis scale to match most of your flight, but not the launch. The launch acceleration is extremely high, and if you scale the graph to show all of it, the rest of the graph will be very small. Deal with this by showing a break of some sort as I did for the initial acceleration spike (see class #29).
    b. On your graph, label the 9 moments in time described in "Spreadsheet #2: Water Rocket Graph Data," from number 5, above. Draw a point for each moment. Label it with its number and a succinct description.
    c. You can turn in a hard copy or a digital version of your graph. If you turn in a digital version, all of it needs to be clear and easy to understand.