Physics 200 Name (s): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Bottle Rocket Analysis

\*\*In an effort to simplify this process, ignore any motion or forces in the X dimension.

Water Thrust Phase: The water thrust phase begins when the first bit of water escapes the rocket. The phase ends when air begins to leave the rocket, creating a *puff* as it hits the rocket’s trailing water column.

Use Logger Pro to find the answers to the following questions. Set your frame rate to 480fps. Use your rocket’s length to set the scale

1. What was your rocket’s Y displacement during its *water thrust* phase? \_\_\_\_\_\_\_\_ m

2. What was the Δt during your rocket’s water thrust phase? \_\_\_\_\_\_\_\_s

3. What was your rocket’s average acceleration during the water thrust phase? \_\_\_\_\_\_\_\_ m/s2

4. What was your rocket’s mass at the beginning of the water thrust phase? \_\_\_\_\_\_\_\_ kg

5. What was your rocket’s mass at the end of the water thrust phase? \_\_\_\_\_\_\_\_ kg

6. Estimate your rocket’s average mass during the water thrust phase. \_\_\_\_\_\_\_\_ kg

7. What approximate net force was acting on your rocket during the water thrust phase? \_\_\_\_\_\_\_\_ N

8. Estimate your rocket’s average weight during the water thrust phase. \_\_\_\_\_\_\_\_ N

9. What average thrust was provided by the water being expelled by the rocket? \_\_\_\_\_\_\_\_ N

10. Using the average rocket mass and average thrust that you provided above, how many of these rockets would be required to lift a 140 pound human? Add an extra 20 pounds for straps, fixtures, and safety gear. You will also need to account for the mass of your bottles. For the bottle mass, simply use the average water mass in each bottle during the thrust phase.

\_\_\_\_\_\_\_\_ Bottles

Air Thrust Phase: This is very brief, and its end is difficult to discern. We will not analyze this phase.

Coasting Phase: This phase begins as soon as all initial acceleration has ended -- and the rocket has reached its maximum velocity. This is apparent when the logger pro Y velocity data become close to constant. Coasting ends when the rocket hits the ground. There is no thrust during the coasting phase. The only forces acting on the rocket are drag and weight.

11. What was the maximum velocity obtained by your rocket? \_\_\_\_\_\_\_\_ m/s = \_\_\_\_\_\_\_\_\_ mph

12. What is your rocket’s Δy up to the moment that it reaches its maximum velocity? \_\_\_\_\_\_\_\_ m

13. \*\* Use Quicktime for this one.\*\* What was the length of your rocket’s flight, in movie frames? \_\_\_\_\_\_\_\_\_\_ frames.

14. The frame rate was 480fps. What was your rocket’s total time aloft?

\_\_\_\_\_\_\_\_ s

15. What was your rocket’s mass after all of the water left the rocket? \_\_\_\_\_\_\_\_ kg

16. Use Logger Pro to find your rocket’s “crashdown speed” -- y velocity just before impact? \_\_\_\_\_\_\_\_ m/s

17. Assuming that your rocket always pointed in its direction of travel, what was its cross-sectional area for drag calculation purposes?

\_\_\_\_\_\_\_\_m2

**18-21. Use your spreadsheet for the remaining questions. To make your spreadsheet more responsive, download it and open it in Excel.**

18. The density of the surrounding air was \_\_\_\_\_\_\_\_\_\_kg/m3.

19. Enter your rocket’s cross-sectional area, and its starting position for the coasting phase. Then manipulate your rocket’s drag coefficient until the spreadsheet time aloft matches your rocket’s actual time aloft. According to this method, what is your rocket’s drag coefficient? Enter all of the following data for this method…

Cd = \_\_\_\_\_\_\_\_ Max Height = \_\_\_\_\_\_\_\_\_\_\_

Time Aloft = \_\_\_\_\_\_\_\_\_\_\_\_ Crashdown Speed = \_\_\_\_\_\_\_\_\_

20. Now find your rocket’s drag coefficient another way. Instead of matching your spreadsheet’s time aloft to your rocket’s time aloft, match your spreadsheet’s crashdown speed your rocket’s measured crashdown speed (from Logger pro). Enter all of the following data for this method…

Cd = \_\_\_\_\_\_\_\_ Max Height = \_\_\_\_\_\_\_\_\_\_\_

Time Aloft = \_\_\_\_\_\_\_\_\_\_\_\_ Crashdown Speed = \_\_\_\_\_\_\_\_\_

23. What max height and time aloft does the online simulator predict for your rocket? Try this with both of your Cd estimates.

Based on Cd from time aloft:

Cd = \_\_\_\_\_\_\_\_ Max Height = \_\_\_\_\_\_\_\_\_\_\_

Time Aloft = \_\_\_\_\_\_\_\_\_\_\_\_ Crashdown Speed = \_\_\_\_\_\_\_\_\_

Based on Cd from crashdown speed:

Cd = \_\_\_\_\_\_\_\_ Max Height = \_\_\_\_\_\_\_\_\_\_\_

Time Aloft = \_\_\_\_\_\_\_\_\_\_\_\_ Crashdown Speed = \_\_\_\_\_\_\_\_\_

. Which method of determining Cd seems to give more similar results when compared to the water rocket simulator?

a. matching times aloft b. matching crashdown speeds

Using the estimated value of Cd that seems most realistic…

19. What was your rocket’s terminal velocity? \_\_\_\_\_\_\_\_ m/s = \_\_\_\_\_\_\_\_\_ mph