Physics 200 Name (s): ____

Bottle Analysis, Part 1

Video Analysis

***** Complete the data-collection steps first. Data collection steps are in bold.**

<u>Part 1. Water Thrust Phase Analysis:</u> The water thrust phase begins when the first bit of water has just escaped from the rocket. The phase ends when air begins to leave the rocket, creating a *puff* as it hits the rocket's trailing water column.

In the Vernier Video Analysis App…

- **Make sure that the frame rate matches your video file frame rate (click the settings wheel).**
- **Use the stick by the launcher to set the scale. The top of the duct tape to the top of the stick is 1.6m.**
- **Set the origin to the tip of your rocket. If needed, tilt the axes so that the X axis matches the horizon.**
- **Advance the video until the moment when your rocket first begins to move. Add your first point here.**
- **Continue adding points until you see the first puff of air. Add your last point when the puff has first appeared.**
- **Use the growing data table to collect the bold data below.**

0. Using the 1.6m of stick (above the duct tape) as a reference, estimate the starting height of your rocket's tip, above the ground. Starting height = _________

1. What was your rocket's Δy during its *water thrust* phase? ________ m

2. What was the Δt during your rocket's water thrust phase? ________s

3. Use Δy and Δt to calculate your rocket's average acceleration during the water thrust phase. ______m/s^2

4. What was your rocket's total mass at the beginning of the water thrust phase? (include both dry mass and water mass) ________ kg

5. What was your rocket's mass at the end of the water thrust phase? (dry mass only) ________ kg

6. Assuming that water left your rocket at a constant rate (which we know is wrong, but it makes the calculations easier), calculate the rocket's average mass during the water thrust phase ($(m_0+m)/2$). ________ kg

7. According to your previous answers, what average net force was acting on your rocket during the water thrust phase? ________ N

8. Calculate your rocket's average weight during the water thrust phase. ________ N

9. What average thrust was provided by your rocket's expulsion of water? ________ N

10. Based on your previous answers, how many of these rockets would you have to strap together to "lift" a 140 pound human plus an extra 20 pounds of straps, fixtures, and safety gear? Don't forget to account for the mass of the bottles themselves, including the water in the bottles. For the bottle mass, simply use the average water mass in each bottle during the thrust phase. Provide an answer that is precise to the nearest 10^{th} of a bottle. [Instead of "lift," the word *suspend* may be better here; this problem is not about actually accelerating a person upward.]

    ________ = Bottles needed to "lift" a 140 pound human

11. Based on some brief scrutiny of the *Game Show Water Bottle Launch*, the crew used 30 bottles to launch the participant, and the participant's mass, plus the non-bottle mass was about 86kg (roughly 190 pounds). Assuming that the water bottles in the video were the same as your water rocket, what height would the participant reach due to the thrust during the "water thrust phase?" Be aware that the participant will keep flying upward after the thrust stops. You must calculate the full height reached.
Maximum Height Reached, using our rockets: ____________________________
[Note: this will be a slight under-estimate, because you are only including the thrust during the "water thrust stage." In reality, the bottles would push a tiny bit more as their air escapes. Also, ignore air resistance.]

Part 2, Air Thrust Phase: This is very brief and difficult to analyze. We will not analyze this phase, but we will try to find the endpoint, which will give us the starting time of the coasting phase.

12. You should have stopped collecting water thrust data when the puff of air appeared. **Now continue collecting data until the y velocity is no longer increasing. This point in time may be unclear, but estimate it as well as you can. This time will be the starting point for the coasting phase analysis.**

End of thrust phase = beginning of coasting phase (spreadsheet starting time**) → t = __________**

Part 3, Coasting Phase Analysis : This phase begins as soon as all initial acceleration has ended -- and the rocket has reached its maximum velocity. This is apparent when the Y velocities stop increasing. 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.

13. **What was your rocket's velocity at the beginning of the coasting phase/end of air thrust? (a.k.a. max velocity)**

________ m/s = _________ mph

14. **What is your rocket's ΔY from its starting point to the beginning of the coasting phase? ΔY ________ m.**

15. Use this ΔY to find the Y position of your rocket's nose at the beginning of the coasting phase (from #0). Y position = ΔY + initial height at the tip.

Y position at beginning of coasting phase = _________

15. **Find your rocket's total time aloft. If you add one last data point at the moment your rocket hits the ground, your last data point will give you the overall time. You can also just read the starting time and final time and subtract.**

Δt = __________ s