

Water Rocket Analysis, Part 1

Video Analysis Data Collection and Spreadsheet Population

Part 1. Water Thrust Phase Video Analysis Data Collection:

In the Vernier Video Analysis App...

- Open the video of your rocket's launch.
- Click the settings wheel and change the frame rate to 240 (unless it's already 240).
- Use the pole to set the scale. The distance from the top of the grey pole to the ground is 2.08m.
- Set the origin to the ground beneath your rocket. If you want, you can tilt the axis.
- Advance the video until the moment when your rocket first begins to move. Add your first point (on the rocket's tip) at this moment.
- Continue adding points until you reach the point where the y velocity seems to stop increasing (this should be soon after you see the puff of air hitting the exiting water)
- Use the growing data table to collect the bold data below.

1. Record the starting height of your rocket's tip, above the ground. Starting height = _____ m
2. Record your rocket tip's height at the end of the thrust phase = _____ m
3. What was your rocket's Δy during its *thrust* phase? _____ m
4. What was the Δt during your rocket's water thrust phase? _____ s
5. What was your rocket's max velocity? _____ m/s
6. What was your rocket's Δv during the thrust phase? _____ m/s

Part 2. Crash-Down Video Analysis Data Collection:

In the Vernier Video Analysis App...

- Open the video of your rocket's landing
- Click the settings wheel and change the frame rate to 240 (unless it's already 240).
- Use the pole to set the scale. The length of this pole is 3m.
- Advance the video until the rocket is close to hitting the ground. I can't tell you exactly how close, and it may turn out that you choose poorly and have to start over, but that's okay. You're resilient!
- Set the origin wherever you want.
- Add your first point at the part of the rocket that you think will hit the ground first.
- If you have a parachute, your rocket is probably very slow. You can skip several frames between data point entry.

7. Average several of your Y velocities to get a good approximation of your rocket's crash-down speed.

Crash-Down Speed = _____ m/s

8. Unfortunately, there's no easy way to measure objects in Video Analysis, but there is a workaround. Use the workaround (or some other method) to estimate your rocket's cross sectional area (A) just before it hits the ground:

Estimated A = _____ m²

Part 3: Full-Length Video Data Collection

In the Vernier Video Analysis App...

- Open one of the full-length videos that your helpers made.
- Click the settings wheel and change the frame rate to whatever it's supposed to be (ask your friend – maybe 30, 60, 120, or 240, depending on their settings)
- Advance the video to the moment of launch. Then add a point anywhere.
- Advance to the point where the rocket reaches its apogee. Add another point anywhere.
- Advance to the point where the chute begins to deploy and add a point. If your chute didn't deploy, skip this.
- Advance to the point where you think the chute is fully deployed and add a point. (or skip this, if your chute didn't deploy)
- Advance to the point where your rocket touched the ground. Add your last point.
- Look at your time data.

9. At what time did your rocket reach its apogee? _____ s
10. At what time did your rocket's chute begin to deploy? _____ s
11. At what time did your rocket's chute reach full deployment? _____ s
12. At what time did your rocket touch down? _____ s

Part 4: Gathering Remaining Data For Your Spreadsheet

13. What was your rocket's dry mass, in kilograms? _____ kg
14. How much water did you put in your rocket [This isn't for the spreadsheet, but I don't want you to forget it]
Water volume = _____ ml
15. What was your rocket's cross-sectional area on its flight to its apogee? _____ m²

Part 5: Initially Populating The Spreadsheet

16. Make a copy of the spreadsheet template. It will look funny, because some formulas are missing. We will work on those together.
17. Enter your data into the yellow cells. [If your chute never deployed, enter numbers into cells E3 and E4 that are higher than your total time aloft]
18. Take a guess at the numbers in the orange cells. [If your chute didn't deploy, you can ignore orange cells in rows 3 and 4.]
19. Scroll down to the bottom of the sheet. If your flight lasted longer than the highest time, in seconds, increase your time increments (cell B3) until the highest time is as long as your rocket's flight.

Part 6: Inferring values for A and Cd: **This will take some thinking on your part. I'll provide hints as needed.**

20. Scroll down until you reach the time when the spreadsheet tells you that your rocket has reached its apogee. If that's not the time your observed time to reach apogee (recorded in number 9), adjust the values in Cells F2 and G2 until the simulation time to reach apogee does match your observed time to reach apogee (from number 9).
21. Adjust your values in the orange Cd cells until the rocket lands at the observed time (from #12, above) and with the correct crash-down speed (from #7, above)
22. Add notes in column 1, describing what's happening. Assume T.V. is reached when $a < 0.01$ (downward).