Unified Systems Problem 4

WATER BOTTLE ROCKET BUILD AND TEST

Learning Objectives

The objectives of this systems problem are for you to:

- Complete a hands-on experience by working with a partner to design, build and test a water rocket with an objective of maximizing the height of the trajectory;
- Assess sources for variability in the launch/test procedures; and
- Demonstrate your understanding of the assumptions and limitations of your analytical model for rocket performance by comparing the results with your test data and discussing the most significant reasons for differences.

Overview

This is the third of the **three** consecutive systems problems devoted to the design and of a small rocket propelled by compressed air and water.

In this systems problem, you will work with a partner to:

1. Design a water rocket that will achieve the maximum height possible given that:
    a. The rocket must begin from rest at ground level.
    b. You must utilize the given launching mechanism without modification or alteration.
    c. The sole source of stored energy must be compressed air at a maximum of 60 psi gauge pressure.
    d. You must be able to launch your rocket five times in rapid succession (<5 minutes turn around time).
    e. You may use any components or materials you wish as long as your design is safe to operate.
2. Build your rocket given that:
    a. Construction materials will be freely available from the TAs while in stock including balsa, clay, and hot glue.
3. Conduct test launches to ensure that your rocket is working as desired given that:

a. Launching mechanisms and inclinometers and/or pressure transducers for measuring altitude will be available for sign out from the TAs during business hours.
b. The maximum sign out period is two (2) hours except when sign out occurs after 4pm in which case return must occur at 9am the following business day.
c. You cannot launch the rocket on your own. Either your partner or another person must be present during launch for safety and to help you launch or measure altitude.

Conduct the “official” sequence of five launches in a time slot on the “official” test days at the “official test site”. The signup sheet will be available outside the TA office.

Safety

Your bottle rocket, when pressurized to 60 psig, can be a very dangerous object, capable of causing severe injury. Several safety precautions must be taken before and during your launches:

You will need to get from the TAs: a launcher, a launch retainer pin, either an inclinometer or a pressure transducer for measuring altitude, and a few metal stakes. You'll want to bring an ample supply of water to the launch site with you as well. The TAs may also have a measuring tape available so that the altitude-recording person can determine his or her distance from the launcher.

1. Go to an open area, clear of people, cars, etc. (Briggs Field is a good launch site)
2. After filling the bottle with water and attaching it to the launcher, stake the launcher to the ground.
3. Make sure that the bottle is completely seated on the o-ring at the base of the launch rod.
4. Insert the launch retainer pin, making sure it will restrain the bottle by passing over the bottle’s neck ring.
5. Carefully pressurize the bottle. At no time should you stand above the bottle. Assume it could blast off at any moment. Do not pressurize the bottle beyond 60 psig.
6. When fully pressurized, make sure that nothing is in the way of the rocket, stay clear, and pullout the launch retainer pin.
7. You will need a partner to record the altitude of the rocket if you are using an inclinometer. Be sure to measure or estimate the distance that your partner is standing from the launch pad so that you can compute the rocket's altitude given its angle above the horizon.

Analysis and reporting

a. Provide drawings of the water rocket that you and your partner designed and tested. Be sure to label your drawings and include enough detail so that someone could reproduce your design. You may not modify the bottle(s) by cutting, but you may use different sizes of bottles, fairings to reduce drag, ballast, etc. Include a list of key design features and provide supporting arguments for each of your design choices. Also include an estimate of the maximum height that the rocket will reach obtained using your spreadsheet. [30 pts]

b. Provide a table of the maximum height the rocket reached during the 5 official test launches. The plot should have appropriate labels. [10 pts]

c. Discuss the sources for variability in the experimental test results. The discussion should be in the form of several thoughtful, concise paragraphs, not just a list. [20 pts]

d. Discuss the possible reasons for the difference in your test results and the performance estimate you obtained from your spreadsheet. Which of assumptions and limitations of the analytical model do you believe are most responsible for the difference between the estimate and the test result? Here again, several thoughtful paragraphs are expected. [40 pts]

Grading Rubric for Systems Problem 4

Student name: _____

	0 not at all	1 poorly done	2 adequate	3 well done	4 excellent
Do the students provide labeled drawings of the water rocket that are clear, approximately to scale, and define the relevant components of the rocket at a level that would enable someone else to replicate their design? [part (a) = 15 pts]					
Do the students provide a short rationale for each design choice that is well founded based on an understanding of the fundamental concepts? [part (a) = 15 pts]					
Do the students provide a table of the maximum height that the rocket reached during the 5 test launches reflecting the fact that they built and tested a rocket? [part (b) = 10 points]					
Do the students discuss the sources for variability between the 5 test launches in a manner that reflects careful observation of the testing procedure? [part c) = 20 points]					
Do the students demonstrate an understanding of the assumptions and limitations of the analytical model in their discussion of the comparison between the results of their spreadsheet and the test results? [part (d) = 40 points]					

Total points: _____