Sit anywhere you'd like!

Experimental and Computational Methods ASEN 2012

Lecture 19: Project 2
November 5, 2018

Project 2 Goals

- Understand bottle rocket performance related to design parameters.
- Integrate your knowledge of incompressible and compressible flow with rocket dynamics.
- Use MATLAB code to simulate the bottle rocket flight.
- Be intellectually prepared to build your bottle rocket, test it in the wind tunnel and on the static test stand, and then launch it, in ASEN2004.

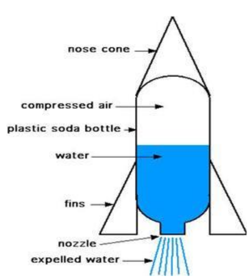
Clicker Quiz

- Have you ever built a water bottle rocket before?

A. Yes
B. No

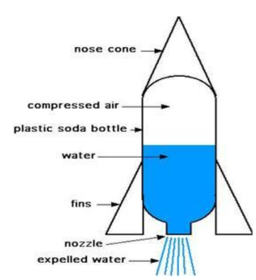
Rocket Phases of Flight

1. Water expulsion
2. Water expelled, air pressure dropping to ambient pressure
3. Ballistic phase



In other words…

1. From t=0 until water expelled
2. After water is expelled, but compressed air expands until pressure drops to ambient
3. Ballistic phase



Flight trajectory

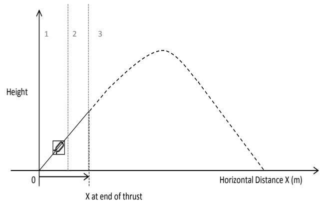
1. Integrate EOM for water thrust phase

Until volume of air = volume of bottle

2. Integrate EOM for air thrust phase

Until pressure of air = ambient pressure

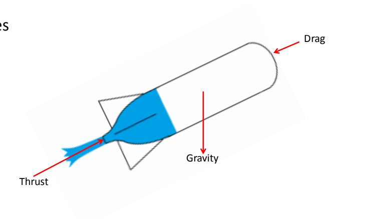
3. Integrate EOM for ballistic phase



The Physical System

Three Forces

- Drag
- Gravity
- Thrust



Heading Vector

v_x: horizontal velocity of rocket
v_z: vertical velocity of rocket
v_h: heading of the rocket

Note: We use x and z in this notation. In 2004 you will extend to calculate the y direction due to wind!

- Calculate each component of the rocket's velocity
- Due to weathervane like effect, rocket points in the direction of its heading, orienting drag and thrust forces in this direction

Equations of Motion

- Using Newton's law:

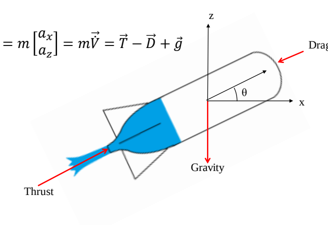
$$\sum \vec{F} = m\vec{a} = m\begin{bmatrix} a_x \\ a_z \end{bmatrix} = m\dot{\vec{V}} = \vec{T} - \vec{D} + \vec{g}$$

$$\vec{h} = \frac{\vec{v}_h}{|\vec{v}_h|}$$

$$\vec{T} = T\vec{h}$$

$$\vec{D} = D\vec{h}$$

$$\vec{g} = \begin{bmatrix} 0 \\ -9.81 \end{bmatrix}$$



Thrust and Drag

- Thrust will change depending on the phase of flight
  - See project document for detailed description!
- Drag will change by:

$$D = \frac{1}{2}\rho |v_h|^2 C_D A_r$$

- Using the equations of motion, constants, and chosen design parameters, use ODE45 to integrate and find the rocket's trajectory

Design Parameters YOU have control over

- Initial air pressure (don't blow up the bottle…)
- Initial mass/volume of water
- Drag coefficient
- Launch angle

One thing to keep in mind…

- In every model of a real physical system, you must make simplifying assumptions. This model:
  - Assumes static stability (i.e. no torque)
  - Assumes no wind
  - Forces due to the rail are ignored
- There are alternative ways to formulate this problem, each making their own simplifying assumptions
- **Please formulate the problem in the way we have asked you**

Assignment

1. Thoroughly read the project document. It describes the equations of rocket flight and where they come from in detail.
2. Using the 10 step method, develop your MATLAB code to model the rocket's trajectory.
3. Check your code against a validation test-case.
4. Adjust your model to meet a new target test case.
   - "Land X meters from the launch point"
   - Adjust based on the parameters you have control over in the design

You're not done with this project!

- In 2004 you will actually design, build, and test your bottle rocket!
- Labs will serve to validate your design and parameters based on your model predictions.
- You will add additional layers of your model to accommodate the requirements of 2004, so spend the time to develop good code now!

Timeline

- November 5 – Project 2 Assigned
- November 8 – Project teams finalized
- November 30, 11:59 pm - Project 2 Due
  - Upload to Canvas
  - Note the extension from the schedule

Partner selection

- By Tuesday midnight, submit your partners using this Google form:

  https://goo.gl/forms/Y7bvuut3nF1eYvXy2
- By Wednesday midnight, John will post the project teams based on the Google form
- You will have until Thursday midnight to let us know if there is an error in the pairings
- As before, you can be partners across sections, but you CAN'T have the same partner as last time

Deliverables

- You will be required to submit a 7 min. presentation of your findings
  - Future lectures will discuss proper presentation styles
  - Submit slides in PowerPoint or PDF form
- Submit video of you and your partner giving the talk
  - Each person must speak approximately 50% of the time
  - You are not allowed to edit the video and it must be filmed from the perspective of an audience member
  - Your slides are not required to be in the video, but you must be standing and speaking as though you are giving the talk to aerospace customers
- You must also submit your MATLAB code as a zip file, ready to compile when run