Bottle Rocket Project

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METHODS

- Started by using ODE to plot a rocket trajectory hitting a target 60.5m away
- Varied 4 parameters (CD, Pressure, Volume of Water, launch angle)
  - Individually
  - All at once
- Narrowed each case down to the ones which hit 85 m +- .5m
- Chose the parameters that got the closest to the original 85m target

VARIATION WITH THETA

- Theta parabolic arc for distance
- Max at theta of 45°
- Reaches a max distance of 60.5m

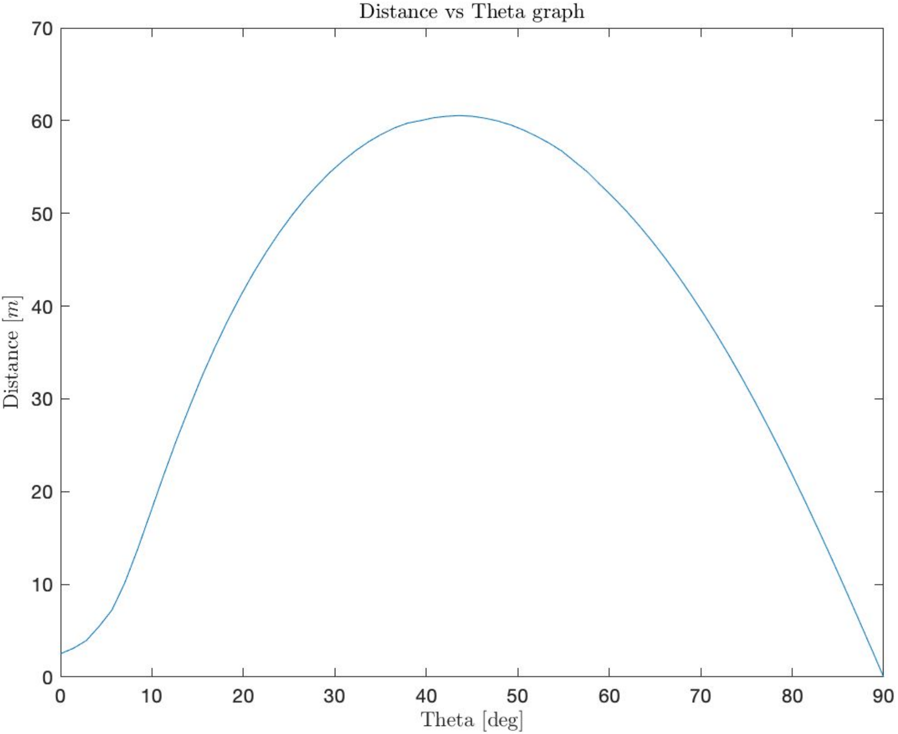


Fig. 1. Distance vs launch angle plot

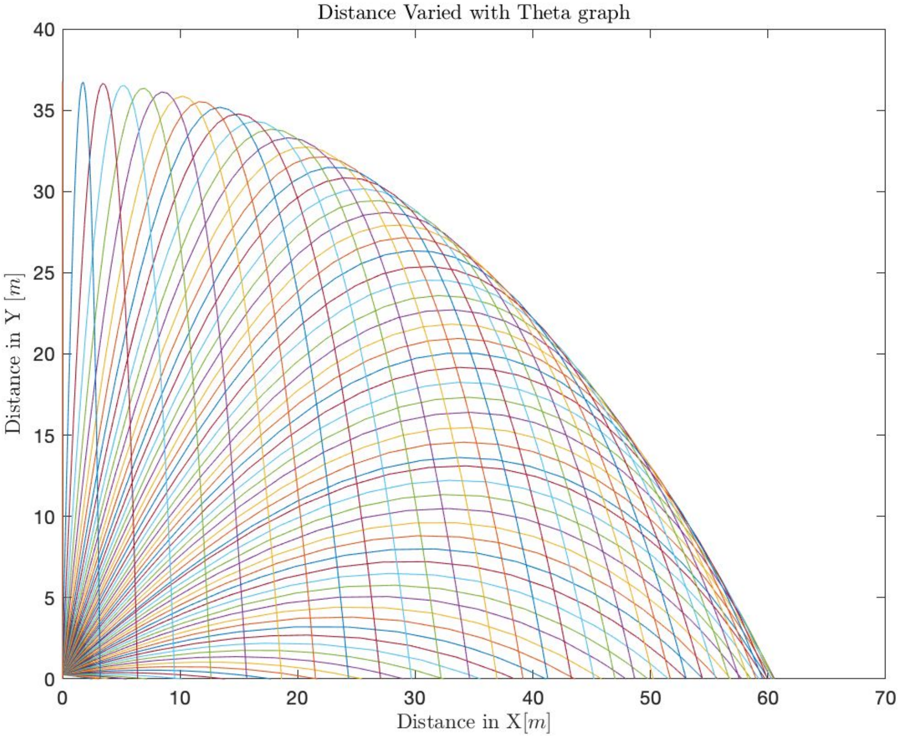


Fig. 2. Distance vs height as Launch angle is varied

VARIATION OF VOLUME OF WATER

- Parabolic function
- Max distance at initial volume of .6 L
- Reaches a max distance of 68.5m

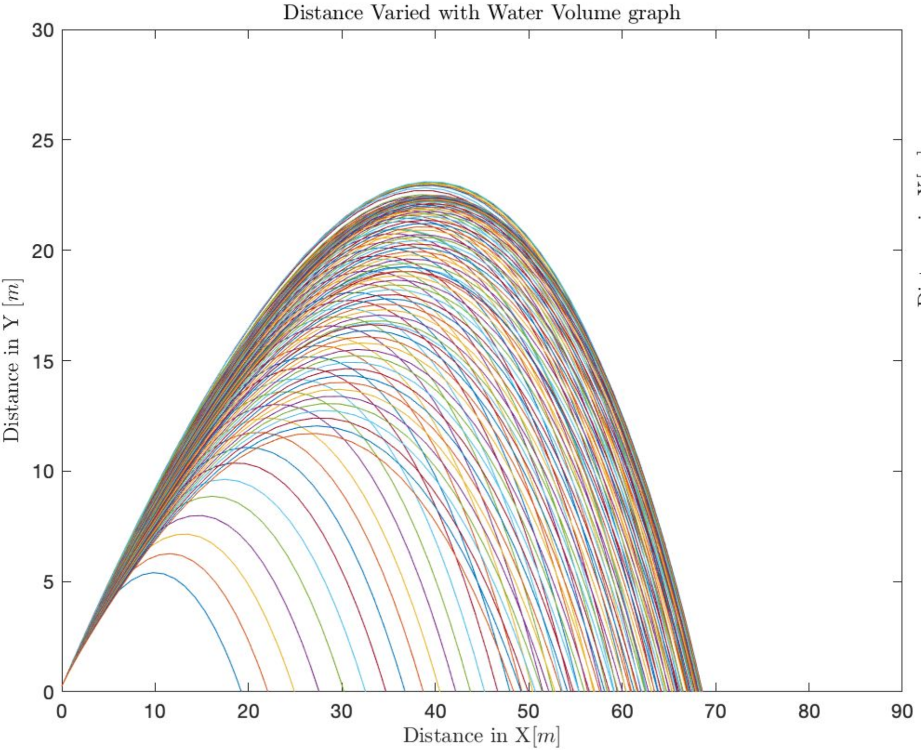


Fig. 3. Distance vs height as Volume of Water is varied

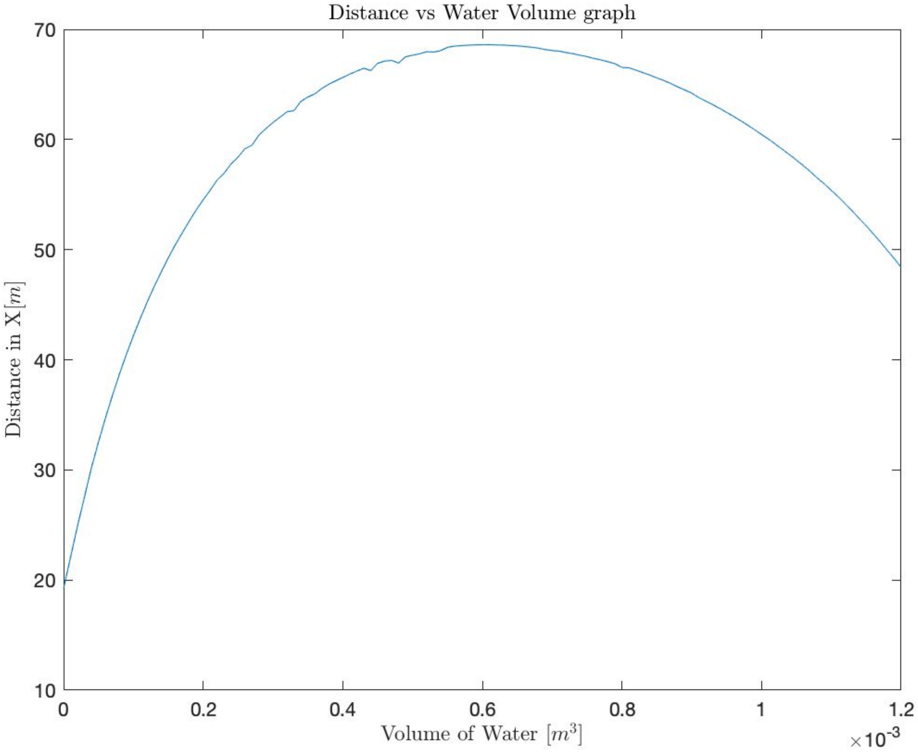


Fig. 4. Distance vs Volume of Water plot

VARIATION OF COEFFICIENT OF DRAG

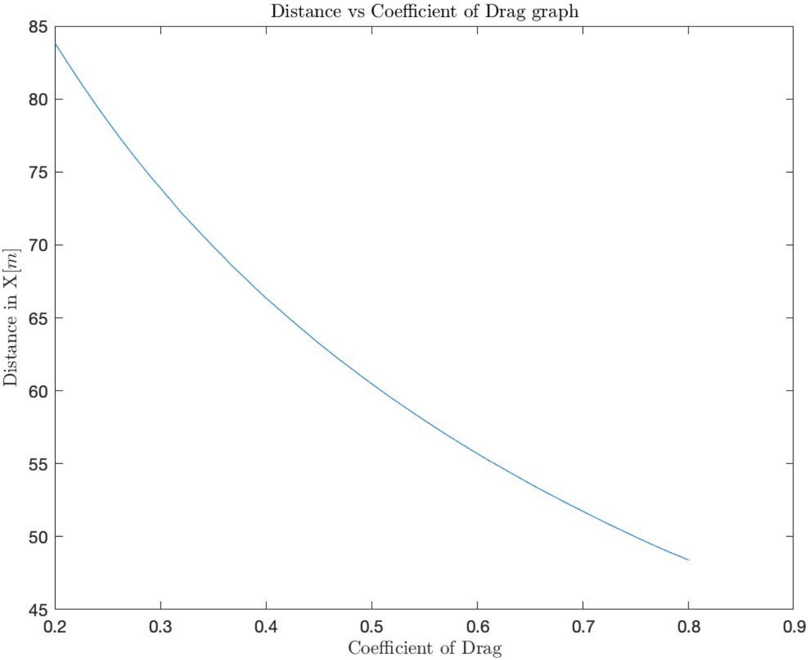


Fig. 5. Distance vs drag coefficient plot

- Decreasing Function
- Max at lowest Coefficient of Drag (.2)
- Reaches a max distance of 83.85m

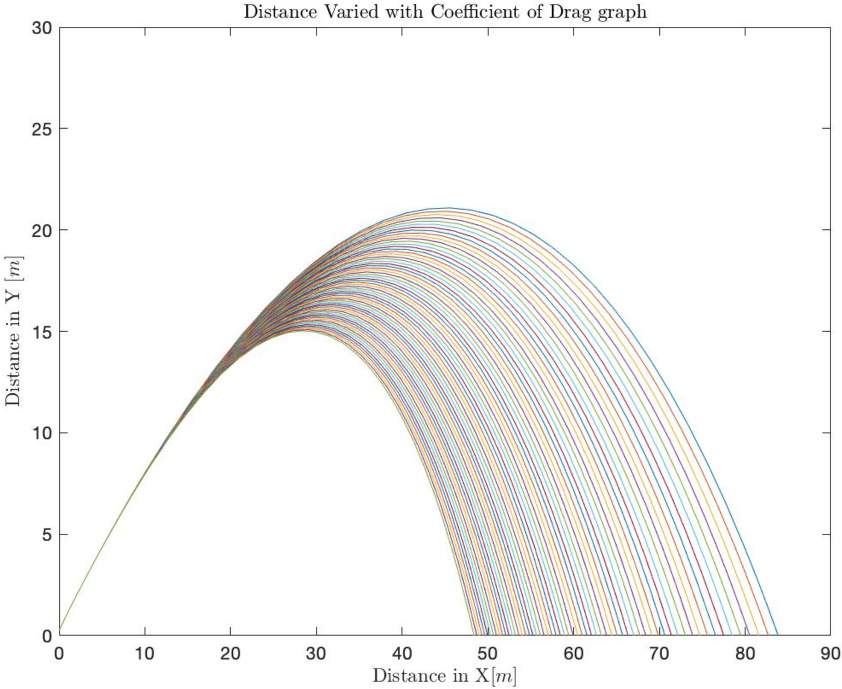


Fig. 6. Distance vs height as drag coefficient is varied

VARIATION OF PRESSURE

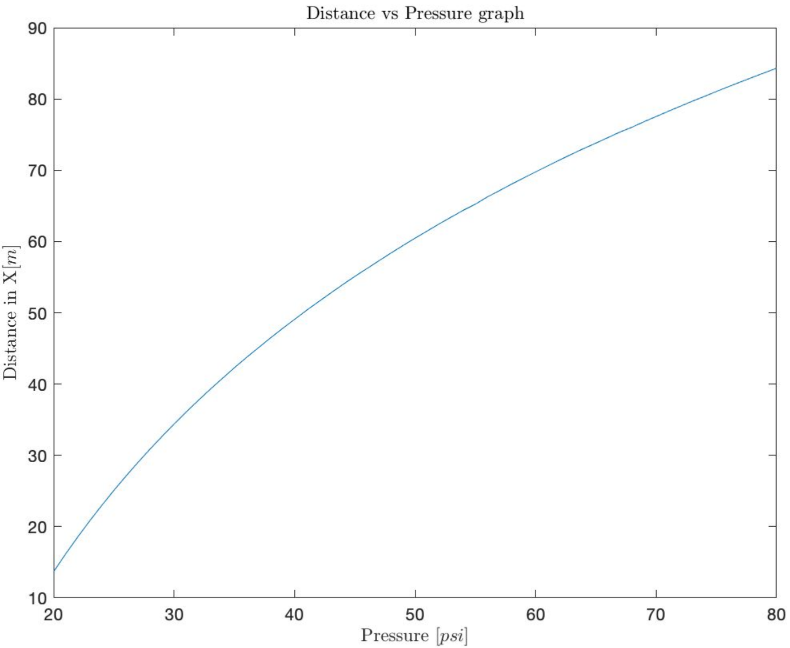


Fig. 7. Distance vs Pressure plot

- Increasing Function
- Max at highest pressure (80 psi)
- Reaches a max distance of 84.3m

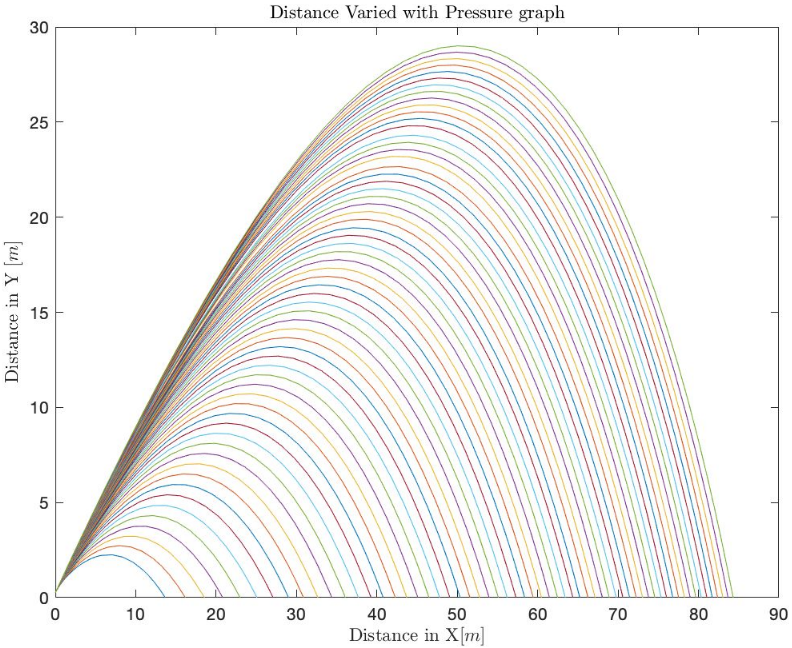


Fig. 8. Distance vs height as Pressure is varied

SUCCESSFUL COMBINATIONS

- Each parameter varied to find combinations that land between 84.5 and 85.5m
- Many different successful combinations
- Certain qualities depend on initial conditions

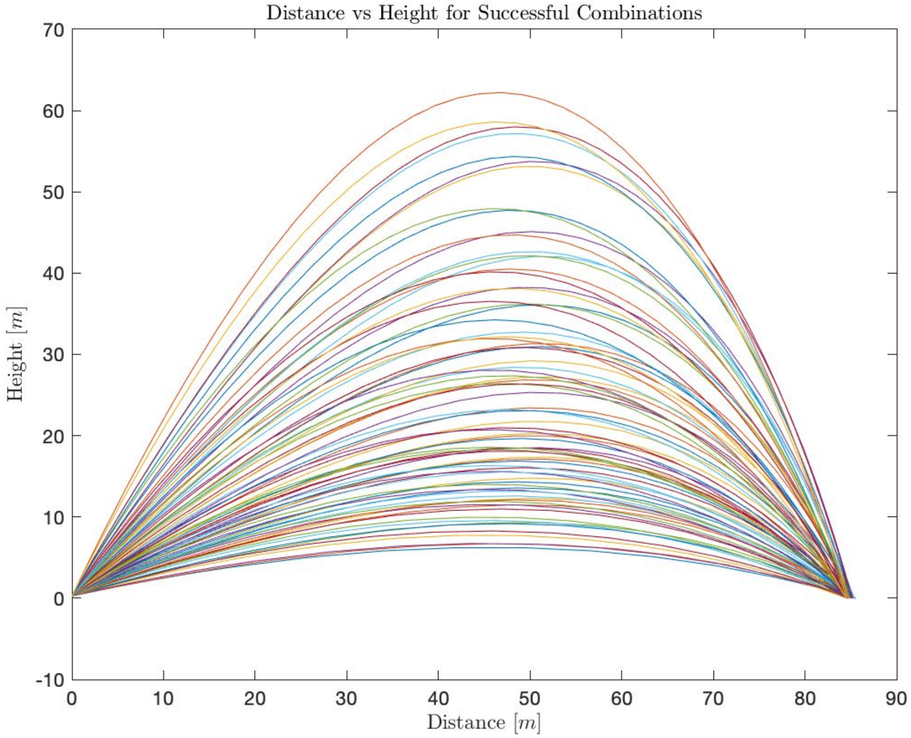


Fig. 9. Distance vs height plot for successful combinations

SUCCESSFUL COMBINATIONS (cont)

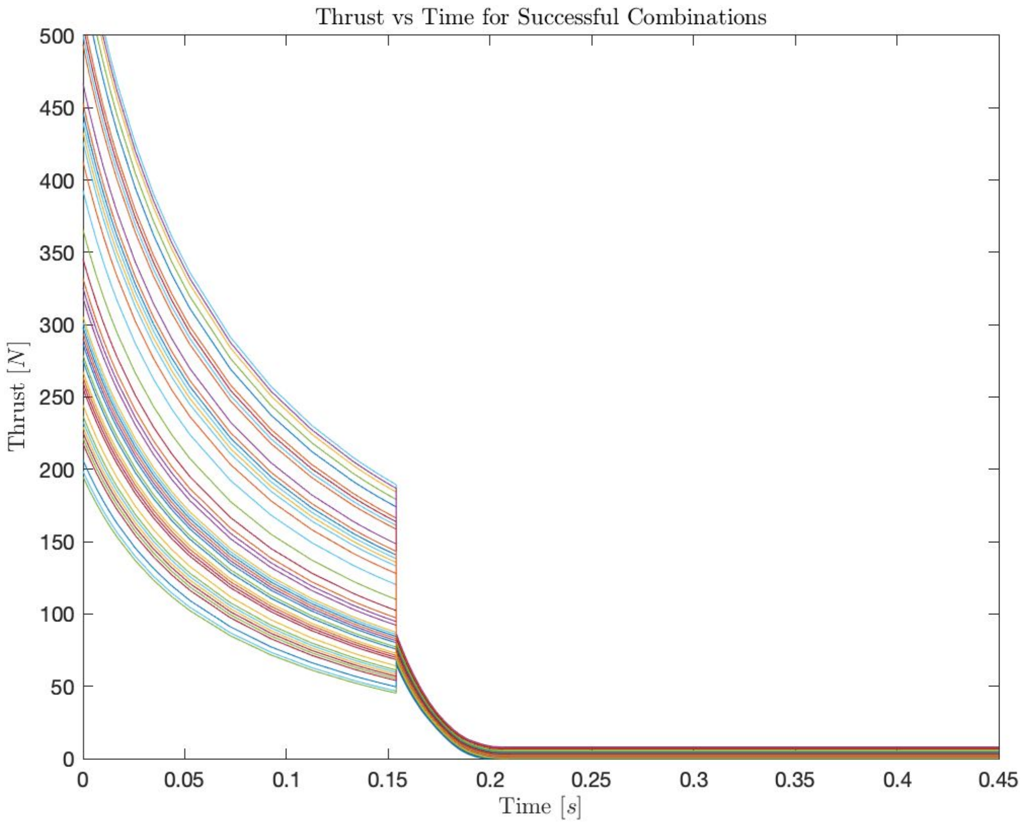


Fig. 10. Thrust vs time for successful combinations

- All combinations have close to same initial water volume
- Thrust profiles look very similar
- Depends on initial pressure

CHOSEN PARAMETERS

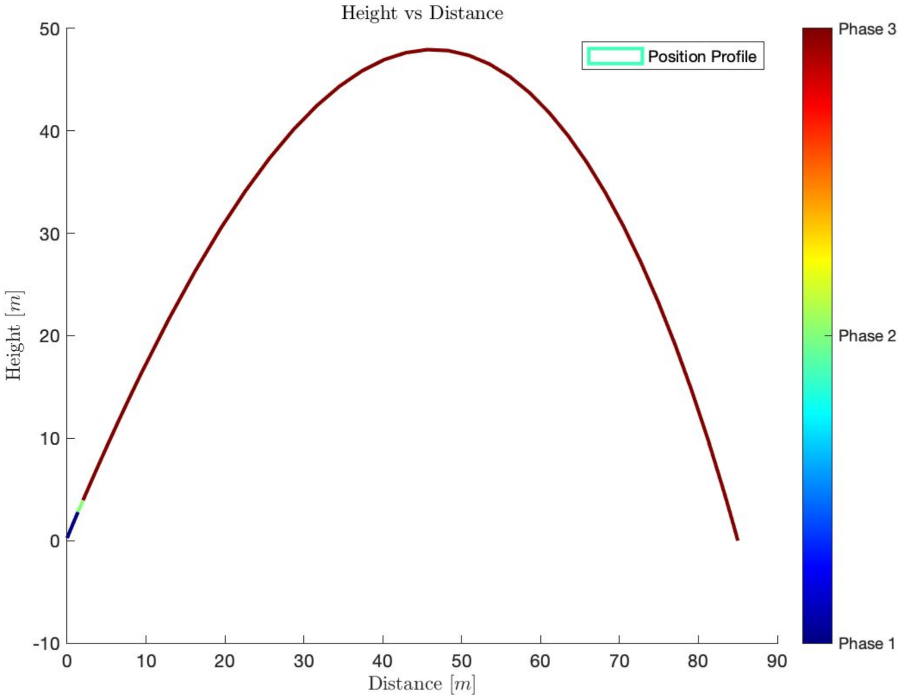


Fig. 11. Distance vs height plot for chosen parameters

- Launch Angle: θ = 63.75°
- Drag Coefficient: C_d = 0.2
- Initial Gage Pressure: P_{gage} = 427490 Pa
- Initial Water Volume: V_{water} = .001 m^3

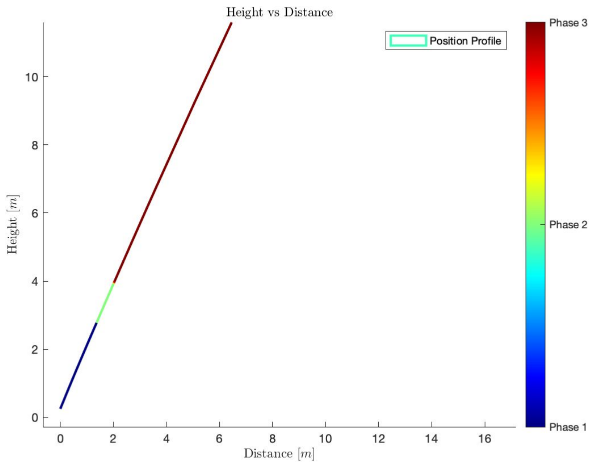


Fig. 12. Distance vs height plot (zoomed in)

CHOSEN PARAMETERS (cont)

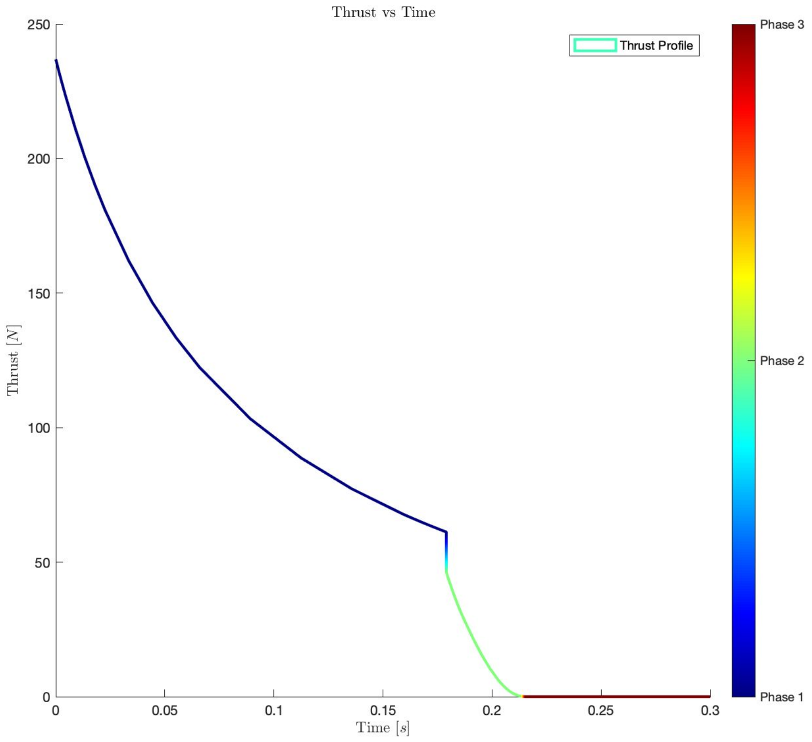
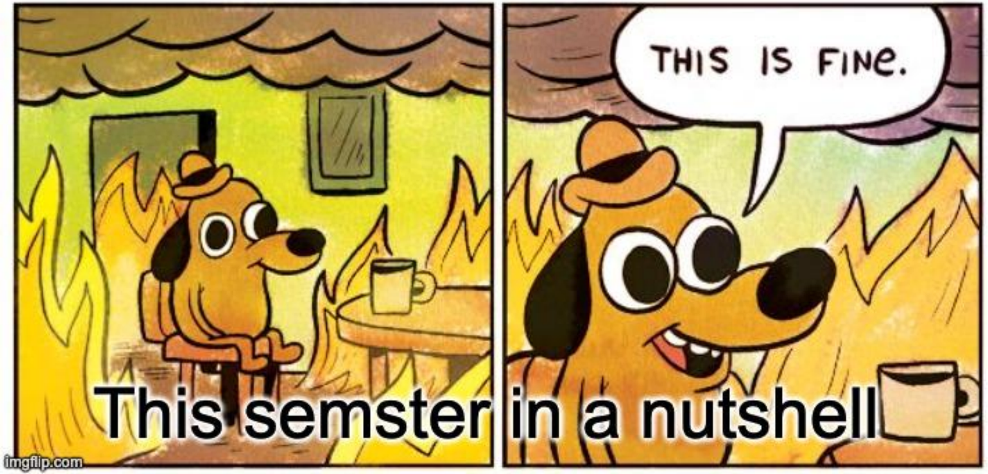


Fig. 13. Thrust vs time for successful combinations

- Color shows actual transition between phases
- When no more water is expelled, thrust transitions to pressurized air
- After air is expelled, thrust converges to zero

CONCLUSION

WRAP UP


THIS IS FINE.
This semster in a nutshell
imgflip.com


Using a if statement to check when rocket hits the ground
Using a function we found online
imgflip.com

Step 1:Purpose

- Use ODE to map flight path of a bottle rocket to hit 65 m
- Vary constats of this rocket to increase distance to 85 m

Step 2:Givens

- Supplied with a table of givens shown below:

Project 2: Verification constants, inputs and trajectory

g = 9.81 m/s2 ... acceleration due to gravity
C_d = 0.8 ... discharge coefficient
$\rho_{air,amb}$ = 0.961 kg/m^3 ... ambient air density
Vol_{bottle} = 0.002 m^3 ... volume of empty bottle
P_{amb} = 12.1 psi ... atmospheric pressure
γ = 1.4 ... ratio of specific heats for air
ρ_{water} = 1000 kg/m^3 ... density of water
D_{Throat} = 2.1 cm ... diameter of throat
D_{Bottle} = 10.5 cm ... diameter of bottle
R = 287 J/kgK ... gas constant of air
M_{Bottle} = 0.15 kg ... mass of empty 2-liter bottle with cone and fins
C_D = 0.5 ... drag coefficient
P_{gage} = 50 psi ... initial gage pressure of air in bottle
$Vol_{water,initial}$ = 0.001 m^3 ... initial volume of water inside bottle
$T_{air,initial}$ = 300 K ... initial temperature of air
v0 = 0.0 m/s ... initial velocity of rocket
θ = 45° ... initial angle of rocket
x0 = 0.0 m ... initial horizontal distance
y0 = 0.25 m ... initial vertical height
l_s = 0.5 m... length of test stand

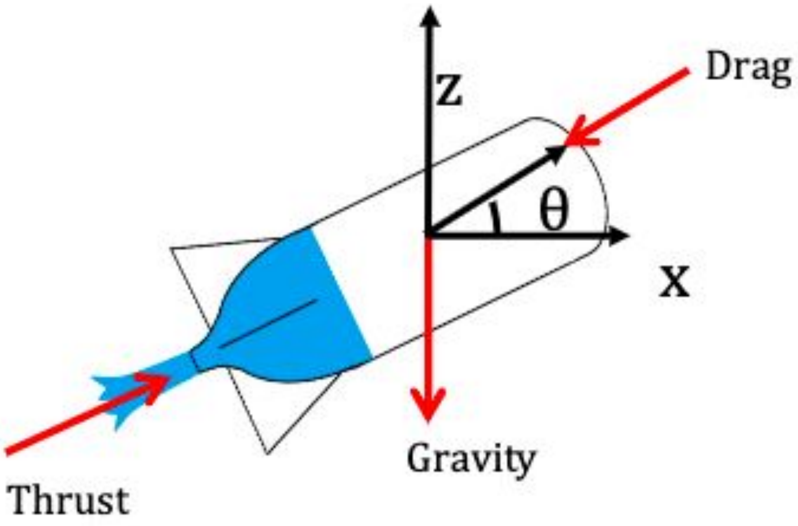
Step 3: Find

- Parameters where rocket hits 85 m within .5 m
- How Pressure, Coefficient of Drag, Launch angle, and Volume of Water vary the rocket
- Thrust vs time

Step 4: Assumptions

- Air is behaving as an ideal gas
- Rocket exists in 2-D(no wind)
- Gravity is 9.8
- Water will reach choked flow

Step 5: Sketch



Step 6: Fundamental Principles

- Ideal gas law
- First law of Thermodynamics
- Newton's laws of motion

Step 7: alternative methods

- Build multiple Rockets for each parameter and Test the distance for each
- Use a rocket simulator

Step 8: Flowchart

- https://docs.google.com/document/d/1KPHG_nPyKQ0oFiM2x7RSuJRN05sIreRjD2k0Zh5tUjA/edit?usp=sharing

- Link to flow charts

Step 9: Hand calculations

- Converting from L to m^3
- Converting psi to Pa
- Checking Constants

Step 10: Reality Check

- Using Physics the max theta should be 45 degrees
- As Coefficient of Drag decreases distance should Increase
- Increase in Pressure should Increase distance and Initial Thrust
- Should not have a max when the bottle is full of water

Table of Contribution

Matt Bechtel	Chris Yakas
50	50

References

https://www.mathworks.com/matlabcentral/answers/429179-how-do-i-extract-an-intermediate-variable-calculated-and-used-inside-my-ode45-function