Scientific Programming

Project 3: Flight of a model rocket

Due 10/24. You must work individually on this project.

Project Goal To simulate the flight of a model rocket with different engines and payloads.

Background The rockets will be flying straight up and down and have three forces affecting them: gravity, rocket thrust and drag due to air resistance.

Drag due to air resistance pushes on the rockets in the opposite direction of its motion. It can be calculated using the following formula:

$$F = \frac{1}{2}\rho C_d A v^2$$

where ρ is the density of the atmosphere, C_d is the coefficient of drag and A is the cross sectional area.

Model rockets are power by solid propellant motors that burn with varying thrusts. Typically they have a large initial thrust that steadies out at a lower level. Rocket motors made by Estes are given a letter and number in their model number, for example C6. The letter indicates how much total thrust and the number the average thrust. Both the C6 and C11 motors have a total of 8,800 Newton-seconds of thrust, but the average thrust of the C6 is approximately 6 Newtons and the average thrust of the C11 is approximately 11 Newtons. So the C6 burns longer at a lower thrust level. For different sized rockets, one may be a better option to use. Our goal with be to determine how high a rocket can fly using each motor and with different payloads.

As the rocket motors fire, they burn off propellant and get lighter. So, the rockets get lighter over time. This varying mass must be taken into account when calculating acceleration.

Project Assignment You will be comparing the flight characteristics of a model rocket using either a C6 motor or a C11 motor. You have the following specifications for the rocket:

Rocket mass	28.35 g
Radius of the rocket	4.1 cm
Radius of the parachute	15 cm
Coefficient of drag of the rocket	.75
Coefficient of drag of the parachute	.9
Density of air	1.27 kg/m^3
Acceleration due to gravity	9.8 m/s^2

You will be comparing the performance of the rocket with each engine choice in three separate experiments:

1. Compare the rockets flight using a C6 rocket to one using a C11 rocket neglecting air resistance. This simulation studies what would happen if their was not atmosphere to slow the rockets down.
2. Compare the rockets with no payload but with air resistance taken into account.
3. Compare the two rockets with payloads of 100 grams and 200 grams. (You should still take air resistance into accounts.)

In each the rocket motor will ignite at time 0 and fire until it burns out. The rocket will continue to coast until it reaches apogee (it's maximum height). At this point in time the parachute will deploy. During its descent, you may assume that the only drag due to air resistance is from the rocket's parachute. Also, in your calculation of drag you should assume that both the rocket body and parachute cross-sections are circular.

For each simulation you should graphs heights and velocities. You should also record data at the major stages of flight: engine burnout, apogee and landing. This data should include the time into flight each occurs, the rocket's velocity and height.

How does the choice of rocket motor's affect the flight of the rockets? (Recall: each produces the same total amount of thrust.) Under what circumstances would you want to use one versus the other? What general conclusions can you make?

The files `thrust_c6.m`, `thrust_c11.m`, `mass_c6.m` and `mass_c6.m` can be found on the course website. The first two define functions `thrust_c6(t)` and `thrust_c11(t)` that give the thrust of the rocket motors in Newtons, t seconds after ignition. The second two define functions `mass_c6(t)` and `mass_c11(t)` give the mass of the rocket motors in kilograms, t seconds after ignition.

Requirements

- You must have a clear, well-written writeup describing your experiments and their results.
- Include your graphs with your text.
- You Matlab code should be included as an appendix to your writeup.
- Your writeup should be much more than just a discussion of your code.

Hints and Suggestions

- Start early.
- When the rocket's engines first fire they do not produce enough thrust to counteract gravity. However, the rocket is still supported, make sure that the rocket's height does not decrease.
- The force of drag always goes in the opposite direction than the rocket is moving. You might want to use an if statement to make sure you have the drag going in the correct direction.
- A while loop might be helpful to stop your simulation once the rocket has reached the ground.
- Make sure you convert all of your units to meters, seconds and kilograms.