Voyages to the Terrestrial Planets Lab 6 – *Predicting rocket heights and other parameters*

Overview: The purpose of this lab is to get you thinking more about your model rocket you are constructing and what factors you should consider when constructing it. Specifically, you will be using rockets constructed by students from a previous course to predict how high that rocket should have flown and how much drag that rocket likely experienced. You will then compare those predictions to videos/tales of how the rockets actually functioned. You will then use that information to inform your decisions as to how to construct your own rocket.

Due: This is due at the beginning of lab next week.

To do: Answer the questions below.

1) The rocket launch cycle…

a) Before we get started with any calculations, let's first develop a conceptual model of what happens during a model rocket launch. Thinking back to the pre-lab discussion, sketch below the different parts of a rocket launch from takeoff to touchdown. Make sure to label the different parts of the trajectory.

b) Does the rocket motor last the whole time during the rocket's flight? Explain.

c) Does gravity act upon the rocket during its entire flight? Explain.

2) Calculating how high a rocket will go…
a) To calculate the height, we need the following pieces of information first:

- -Total impulse of the motor (I; taken from the chart of engine motors)
- -Liftoff weight of the model (Wl; measure on a scale, convert to kg, then multiply by gravity)
- -Propellant weight (Wp; engine weight measured on a scale, convert to kg, multiply by gravity)
- -Burnout weight of model (Wb; Wl – Wp)
- -Duration of thrust (tb; taken from chart of engine motors)
- -Acceleration due to gravity on Earth (g)

Record this information below for your own notes…make sure to keep your units consistent!

b) The next step is to calculate how fast our rocket is travelling; this is our maximum velocity (Vmax) and it can be calculated as follows:

$$Vmax = (I*g)/Wb$$

Perform your calculation in the space below:

c) Now we can calculate how high the rocket goes when the motor runs out. To do that, we need to calculate our average velocity (Vavg), where we assume our initial velocity is 0 m/s and our final velocity is Vmax. Our height at burnout (hb) is therefore:

$$hb = Vavg*tb$$

Calculate your burnout height in the space below:

d) However, even though the engine has burned out, our rocket is still travelling upward; in other words, it is coasting. Now we need to calculate how high it goes when it is coasting (hc), which can be calculated as:

$$hc = Vmax^2/(2g)$$

Calculate your coasting height in the space below:

e) Now, your total height the rocket travelled can be calculated by adding hb and hc together:

Max height of rocket = burnout height + coasting height

How high should the rocket theoretically go and how long should it take to get there? Show your work in the space below.

d) On a sheet of graph paper, create a graph that shows the altitude of the rocket over the course of the time of flight; altitude should be on the y-axis and time of flight (in seconds) should be on the x-axis. Assume a downward travel time of 8.5 seconds.

e) Watch a video of the rocket launch and describe what actually happens to the rocket. Is there a discrepancy between your observations and calculations? Explain. Did we ignore anything with our calculations?

3) Now let's think about drag. The drag (D) an object experiences as it moves through a fluid can be described with the following equation:

$$D = 0.5*\rho*V^2*C_d*A$$

Where ρ is the density of the fluid the object is moving through (air), V is the velocity of your rocket, C_d is the drag coefficient of your rocket design, and A is the frontal area of your rocket.
You don't have to calculate anything with this equation here, but I want you to consider the following questions:

a) What happens to drag as each of the following changes:

-velocity increases:

-C_d increases:

-A increases:

b) Which individual factor above will have the greatest effect on drag? Why?

c) Of the rockets you examined earlier in this lab, which one likely has the greatest drag? What are the implications for trying to launch the rocket? When answering this question, make sure to consider all factors listed in the equation above.