Dave Dale – Estes Chemical Rocket Computer Simulation

NS 548

Aim Of This Simulation

This chemical rocket simulation is designed to be used in a classroom to supplement a hands-on chemical rockets project and lab. It will display for students a basic flight pattern of their chemical rocket which they are to construct with in-class materials. Upon beginning the project, many students have never seen a chemical rocket in flight, do not have any idea what they are building, and how to visualize its flight pattern. The simulation uses basic flight data about Estes chemical rocket engines as well as basic projectile equations to illustrate force and motion concepts such as Newton's Second Law (F=MA), the concept of thrust (as impulse momentum) and gravitational acceleration ($g = 9.81\ m/s^2$).

Computer Simulation Lab as part of the total project

There is an existing lab attached which accompanies this simulation. Students will use the simulation to calculate additional data before launching their rocket including, gravity figures from other planets, such as the moon, Jupiter, or Mars. They will input their rocket's mass and assume a certain angle which it might be launched at. These will be inputted in the appropriate panels underneath in order to visualize a possible flight pattern (assuming a somewhat ideal flight path which does not account for the ejection explosion which occurs at the end of its flight).

Analysis Part of Lab

The written part of the lab involves creating a free-body diagram. For 9th graders, in September of the school year, this will surely be their first and it is therefore given some idealized conditions. However, they do use appropriate force and motion equations here as well as gravitational acceleration (g). The additional idea of impulse is merely introduced in this lab. Furthermore, this lab serves as a nice lead in activity to the next chapter which concerns impulse and momentum.

Further Lab Explorations

There are also existing, fun tangents the maker of this simulation would like to eventually include which involve graphing the thrust over time for three different possibilities of propellant burn. These three possibilities are neutral burn, progressive burn, and regressive burn, each of which has their own accompanying graph which could be displayed as a function of impulse over time. In reality, the students figures for an actual flight for a chemical rocket would not be able to coincide with these three types of burns because they involve a rocket's thrust coordinates changing over time as the rocket is leaving the earth's atmosphere which is obviously something which these chemical rockets will never achieve. However, these graphs could be shown manually to students that they might speculate about various ideas such as escape velocity of spacecrafts leaving earth's orbit etc. One question to make students give a written answer to after seeing their actual chemical rocket flight is what kind of propellant burn (from the above three) would their chemical rocket have to be, based on inspection of their engine (ie. the way the propellant is packed in it) and the rocket's flight pattern and why.

A second added discussion with students here is how much of the talk of a real life manned trip to Mars is just pure fantasy vs. real life. This is a wonderful discussion to begin with students as it gives them something to dream a little bit about. It can be very relevant to bring this up when discussing rocket propellants. One obvious issue with a manned flight to Mars is how to create a spaceship which holds enough fuel to take it on a 6 month voyage to the red planet and back again on a mere NASA budget. Robert Zubrin, in his 1996 book, "The Case For Mars, The Plan To Settle The Red Planet And Why We Must" gives a wonderful explanation of how to create one's own fuel WHILE ON the red planet by accessing it's already large supply of CO_2 making it possible to only need enough fuel supply for the trip there. He brings up a 19^{th} century chemical reaction known as the Sabatier reaction which creates methane (CH_4) from mere CO_2 and H_2. This is not the only issue there is against a manned spaceship voyage to Mars, but it is one which sparks much interest with students and can be discussed when propellant amount is discussed.

Construction of the chemical rocket

2-3 days are also allotted for the actual construction of the students' rockets. This, in itself is a rather painstaking process which will not covered in this write up as it is a separate part of the lab. An old (rather rustic) version of the writer's original class write up from 2004 from his outdoor education employment is included for fun. It is a rather involved process by itself but was written to educate a non-science layman on how to walk a group of students through the process of constructing a home-made chemical rocket. (Apologies for the lack of a good word processor from those days, the writer has never bothered to attempt to rewrite it on account of all of the intricate drawings which are crucial to the write up yet rather hard to duplicate.)

Chemical Rocket Computer Simulation Analysis
NAME______________________________

1.) Mass of Your Rocket in kg (from written part of lab)

____

2.) Try inputting a value for gravity on Jupiter. (Jupiter g = 25.95 m/s^2)

What does your rocket do differently?

____
____
____

3.) Try inputting a value for gravity on the moon. (moon g = 1.62 m/s^2)

What does your rocket do differently?

____
____
____

4.) Add some mass to your computer rocket, and create a slight angle to your launch.

Launch it again with more mass. Does adding mass have any effect on the angle of your rocket? Why or why not?

____
____
____

5.) Change the rocket engine thrust time to a different thrust time which corresponds to a different size Estes Rocket Engine. What affect does this have on your simulated flight path?

____

____

____

6.) Try changing the velocity in both the v_x direction and the v_y direction. What affect does this have on your chemical rocket's flight path?

____

____

____