NAR Education Resource CD-ROM v1.0

Simulations Lesson Overview

Why use computer programs to simulate model rocket launches? Simulations are an excellent way to introduce material that students are too busy and excited to absorb at model rocket launches. The simulations take place in the classroom and occur at a slower pace than activities at the launch site. You may be in situation or location that prevents you from launching with your students at all. Simulation will give your students an appreciation for "real world" performance and lets them see what model rockets can do under a variety of conditions.

There are two excellent introductions to simulation included on this CD. The first: "A Rocksim Lesson in Rocket Stability" (Rocket_Stability.pdf) is a great guide to what you can accomplish in the classroom using simulations. It shows a typical model rocket flight simulation for the classroom using text and quicktime movies. The Rocksim lesson will show you the text results of your simulation and how to view an informative and entertaining animation of the simulated flight. A second lesson: "wRASP, A Primer" (wRASPprimer.pdf) is meant to be printed out and read as you proceed through a wRASP simulation. This guide will show you the wonderful graphs that you can generate with rocketry simulation programs. The graphs are a very useful tool for the students to compare the results two or more different simulations.

General Simulation Guidelines

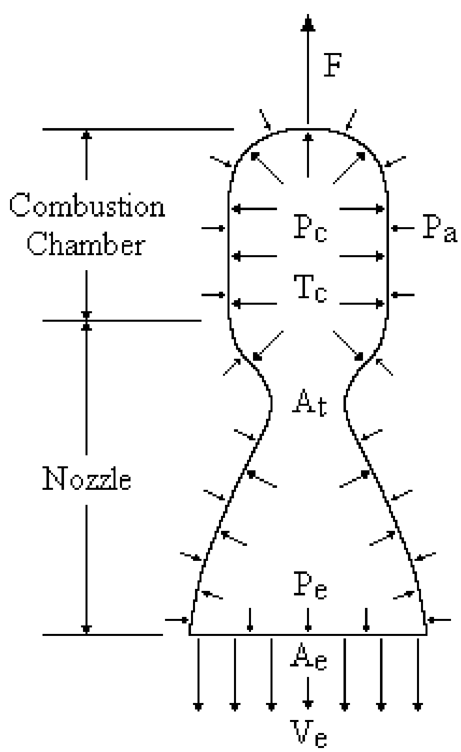
Not all lesson plans are appropriate for all ages and groups. Adapt your lesson plan to accommodate your students' needs. When teaching a given concept, elements and activities can be removed to adjust the concept down to your students' level. Also, additional background and mathematics can be added to make a lesson suitable for older students. Activities and illustrations from your text should be added to complete the outlines shown here. We hope that from the ideas presented here you see that you can create a lesson plan using computer simulations of model rocket flights that fits into your curriculum.

Suggested Concepts

1) Newton's First Law - An object at rest remains at rest; an object in motion remains in motion, until acted upon by an outside force.
Simulation Activity: Simulate the flight of a model rocket. Vary the mass of the rocket while keeping the shape of the rocket the same and keeping same motor. Note the altitude of each simulated flight. You will see there is an optimum mass for most model rockets. The rocket will actually fly higher when it is heavier. (Up to the point of optimum mass and then the altitude will decrease as the mass increases.) Why? To get this to work you may have to use a fairly large model rocket and motor in the simulation.
Follow up questions: Which is heavier a baseball or a feather? Which can you throw farther? Why? How do rockets use gyroscopes to steer in space? How do rockets use fins to steer in air?

2) Newton's Second Law - Force = (Mass) * (Acceleration)
Discussion: definitions of force, distance, time, velocity, and acceleration (F=ma, V=x/t, A=(change in velocity)/t); How computer rocket simulations work by integrating the acceleration. (see wRASP Technical Data (wRASP_tech.pdf) for details)
Activity: Show the difference between constant velocity and constant acceleration.
Simulation Activity: Keeping the rocket design and motor constant, vary the mass of the rocket in the simulation. Note that the heavier rocket will have a slower acceleration during the engine burn. The velocity of the heavier rocket will always be lower at engine burn out than the lighter rocket. (Even if the rocket coasts to a higher altitude.)

3) Newton's Third Law - For every action, there is an equal and opposite reaction.
Discussion: The principle of action and reaction is what makes a rocket motor work. How? What does a rocket motor push against? Discuss this picture of a rocket motor. What is the fuel? Does it matter?



Activities: water rockets, blow up a balloon and let it go, Newton's balls
Simulation Activity: Simulate a normal model rocket flight, now move the engine off-center (Rocksim). What happens?
Question: Will a rocket work in space? How?

4) Rocket Stability Part 1 - Center of Gravity
Discussion: Definition of Center of Gravity - The balance point of an object due to the force of gravity.
Activities: Throw a ball in the air so that it spins. What point does the ball spin around? Why. Balance a hammer on your finger. Mark the spot where the hammer balances with brightly colored tape. Throw the hammer in the air so that it spins (end over end). What point does the hammer spin around? Why. Place a ball in a sock. Throw the ball across a distance. What point leads? Does it matter how you throw the ball in the sock? Balance a rocket to find its Center of Gravity.
Simulation Activity: Simulate a normal model rocket flight, now move the Center of Gravity back in the rocket. You can do this by adding weight to the back of the rocket, moving the parachute back, or even by using a larger motor. What happens?
Questions: Will adding weight to the nose of a rocket make it more or less stable? As the propellant burns will the rocket become more or less stable? Why insert the engine before checking a rocket's Center of Gravity? Will bigger fins at the rear of the rocket move the Center of Gravity forward or backwards?

5) Rocket Stability Part 2 - Center of Pressure
Discussion: Definition of Center of Pressure - The balance point of all the forces due to the motion of air across an object.
Activities: Cut out a accurate, full scale outline of a model rocket in cardboard. Find out where the outline balances. This is a good estimate of the Center of Pressure. Compare this to the Center of Gravity of the rocket. Throw the ball in the sock from Part 1 again. What part always follows? Why?
Simulation Activity: Simulate a normal model rocket flight, now move the Center of Pressure forward. You can do this by making the fins smaller, using fewer fins, changing the sweep of the fins, or making the nose cone wider. What happens?
Questions: Will bigger fins at the rear of the rocket move the Center of Pressure forward or backwards? Can the fins ever go at the front of the rocket? Where does the Center of Gravity need to be in relation to the Center of Pressure for the rocket to fly in a stable manner? Is it easier to make a long rocket or a short rocket stable?

6) Scientific Method
Discussion: The Method:

- write a question
- research previous work
- write a hypothesis
- construct an experiment
- collect data
- form a conclusion

definitions: independent variable, dependent variable
Simulation Activities: use a computer simulation to hold many parameters constant and vary the independent variable then verify your findings with actual launches.

Simulation Programs

Rocksim 5.0 - Apogee Components, http://www.apogeerockets.com/
Tools: 3D rocket design, flight data window, flight path animation
Classroom Rockets Included: Apogee Blue Streak, Estes Bullpup 12D, Estes Viking, Estes Alpha, Estes Fatboy
How to Use: Good for viewing CP and CG on a drawing of the rocket. Good for viewing simulated flight paths. Very powerful overall. For best results, take some time and enter all of the components of the rocket you will be working with in the design window (easy to use). Rocksim will then be a powerful tool for simulating all aspects of your model's flight.

VCP - Visual Center of Pressure, http://www.missileworks.com/VCP.htm
Tools: 2D rocket design, fin layouts and patterns
Classroom Rockets Included: Shecter Rockets (in Launch Menu)
How to Use: Good for easy viewing of CP. Great tool for quick and dirty analysis of a new design. Easy to see how rocket design changes effect the CP. Great for printing patterns for transition cones and fins.

wRASP - Rocket Altitude Simulation Program (windows), http://www.wrasp.com/
Tools: provides graphs of rocket flight performance
Classroom Rockets Included: Aerotech Initiator, Apogee Blue Streak, Estes Alpha, Estes Alpha III, Estes Bull Pup, Estes Fatboy, Estes Generic E2X, Estes Viking, Estes Wizard, Estes Yankee, Pratt Polaris, Pratt Super Six, Quest Astra, Quest Gamma Ray, Quest Nike Smoke, Quest Starhawk, Quest Sprint, Shecter Rockets (in Launch Menu)
How to Use: Good for comparing aspects of two different flights. You can compare the velocity and altitude at motor burn out or apogee. Good visualization for math-based lessons. Good for quick estimate of a rocket's maximum possible performance.

Winroc 4.5 - http://www.winroc.org/
Tools: Alticalc, a rocket altitude and performance simulator; Winroc Graph, which works closely with Alticalc for displaying graphs; Thrust Curve Manager, which manages and allows you to add or alter motor data; Motor Wizard, which walks you through creating a motor record; CPCalc, a virtual blueprint for calculating center of pressure.
Classroom Rockets Included: Aerotech Initiator, Estes Alpha
How to Use: Good for comparing aspects of two different flights. You can compare the velocity and altitude at motor burn out or apogee. Good visualization for math-based lessons. Good for quick estimate of a rocket's maximum possible performance. Good for easy viewing of CP. Easy to see how rocket design changes effect the CP.

Additional simulation and CP files can be found at
http://www.rocketreviews.com/cp_rocksim.shtml#CP

Model rocket construction and launch tips are in the Launch Lessons.

Bibliography

*Basics of Model Rocket*ry, Douglas R. Pratt, Kalmbach, 1981
Cosmic Classroom: Moving In Space, Space Center Houston 1998
*Handbook of Model Rocket*ry, G. Harry Stine, John Wiley & Sons, 1994
*Model Rocket Design and Constructi*on, Second Edition, Timothy S. Van Milligan, Apogee Components, 2000
*69 Simple Science Fair Projects with Model Rocke*ts, Timothy S. Van Milligan, Apogee Components, 1996
Teaching Science Through Model Rocketry, Tony Wayne, 3 Pigs Publishing, 1994