Mathematics

How High Did It Go?

STEP 1. LEARN (First class session: 15 minutes)

NATIONAL STANDARD

Standard 6
Understands and applies basic and advanced concepts of statistics and data analysis

Benchmark 5
Uses data and statistical measures for a variety of purposes

Objectives

- Students will discover what data is collected to use to calculate how high their rocket launched.
- Students will use the Estes Altitrak™ to get data for altitude calculations.
- Students will utilize the launch data collected for each class members' rocket to calculate how high each rocket went when launched.
- Students will construct and launch an Estes model rocket.

Materials

1. Generic E2X®, Alpha III® or UP Aerospace™ SpaceLoft ™ Rocket Lab Pack™ (12 pack) - 2 or more
2. Rocket Engine Lab Pack™ (24 pack) - 1 or more
3. Electron Beam® Launch Controller - 1 or more
4. Porta-Pad® II Launch Pad - 1 or more
5. Paper, pencil, white or carpenter's glue or plastic cement, scissors, modeling knife, ruler and masking tape for each student
6. Launch Data Sheet for each student
7. Model Rocket Flight Profile, Model Rocket Safety Code and Table of Tangents handouts
8. Estes Altitrak™ - 3 or more
9. Tennis ball - 5 or more

Time

Two class sessions

Background

Building a model rocket, launching it and collecting data are super activities for math class. Students will learn about how a model rocket launches and all safety procedures that are included in the Model Rocket Safety Code by the National Association of Rocketry (NAR).

A Typical Model Rocket Flight

Thrust is the upward force that makes a rocket move off the launch pad. This is a demonstration of Newton's Third Law of Motion: "For every action there is an equal and opposite reaction." The action of the gas escaping through the engine nozzle leads to the reaction of the rocket moving in the opposite direction.

The casing of a model rocket engine contains the propellant. At the base of the engine is the nozzle which is made of a heat-resistant, rigid material. The igniter in the rocket engine nozzle is heated by an electric current supplied by a battery-powered launch controller. The hot igniter ignites the solid rocket propellant inside the engine which produces gas while it is being consumed. This gas causes pressure inside the rocket engine, which must escape through the nozzle. The gas escapes at a high speed and produces thrust.

Located above the propellant is the smoke-tracking and delay element. Once the propellant is used up, the engine's time delay is activated. The engine's time delay produces a visible smoke trail used in tracking, but no thrust. The fast moving rocket now begins to decelerate (slow down) as it coasts upward toward peak altitude (apogee). The rocket slows down due to the pull of gravity and the friction created as it moves through the atmosphere. The effect of this atmospheric friction is called drag.

When the rocket has slowed enough, it will stop going up and begin to arc over and head downward. This high point or peak altitude is the apogee. At this point the engine's time delay is used up and the ejection charge is activated. The ejection charge is above the delay element. It produces hot gases that expand and blow away the cap at the top of the engine. The ejection charge generates a large volume of gas that expands forward and pushes the recovery system (parachute, streamer, helicopter blades) out of the top of the rocket. The recovery system is activated and provides a slow, gentle and soft landing. The rocket can now be prepared for another launch.

To summarize, the steps of the Flight Sequence of a Model Rocket are:

1. Electrical Ignition and Liftoff
2. Acceleration or Thrust Phase
3. Coast Phase and Tracking Smoke

4. Peak Altitude (Apogee) and Ejection
5. Recovery System Deployed
6. Touchdown

Activity

1. Students will draw what they know about model rockets using a webbing chart format.
2. Hand out Model Rocket Flight Profile and Model Rocket Safety Code sheets to all students. Summarize both sheets with the class.
3. Students will take summary sheets home to review so they will be ready for the class launch.
4. Discuss how recording launch data will be useful for figuring out how high their rocket went.
5. Practice using the Estes Altitraks. When students track the launched rocket, they will track a moving object. To practice tracking a moving object, students will use a tennis ball. One student will throw the ball up in the air while the other student tracks with the Altitrak™.

KEY WORDS

accelerate
altitude
apogee
data
decelerate
drag
ejection charge
gravity
igniter
nozzle
predicted
propellant
time delay

STEP 2. BUILD (First class session: 35 - 40 minutes)

Activity

1. Students will make and launch an Estes model rocket to acquire launch data to use to calculate how high up the rocket went.
2. Build the Alpha III®, Generic E2X® or UP Aerospace™ SpaceLoft™ together with students, using step-by-step procedures. E2X® rocket kits contain parts that are colored and easy to assemble. Glue the parts together as per the instructions, apply the self-stick decals, attach the recovery system and you are ready to launch.

STEP 3. LAUNCH (Second class session)

Activity

1. Assign and post launch jobs for students. Launch jobs are in the *Estes Educator Guide for Teachers & Youth Group Leaders*.
2. Prepare rockets for launching in your classroom before going outside to launch. Follow the Engine Preparation steps located in the rocket instructions.
3. Launch rockets outside at a soccer field, football field, baseball field, green grass area or blacktop area.

HOW HIGH DID IT GO?

All students will select a launch partner. When one partner launches their rocket, the other partner will use the Estes Altitrak™ to collect the launch data for their partner's rocket launch. Students will record launch data on the Launch Data Sheet.

1. Measure and mark 500 feet (152 meters) from each launch pad. The partner (tracker) using the Altitrak™ will stand here.
2. The tracker will hold the Altitrak™ at arm's length, pointed at the rocket. Next, pull and hold the trigger then signal for the launch.
3. Tracker will track rocket through forward sight. When the rocket reaches maximum altitude (apogee), they will release the trigger.
4. Partners will record the angle in degrees from the Angle Scale on the Altitrak™.
5. Make sure the predicted altitude is filled in before each rocket launches.
6. Partners will switch places and repeat the launch procedure.
7. When all launches are completed, return to the classroom and let students fill in the launch angle in degrees for each student's rocket.
8. Students will calculate the altitudes of all rockets. The formula to use is: Altitude = Angle Tangent times Baseline Distance

Example: 30° Angle reading: Tangent = .58
Baseline = 500 ft.
.58 X 500 ft. = 290 ft.

The rocket's altitude is 290 ft.

Optional: Use the metric system.

Example: 30° Angle reading: Tangent = .58
Baseline = 152 meters
.58 X 152 m = 88 m

The rocket's altitude is 88 m.

Notes:

1. You may choose to let your students make their own altitude tracker. For information on how to make your own trackers see the Estes Educator™ Science and Model Rockets Curriculum available at www.esteseducator.com.

2. To avoid travel delays when switching altitraker positions, groups of students can move out to the tracking site and use walkie-talkies (or shouting) to let them know when their partner's rocket is going to be launched. You can have the next altitraking group begin to move out to the tracking site as the current group is finishing.

Wrap Up - Touch Down & Recovery

1. Students will record their rocket's altitude on a spreadsheet or class chart.
2. Students will determine whose rocket(s) were the highest flyer(s).
3. Students will compare their altitude predictions (their rocket & their partner's rocket). How close was their prediction to the actual height? Which factors contributed to make their prediction too low or too high?

Extensions

1. Students can hypothesize what might happen if partners launch two different rockets with the same engine. What factors will affect the altitude of these two different rockets?
2. More math can be done using statistics. Using the altitude results, have students calculate mean, medium, mode, produce a stem or a leaf plot.

Evaluation/Assessment

- Students will draw what they know about model rockets using a webbing format.
- Students will assemble and launch an Estes model rocket.
- Students will record launch data from the Altitraks on the Launch Data Sheet.
- Students will calculate the height of their own and their partner's rocket flight.

References

- *Estes Educator™ - Guide for Teachers and Youth Group Leaders*
- Estes Educator™ Website – www.esteseducator.com
- Estes Educator™ - *Elementary Mathematics of Model Rocket Flight*