GRADES 6-8
Three Class Lesson Plan

Mathematics

How High Was It?

STEP 1. LEARN (First class session)

NATIONAL STANDARD

Standard 1
Uses a variety of strategies in the problem-solving process

Benchmark 2
Uses a variety of strategies to understand problem-solving situations and processes

Objectives

- Students will record flight data to use for altitude tracking.
- Students will operate the Estes Altitrak™.
- Students will use flight data to calculate rocket altitudes.
- Students will find rocket altitudes using graphs.
- Students will make and launch an Estes model rocket to practice two methods of altitude tracking.

Materials

1. Viking™, Alpha® or Wizard™ 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, carpenter's wood glue or white glue, scissors, modeling knife, ruler, masking tape, sandpaper and spray paint for each student
6. Visuals/Overheads: Model Rocket Flight Profile, Altitude Tracking
7. Model Rocket Safety Code for each student
8. Graphing Using One Station Tracking handout for each student
9. Table of Tangents and Launch Data Sheet for each student
10. Tennis ball - 5 or more
11. Protractor for each student
12. Estes Altitrak™ - 3 or more

Time

Three class sessions

Background

Model Rocket Flight Profile

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

Calculating Rocket Altitude with Launch Angles

All students need to have 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. (See Altitrak™ instructions.)

1. Baseline Distance - 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, 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™. Also record the meters from the Altitude in Meters Scale.
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, students will fill in the launch angle in degrees for every student's rocket.
8. Students will calculate the altitudes of all rockets. The formula to use is:
   Altitude = Angle Tangent multiplied by Baseline Distance

   Example

   Tangent for 30° Angle = .58
   Baseline = 500 ft. (152 m)
   .58 X 500 ft. = 290 ft. or
   .58 X 152 m = 88.16 m

   The rocket went 290 ft. (88.16 m) high.

KEY WORDS

accelerate
action
altitude
apogee
baseline
decelerate
ejection
igniter
nozzle
propellant
reaction

Graphing Rocket Altitude

To use this method, a student must be able to plot angles with a protractor and layout scaled distances on graph paper. Use the horizontal axis to plot the baseline distance (distance form launch pad to tracker). With the same scale, use the vertical axis to plot the rocket's altitude. The rocket is launched at the origin on the graph paper and climbs vertically up the vertical axis. Mark the tracker's position on the horizontal axis (e.g., 250 ft.). Use a protractor to plot the angle in degrees from the Altitrak's Angle Scale at the 250 ft. mark. Extend the angle (line of sight) until it intersects the vertical axis. The intersected point on the vertical axis is the rocket's altitude.

Activity

1. Use the Model Rocket Flight Profile as a visual aide to show the class how a model rocket works and launches.
2. Show students how to use the Altitrak™. Hold at arm's length, pull and hold the trigger, point at object upward like something on the ceiling and release the trigger. Let students practice doing this to feel comfortable using the Altitrak™.
3. Explain to students how to use the Altitrak™ when launching the rockets.
4. Students will practice using the Altitrak™ and recording the data by going outside on the school grounds. Students will record data from the Angle Scale for the following:
   a. flag pole
   b. school roof (one story high or two stories high or both)
   c. specific playground equipment
   d. trees (tallest and shortest)
   e. houses or buildings next to school (highest part of their roof)
   f. other school yard objects suitable to use to calculate height

Moving Objects

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™.

5. After data is collected outside, students will calculate the height of all the objects outside.
6. Use the Altitude Tracking Overhead or visual to show students how to graph the altitude of the objects from the school grounds.
7. Students will graph the altitude of all the objects outside.
8. Students will compare both answers to decide which method (calculation or graphing) is most accurate.
9. Students will discuss possible sources of experimental error.

Note: You may use your unit preference (English, metric or both) when altitude tracking.

STEP 2. BUILD (Second class session)

Activity

1. For many of your students, this will be the first time they have built and launched a model rocket. When they make and launch their rocket, they will be able to experience what it is like to be a rocket scientist or engineer working on a problem (data collection, analyzing and calculating results).
2. Build the Alpha®, Wizard™ or Viking™ model rocket together with students, using step-by-step procedures. Skill Level 1 rocket kits require some cutting, gluing, sanding and painting. Features to make building easy include step-by-step instructions, balsa or card stock fins, plastic nose cones and self-stick decals. The Viking™ and Wizard™ rockets use streamer recovery and the Alpha® rocket is recovered by parachute. Assembly will take one class session. If you are inexperienced with model rockets, it is a good idea to build and launch one before your students do so you can assist them during the building and launching activities.
3. Review the Model Rocket Safety Code with the class.

STEP 3. LAUNCH (Third 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.
4. Students will work with launch partners to record their predicted altitude (estimated) and launch angle.

Wrap Up - Touch Down & Recovery

1. Each student will calculate and graph their rocket's altitude.
2. Every student will record both altitude answers on a class chart, whiteboard or overhead.
3. The class will determine whose rocket or rockets were the highest flyer(s).
4. Students will compare the altitudes they found from using both methods (calculation & graphing).
   - Were the answers the same?
   - Which method do you think is more accurate - calculating with the launch angles or graphing?

Extensions

1. Students will change the Altitrak™ reading for Altitude in Meters into feet.

   Convert Meters to Feet
   1 meter = 3.28 ft./meter
   Feet = meters multiplied by 3.28 ft./meter

   Example: 230 m X 3.28 ft./m = 754.4 ft.

2. Students can do two station tracking using graphs. Set up two tracking stations on opposite sides of the launch pad. For example, tracking stations A and B are located on a 1000 feet (305 m) baseline. Place the launch pad between the tracking stations at 500 feet (152 m). Station A calls in an angular distance of 34° and station B calls in an angular distance of 22°. Plot angles A and B, then extend them until they intersect. The point of intersection extended to the vertical axis is the rocket's altitude.

Evaluation/Assessment

- Students will make and launch an Estes rocket.
- Students will use the Estes Altitrak™ to track and record launch data.
- Students will calculate and use graphing to find their rocket's altitude.

References

- *Estes Educator™ - Guide for Teachers and Youth Group Leaders*
- Estes Educator™ Website - www.esteseducator.com
- NASA - *Rockets - A Teacher's Guide with Activities in Science, Mathematics, and Technology*
- Estes Educator™ - *Mathematics and Model Rockets Curriculum*