Mathematics

Blast Off with Rocket Math!

GRADES 9-12
Three Class Lesson Plan

STEP 1. LEARN (First class session)

Objectives

- Students will learn one and two station altitude tracking.
- Students will use the Estes Altitrak™ to record rocket flight data.
- Students will construct and launch a model rocket to practice one and two station altitude tracking.
- Students will use flight data from one and two station tracking to calculate the rockets' altitudes.

NATIONAL STANDARD

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

Benchmark 1
Uses a variety of strategies (e.g., identify a pattern, use equivalent representations) to understand new mathematical content and to develop more efficient solution methods or problem extensions

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. Table of Tangents and Launch Data Sheet for each student
9. Estes Altitrak™ - 4 or more
10. Tennis ball – 5 or more
11. Measuring Tape

Time

Three class sessions

Background

A Typical Model Rocket Flight

Thrust is the 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 propellant is contained in the casing of a model rocket engine. 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

One Station Tracking: Calculating Rocket Altitude with Launch Angles
All students should be grouped into launch teams of two students. When one teammate launches their rocket, the partner will use the Estes Altitrak™ to collect the launch data for the other's rocket launch.

1. Baseline Distance - Measure and mark 152 meters (500 feet) 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
30° Angle:Tangent = .58
Baseline = 152 meters
.58 X 152 m = 88.16 m

The rocket went 88.16 meters high.

Note: *Directions on how to use the Altitrak™ are on the back of the package panel.*

Two Station Tracking
Two station tracking is done to give you more accuracy. You will need teams of three for two station tracking. One member will launch their rocket while the other two teammates will use the Altitraks to gather the launch data.

1. Set up two tracking stations on opposite sides of the launch pad. Each will be 152 meters (500 ft.) from the pad. To have the greatest accuracy, the stations should be in line with the wind. If the wind is blowing to the south, one station will be north and the other south of the launch area.
2. When one student launches their rocket, the two trackers will record the angle in degrees from the Angle Scale. They should also record the meters from the Altitude in Meters Scale (for Extension activity).

3. Students will determine the altitude using the formula:
   Altitude = Angle Tangent multiplied by Baseline Distance
4. For the final altitude answer, average the answers from the altitudes calculated from the two trackers recorded data.

Example

Baseline = 152 meters
Tracker 1 = 36° (Tangent - .7265)
.7265 X 152 m = 110.43 m
Tracker 2 = 33° (Tangent - .6494)
.6494 X 152 m = 98.71 m

110.43 m + 98.71 m = 209.14 m
209.14 m ÷ 2 = 104.57 m
The rocket went 104.57 meters high.

Activity

1. Demonstrate how a model rocket works and launches. An overhead, PowerPoint or interactive whiteboard may be used to demonstrate the Model Rocket Flight Profile.
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 do this so they feel comfortable using the Altitrak™.
3. Explain to students how to use the Altitrak™ when launching the rockets.
4. Review how to calculate the altitude by using the degrees from the Angle Scale.
5. Students will practice using the Altitrak™ and recording the data. Students will record data from the Angle Scale and Altitude in Meters 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. light poles
   g. other school yard objects suitable to use to calculate height

KEY WORDS

accelerate
action
altitude
apogee
baseline
decelerate
drag
ejection
gravity
igniter
nozzle
predicted
propellant
reaction

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™.

6. When data collection is finished, students will calculate the height of all the objects outside.

STEP 2. BUILD (Second class session)

Activity

1. When students 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 are streamer recovery and the Alpha® rocket is recovered by parachute. Assembly will take one class session. Build and launch one of the rockets 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 inside before going out 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. For one station tracking have teams of two and for two station tracking have teams of three.

5. To do both one and two station tracking, half of the class will do one station tracking and the other half of the class will do two station tracking. Each rocket may be launched twice, the first launch with one station and the second launch with two stations. Another way to do this is to launch all rockets using two station tracking and use one predetermined launch angle for calculating the one station altitude.
6. All rockets will be launched with the same model rocket engine.

Wrap Up - Touch Down & Recovery

1. Each student will calculate their rocket's altitude using one and two station tracking data.
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 decide which method, one or two station tracking, is more accurate.

Extensions

1. Students will change the meters recorded from the Altitude in Meters Scale into feet.

CONVERT METERS TO FEET:
1 meter = 3.28 ft./m
Feet = Meters X 3.28 ft./m
Example: 230 m X 3.28 ft./m = 754.4 ft.

2. Students will compare the altitudes they found from using both methods (Launch Angles and Meters).
   - Were the answers the same?
   - Which method do you think is more accurate – calculating with the launch angles or the Altitrak's Altitude in Meters scale?

Evaluation/Assessment

- Students will practice using the Altitrak™, record data from the school grounds and use the data to calculate the objects.
- Students will successfully make and launch a model rocket.
- Students will record launch data on the Launch Data Sheet.
- Students will calculate rocket altitudes using one and two station tracking data and record the altitudes on the Launch Data Sheet.

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*