Science

Viking™ Varieties, Wonderful Wizards,™ Awesome Alphas®

STEP 1. LEARN (First Class Session)

Objectives

- Students will learn the parts of a model rocket and its flight profile.
- Students will demonstrate controlled experimentation.
- Students will plan and conduct a scientific investigation using model rockets.
- Each student will assemble and launch an Estes model rocket.

NATIONAL STANDARD

Standard A
Science as Inquiry

Standard 12
Understands the nature of scientific inquiry

Benchmark 2
Designs and conducts scientific investigations (e.g., formulates hypotheses; identifies and clarifies the method, controls, and variables; analyzes, organizes, and displays data; revises methods and explanations; presents results; receives critical response from others)

Materials

1. Viking™, Wizard™ or Alpha® 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 Nomenclature, Model Rocket Flight Profile, Parts of a Fin, Common Fin Shapes, What is Drag? and Fin Positions
7. Model Rocket Safety Code and Launch Data Sheet for each student
8. Viking Varieties, Wonderful Wizards, Awesome Alphas Project Form for each student
9. Estes Altitrak™ - 3 or more
10. *Ignite the Imagination™* Video

Time

Three class sessions

Background

Parts of a Model Rocket

The main parts of a model rocket are the body tube, engine holder assembly, fins, launch lug, nose cone, shock cord and recovery system. Model rockets are made of lightweight materials like paper, balsa wood and plastic. The body tube is the main structure of the rocket. It determines the main shape of the rocket and is usually long and slender. All other parts are attached to the body tube. The engine holder assembly holds the engine in place inside the rocket while the fins give directional stability and help the rocket fly straight. The launch lug is the hollow tube that slips over the launch rod. The nose cone is attached to the top of the rocket and is tapered to cut through the air more efficiently and reduce drag. The rubber shock cord attaches the nose cone to the body tube so the rocket is recovered in one piece. The recovery system returns the rocket to the ground.

Model Rocket Flight Profile

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

Model Rocket Fins
The primary purpose of fins on a rocket is to serve as the rocket's control system. Fins give directional stability and help the rocket fly straight. Model rocket fins may be made of plastic, balsa wood or stiff cardboard. Fins should be attached in a symmetrical form of three, four or possibly more. Model rocket fins are usually fixed; while some actual rockets have fins that have movable components. Movable components allow for the in-flight control of the rocket's guidance.

The four most common shapes of fins are rectangular, elliptical, straight-tapered and swept-tapered (visual/overhead Common Fin Shapes). The four parts of a fin are leading edge, trailing edge, root edge and tip (Parts of a Fin).

The effect of drag is one of the major concerns when designing fins. Drag is the frictional force or resistance between the surface of a moving object and air.
The visual/overhead What is Drag? shows the effects of drag on a hand placed into moving air (wind). The amount of drag is directly proportional to the amount of surface area that comes into contact with the leading edge of the rocket as it cuts through the air. Because the palm of the hand has a greater surface area coming in contact with the moving air, it produces greater drag than the edge of the hand.

The shape of a fin is one factor that determines the amount of drag produced. Fin characteristics such as the total surface area, total span and sweep angle all help to determine the amount of drag produced by a rocket's fins. When viewing the fin from the fin's tip, the sectional shape is a determiner of the amount of drag produced by a rocket's fin.

For students to understand fins, compare a model rocket to a tree. A tree has a trunk, a model rocket has a body tube. A tree has roots, a model rocket has fins. The roots of a tree anchor the tree and give it stability to help it stand up straight. The fins of a model rocket give it guidance and stability so it flies straight.

Controlled Experiments

Experiments provide useful information. Controlled experiments use experimental trials that are the same and have one element in the trials that is the control variable. When conducting controlled experiments with model rockets, the teacher will build a model rocket exactly as it was designed to be built. This is the control rocket. Students will build a model rocket that is exactly like the control rocket, except for one feature they want to change on the rocket.

Activity

1. Build the Viking™, Wizard™ or Alpha® rocket before you begin the first class activity. This will help you to be familiar with this rocket and learn its parts. This is also the control rocket.
2. Show the class the Rocketry 101 video segment from the *Ignite the Imagination*™ Video.
3. Review with the class the parts of a model rocket and its flight profile. Use the visuals/overheads Model Rocket Nomenclature and Model Rocket Flight Profile. Visuals/overheads may be used as a PowerPoint or on an interactive whiteboard. Using the control rocket, identify the parts of a model rocket.
4. Rocket scientists figure out how to alter rockets to make them better. Explain to students they will become model rocket scientists for the next three days. As a model rocket scientist they will design, build and launch their Viking™, Wizard™ or Alpha® rocket so it will fly higher than the control rocket.
5. Students will plan their experiment by filling out the Viking™ Varieties, Wonderful Wizards™, Awesome Alphas® Project Form.

PROBLEM: What change to the Viking™, Wizard™ or Alpha® rocket will make it fly higher than the control Viking™, Wizard™ or Alpha® rocket?

HYPOTHESIS: Each student will decide on one way to make their rocket different than the control rocket. They can change the fins or the body tube.

Fins – Fins can be changed several ways.

- Fin Numbers: You can have three, four or five fins on the Viking™. The Wizard™ and Alpha® have three fins so their number of fins cannot be changed.

KEY WORDS

accelerate
aerodynamic
apogee
body tube
control variable
decelerate
drag
elliptical
engine holder assembly
fins
gravity
hypothesis
igniter
launch lug
nose cone
propellant
recovery system
rectangular
shock cord
stability
symmetrical
tapered

- Fin Positions: The root edge (the edge that is glued to the body tube) can be changed to any one of the four fin edges. The fins can point downward or upward (inverted or reversed). Students can also keep the same root edges with one fin in the correct place (3/8 in. up or down from the bottom of the body tube) and the other two fins 3/8 in. up or down from the bottom of the body tube. Use the visual/overhead Fin Positions to show different fin placements.

Body Tube – The length of the body tube can be made longer or shorter than the control rocket.
- If the length is shortened, the shortest it should be is $^{1}/_{2}$ its original length.
- If the length is made longer, you can do this by taping the two body tube lengths together.

VIP NOTE: Remind students they can only make one thing different than the control rocket – the fins or the body tube. They can't change both in this experiment.

PROCEDURE: Students will complete this on the project form indicating how their rocket will be changed and that all rockets will be launched and have their altitudes tracked to determine which one went the highest.

6. Based on the various fin configurations, each student or the entire class will decide which rocket will fly higher. Students need to consider what will be the fin number and position that will produce the least amount of drag as this will help the rocket travel higher. You can also use a spreadsheet to record all students' predictions.

Note: *These activities can be done with students working in small groups to specify their control and variable, then have it approved and analyzed by the teacher.*

7. When the rockets are launched, students will track the rocket's altitude with the Estes Altitrak™. If there is time, let each student practice using the Altitrak™. You can also do this the second class period after the rockets have been built or the third class period before the rockets are staged for the launch.

HOW HIGH DID IT GO?
All students should be grouped into launch teams. They can pair up or you can assign teams. When one teammate launches their rocket, the other partner will use the Estes Altitrak™ to collect the launch data for their partner's rocket

launch.

1. 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 Altitude in Meters from the Altitrak™.
5. Partners will switch places and repeat the launch procedure.

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. Remind students they are model rocket scientists participating in a controlled experiment.
2. Build the Viking™, Wizard™ or Alpha® 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. Assembly will take one class session. The control rocket should be built before you begin these lessons with your students.
3. If students are changing the length of the body tube as their one change, they should make this change first before starting to build the rocket.
4. When students attach their fins, they should make sure they have glued the number of fins (3,4 or 5) and the root edge according to their hypothesis.
5. Review the Model Rocket Safety Code with the class.
6. Practice using the Altitraks and go over launch procedures for launch day, time permitting.

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. Launch the control rocket first and record its altitude.
5. Launch teams will use the Altitrak™ to record the height of both rockets.

Wrap Up - Touch Down & Recovery

1. Each student will record their rocket's altitude on a class chart, overhead or whiteboard. (e.g., Tina – 4 fins, changed root edge – 280 ft. or Chad – body tube 7" – 310 ft.)
2. Students will analyze and record their RESULTS based on the results of the entire class rockets' altitudes.
   - What rocket or rockets went higher than the control rocket?
   - What is the design change made to the highest rocket or rockets?
   - Why did this change go the highest?
   - If time permits, students will graph design changes and their altitudes.
3. Students will complete the experiment by completing the CONCLUSION on the project form. What did this experiment show? They should include why or why not their design change made the rocket go lower or higher than the control rocket and the other rockets in the class. How can they change their design to make it go higher or to be more aerodynamic?

Extensions

1. Students can convert the altitude in meters to feet. The formula is:
   FEET = METERS multiplied by 3.28 ft./m
2. Have student teams design reusable rockets (spaceships) they think will be used in 50 years. Each group should explain how their rocket is powered, where it flies, what it is called and how it is a more effective means of travel than current spaceships. They will create a poster of their design with labels and explanations. They can also make a model of their new rocket.

Evaluation/Assessment

- The students' participation in class discussions.
- Students will plan, conduct, analyze and record their model rocket investigation on the Viking™ Varieties, Wonderful Wizards™, Awesome Alphas® Project Form.
- Students will successfully build and launch a model rocket.

References

- *Estes Educator™ - Guide for Teachers and Youth Group Leaders*
- Estes Educator™ Website - www.esteseducator.com
- *"Versatile Viking," 4-H Aerospace Adventures*

Name____________________ Date_____________

Class____________________

Viking™ Varieties, Wonderful Wizards,™ Awesome Alphas®

PROBLEM

____

____

____

____

HYPOTHESIS

____

____

____

____

____

PROCEDURE

____

____

____

____

____

____

____

RESULTS

____

____

____

____

____

CONCLUSION

____

____

____

____

____

____