Science

Fintastic Rockets!

STEP 1. LEARN (First class session)

Objectives

- Students will learn the function of fins and how they effect flight.
- Students will identify the parts of a fin and the different fin shapes.
- Students will conduct a scientific inquiry about model rocket fins.

Materials

1. Viking™, Wizard™ or Alpha® Rocket Lab Pack™ (12 pack) - 2 or more
2. A8-3 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, Common Fin Shapes, Parts of a Fin, What is Drag?, Fin Positions
7. Design Considerations for Fins Worksheet for each student
8. Fintastic Rockets! Project Form for each student
9. Estes Altitrak™ - 3 or more
10. *Ignite the Imagination*™ Video
11. Model Rocket Safety Code for each student

Time

Three class sessions

NATIONAL STANDARD

Standard A
Science as Inquiry

Standard 12
Understands the nature of scientific inquiry

Benchmark 3
Designs and conducts a scientific investigation (e.g., formulates hypotheses, designs and executes investigations, interprets data, synthesizes evidence into explanations, proposes alternative explanations for observations, critiques explanations and procedures)

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. 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 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

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? illustrates 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.

Fins R Roots
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.

Activity

1. Show the class the Rocketry 101 video segment from the *Ignite the Imagination™* Video.
2. Use a model rocket and overheads or handouts of Model Rocket Nomenclature and A Typical Model Rocket Flight to show students the parts of a model rocket and what happens when it is launched.
3. When you are covering the parts of a model rocket, students will fill out the blank Model Rocket Nomenclature sheet.
4. Discuss why rockets have fins. Ask students if they know of any control systems on other types of transportation.
5. Use the What is Drag? visual/overhead to explain drag.
6. Show the class the most common fin shapes and the parts of a fin using the visuals/overheads – Common Fin Shapes and Parts of a Fin.
7. Discuss with students which fin shape will create the least amount of drag and make the rocket more aerodynamic.
8. Students will complete Design Considerations for Fins and label the parts of a fin on one of their sketches.
9. Students will have a PROBLEM to solve about their rocket's fins. The problem to solve: Which rocket will launch the highest?
10. To do this with the Viking™ rocket, students will decide if their rocket will have three, four or five fins. They should include in their hypothesis how many fins will go the highest.
11. When using a Wizard™ or Alpha® rocket, students will change the root edge of the rocket's fins. If they do not want to change the root edge, they can also invert the fins keeping the original root edge (See Fin Positions). They should include in the hypothesis the changes made in the fins.
12. Students will complete the problem, hypothesis and procedure on the Fintastic Rockets! Project Form.
13. During the launch, students will track their 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 session after the rockets have been built or the third class session before the rockets are staged for the launch.

KEY WORDS

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

HOW HIGH DID IT GO?

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 date for their partner's rocket launch.

1. Measure and mark 76 meters (250 ft.) 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 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 most of your students, this will be the first time they have built and launched a model rocket. Explain to students that when they complete this project, they will be a Model Rocket Scientist.
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. If you have never built one of these rockets, it is a good idea to build and launch one before your students build and launch their rockets.
3. When students attach their fins, make sure they have glued the number of fins on their rocket (3, 4 or 5), changed the root edge or inverted the fins according to their hypothesis.
4. 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 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. Students will launch and record the altitude for each other's rockets using the Altitrak™.

Wrap Up - Touch Down & Recovery

1. Each student will record their rocket's altitude on a class chart, overhead or whiteboard. (e.g., John – 3 fins – 290 ft.)
2. Students will analyze and record the data from the entire class. Which rockets went higher – rockets with three, four or five fins or those with a root edge or inverted fins?
3. Students will graph the class launch heights comparing three, four and five fins, root edges, etc.
4. Students will complete the project by writing their conclusions on their project form.

Extensions

1. Students can convert their rocket's altitude in meters to feet. The formula is: Feet = meters multiplied by 3.28 ft./meter.
2. Students will research the evolution of fins from their beginnings to today's fins on rockets (e.g., Delta II, III or IV rockets).

Evaluation/Assessment

- Students will complete the Design Considerations for Fins Worksheet.
- Students will record their experiment results on the Fintastic Rockets! Project Form.
- Students will build, launch and track the altitude of an Estes rocket.

References

- *Estes Educator™ - Guide for Teachers and Youth Group Leaders*
- Estes Educator™ Website - www.esteseducator.com
- Estes Educator™ - *Reproduction Masters for Model Rocketry*

Name______________________________ Class ______________________________
Date ______________________________

FINTASTIC ROCKETS!

PROBLEM

HYPOTHESIS

PROCEDURE

RESULTS

CONCLUSION