GRADES 6-8
Three Class Lesson Plan

Technology

Flying High With Fins!

STEP 1. LEARN (First class session)

Objectives

- Students will learn the purpose of fins.
- Students will identify the different parts of a fin and different fin shapes.
- Students will solve a fin problem through experimentation.
- Students will build and launch an Estes model rocket to help solve the fin problem.

NATIONAL STANDARD

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Benchmark H
Some technological problems are best solved through experimentation.

Materials

1. Viking™, Wizard™ or Alpha® Rocket Lab Packs™ (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 (various colors) 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. Estes Altitrak™ - 3 or more
9. Model Rocket Safety Code for each student

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 that 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 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 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 factor in determining the amount of drag produced by a rocket's fin.

To help students 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. Discuss the parts of a model rocket and its flight profile. Use the visuals Model Rocket Nomenclature and Model Rocket Flight Profile. Overheads may be reproduced visually or electronically.
2. Ask students:
   • Why do rockets have fins?
   • Do you know of any control systems for other types transportation?
3. Explain drag by using the What is Drag? visual aide.
4. Show students the most common fin shapes and the parts of a fin using the visuals/overheads – Common Fin Shapes and Parts of a Fin.
5. Discuss what fin shape will create the least amount of drag and make the rocket more aerodynamic.
6. Students will complete Design Considerations for Fins and label the parts of a fin on one of their sketches.
7. Explain to students they will have a PROBLEM to solve about fins. The problem is: How can you change the fin's root edge or placement to make the rocket more aerodynamic and fly higher?
8. Students will change the root edges, keep the same root edges and reverse the fins, keep the same root edges with one fin in the correct place, up or down 3/8 in. from correct placement and the other two fins 3/8 in. up or down from correct placement (Fin Positions).
9. Based on the various fin configurations, each student or the entire class will predict which rocket will fly higher.
10. When the rockets are launched, students will track the rockets' altitude with the Estes Altitrak™. Each student should practice using the Altitrak™ during one of the three class sessions.

KEY WORDS

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

HOW HIGH DID IT GO?

All students need to be organized into launch teams. They can pair up or you can assign teams. When one team member launches their rocket, the other member will use the Estes Altitrak™ to collect the launch date for the other's rocket launch.

1. Measure and mark 150 meters (500 feet) from each launch pad. The team member (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. Each team member will record the Altitude in Meters from the Altitrak™.
5. Students will switch places and repeat the launch procedure.

STEP 2. BUILD (Second class session)

Activity

1. Each student will sketch how they are going to change the fins on their rocket so it will go the highest.
2. Build the Wizard™, Viking™ 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 are not familiar with the rocket you will be using, it is a good idea to do make and launch the rocket before your students do so you can assist them during the building and launching activities. Make sure each student applies the fins according to their modifications.
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. Launch all rockets using the same Estes engine.
5. Students will be organized into launch teams to help track and record each others rocket's altitude with the Altitrak™.

Wrap Up - Touch Down & Recovery

1. Every student will record their rocket's altitude on a class chart or visual.

2. Discuss with students:
   - What rocket or rockets were the highest flyers?
   - Was your assumption or the assumption of the class correct?
   - Why or why not?

Extensions

1. Students can convert the altitude in meters to feet. The formula for this is: Feet = Meters multiplied by 3.28 ft./meter.
2. Students will do a web quest to look for early fin designs on rockets up to the present rockets that NASA is launching. They will record their results to show how fin designs have changed.

Evaluation/Assessment

- Students will complete the Design Considerations for Fins Worksheet.
- Students will sketch their rocket with the fin changes to it.
- Students will build, launch and track the altitude of an Estes rocket.
- Students will record rocket altitudes on a class chart.

References

- *Estes Educator™ - Guide for Teachers and Youth Group Leaders*
- Estes Educator™ Website - www.esteseducator.com
- Estes Educator™ *- Industrial Technology and Model Rockets Curriculum*