Technology

Rocket Flight Challenges

STEP 1. LEARN (First Class Session)

Objectives

- Students will identify drag and the purpose of fins.
- Students will be able to describe the different parts of a fin and different fin shapes.
- Students will solve a model rocket design problem through experimentation.
- Students will construct and launch an Estes model rocket.
- Students will time each rocket's flight duration.

Materials

1. Viking™ or 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, Common Fin Shapes, Parts of a Fin, What is Drag? and Fin Positions
7. Model Rocket Safety Code for each student
8. Estes Altitrak™ - 3 or more
9. Stopwatch - 4 or more

Time

Three class sessions

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 I
Students should learn that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.

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/overheads Model Rocket Nomenclature and Model Rocket Flight Profile. May be reproduced electronically or by other methods.
2. Discuss with students:
   - Why do rockets have fins?
   - Do you know of any guidance systems for other types transportation?
3. Explain drag by using the What is Drag? visual/overhead.
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. Show the class the Viking™, Wizard ™ or Alpha® rocket. Ask students: What is the fin shape of this rocket?
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 with model rockets. The problem is: Which rockets will have the longest and shortest flight durations?
8. Rocket information students need to help make their assumption is:
   - Fin material - Viking™: card stock
     Wizard™: balsa wood
     Alpha®: balsa wood
   - Fin shape – Swept-tapered, rectangular, elliptical or straight-tapered
   - Fin placement – Viking™ and Alpha® fins are placed at the bottom of the body tube. Wizard™ fins are placed 3/8 in. up from the bottom of the body tube.
   - Rocket weight without an engine: Viking™: 0.6 oz. (17 g)
     Wizard™: 0.5 oz. (14.2 g)
     Alpha®: 0.8 oz. (23 g)
   - Body tube diameter: Viking™: 0.74 in. (18.8 mm)
     Wizard™: 0.74 in. (18.8 mm)
     Alpha®: 0.98 in. (24.9 mm)
   - Total length: Viking™: 12.1 in. (30.7 cm)
     Wizard™: 12 in. (30.5 cm)
     Alpha®: 12.3 in. (31.2 cm)
9. Students should not decide on the rockets that will have the longest and

KEY WORDS

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

shortest flights until all rockets are built and they have reviewed the rocket information above. Based on a comparison of all completed rockets and the rocket information above, each student will predict which rocket will have the longest and shortest flight duration. Students will consider: Will more or less fins and/or the placement of the fins help or hinder the rocket's flight duration?

10. Handout the Model Rocket Safety Code for students to review.

STEP 2. BUILD (Second class session)

Activity

1. Before building begins, give students the option of changing the root edges of the fins, inverting the fins or moving placement up (no more than 3/8 in.) or down on the body tube. The change is made to give the rocket a chance to have a longer or shorter flight time. Use the visual/overhead Fin Positions to show students how to change the fin placement.
2. Build the Viking™, Wizard™ or Alpha® rockets 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 inexperienced with model rockets, build and launch a rocket so you can assist students 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. Launch all rockets with the same Estes model rocket engines.
3. Prepare rocket engines inside before going out to launch. Follow the Engine

Preparation steps located in the rocket instructions.

4. Launch rockets outside at a soccer field, football field, baseball field, green grass area or blacktop area.
5. Organize students into launch teams of two. One student will be the timer and one student will be the launcher. Each student should launch their own rocket while the other student times the flight. To time the flight, start the stopwatch when the rocket lifts off and stop the stopwatch when the rocket touches the ground. Students will record their rocket's flight time.

Wrap Up - Touch Down & Recovery

1. Each student will record their rocket's flight time in seconds or minutes and seconds on a class chart, electronic chart, overhead, whiteboard or interactive whiteboard.
2. Discuss with students:
   - What rocket or rockets had the longest and shortest flight times?
   - Was your assumption or the classes assumption correct?
   - Why or why not?
   - What design feature hindered or helped your rocket fly longer or shorter than your teammate's rocket?
   - If your rocket's flight time was shorter than your teammate's rocket, how would you change its design?

Extensions

1. Let students create a new problem with the Wizard™, Viking™ or Alpha® to solve through experimentation. What is the assumption of this problem? What steps will they take to prove or disprove their assumption?
2. Students can investigate and report on a product designed for spaceflight that is a common used product today (e.g. Velcro, cordless drill, etc.).

Evaluation/Assessment

- The students' participation in class discussions.
- Students will complete the Design Considerations for Fins worksheet.
- Students will construct a model rocket with fin modifications, launch it and time the flight duration.

References

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