Lesson 4:
To the Moon (and Mars) or Bust!

TEACHER PAGES

Overview:

This lesson focuses on *thrust* (the force used to move an aircraft forward) and the systems created by engineers to produce it. The ways *control surfaces* are used to regulate the flight of the *Space Shuttle* and NASA's newest space vehicle, *Orion*, are studied. Students experiment with a simple aircraft model to learn how variations in *thrust* and *control surfaces* affect the movement of the vehicle. Follow-up questions and lesson extensions are included.

Objectives:

- Upon completion of activity, students will identify *thrust* as one of the four forces affecting an aircraft's flight.
- Following a hands-on activity, students will list three different systems that can generate an aircraft's *thrust* and evaluate the effectiveness of each for long-distance space flights.
- After examining data collected during the activity, students will explain factors in an aircraft's design that affect the force of *thrust* needed to fly.
- After studying a table comparing proposed space vehicles to earlier NASA space vehicles, students will construct a graph that illustrates the height of each vehicle.

Time Required:

Approximately two 45-minute class periods.

Day 1: Topic Introduction

- Give students copies of **Background** reproducible.
- Discuss important terminology and give brief overview of upcoming lab.

Day 2: Lab Activity

- Teams construct two models, conduct experiments, and record data (use **Background**, **Lab Activity**, and **Data Sheet** reproducibles).
- Assign **Follow-Up** reproducible as homework.
- Use portion of following class period to discuss results and summarize lesson.

Materials Needed:

For each team of 2 students:

- 2 foam dinner plates (full size)
- scissors
- masking tape
- 2 large paper clips
- 2 rubber bands: one large and one small (for example: 6 cm and 10 cm)
- 2 plastic straws (non-flexible)
- 2 metric rulers
- safety goggles (optional, for safe use of rubber bands)

Lesson 4

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Steps for Conducting Lab:

Day 1: Setup and Topic Introduction

- Obtain foam plates: include extras in case of mistakes; copy required sheets.
- Find a safe place outside to conduct the activity; identify launching site for aircraft.
- Create model of aircraft to show students when introducing lesson.
- Test model to be prepared for questions.
- If time is too short, consider creating class set of triangle templates for tracing around on plates; reducing number of trials; allowing larger groups to test models at the same time.
- Before lab, provide students with copies of **Background** reproducible; discuss important terminology and give brief overview of upcoming lab.

Day 2: Lab Activity

- Before class, place sheets and supplies in central location.
- As students enter, have them pick up required sheets (**Lab Activity**, **Data Sheet**, and **Follow-Up** [two pages]).
- Tell class **Background** sheet may be used as a reference.
- Use your model to illustrate how to attach paper clips and rubber bands.
- Review safety issues (launch aircraft away from others, use care with rubber bands, etc.) and testing methods (several teams called up to test at same time, etc.).
- Instruct students to begin.
- When student teams are ready, call groups forward to launch their crafts.

Teacher Resources

"Aircraft Yaw Motion": Includes background information on contact surfaces complete with computer animation:
www.grc.nasa.gov/www/K-12/airplane/yaw.html

More detailed information on aircraft control surfaces is available at:
www.furball.warbirdsiii.com/krod/basic-control-surfaces.html

Wide variety of images and the latest information on space and flight:
www.space.com

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Connections to *National Science Education Standards*

Unifying Concepts and Processes
- Evidence, models, and explanation
- Change, constancy, and measurement
- Form and function

Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science
- Motions and forces
- Transfer of energy

Science and Technology
- Abilities of technological design
- Understandings about science and technology

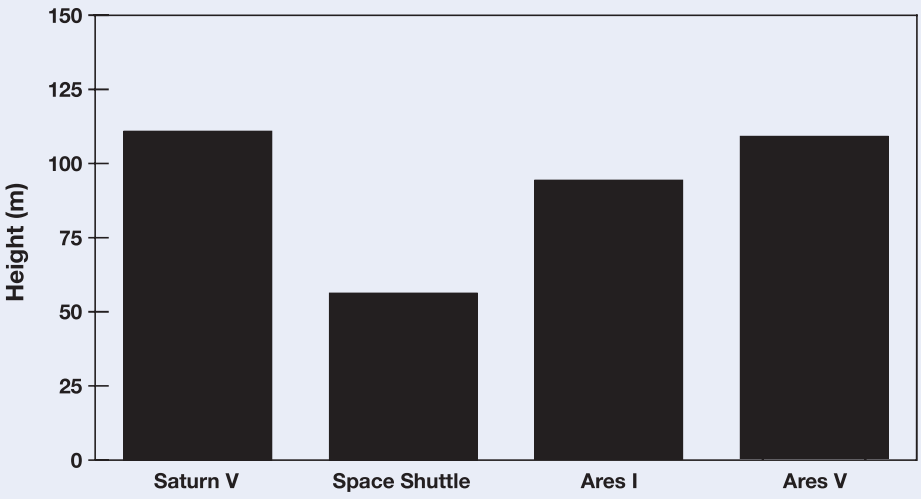
Science in Personal and Social Perspectives
- Risks and benefits
- Science and technology in society

History and Nature of Science
- Science as a human endeavor
- Nature of science

Source: National Research Council

Reproducible Answers:

Data Sheet: *Observations*: 1. one launched with larger rubber band; 2. speed of aircraft launched with large rubber band was greater. *Analysis*: 1. C. rubber band; 2. B. aircraft would spin over and over. **Follow-Up:** 1. over five times greater; 2. the *Ares V* would require the greatest thrust because of its heavy payload; 3. answers will vary; 4. see completed graph below:



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Background

TO THE MOON (AND MARS) OR BUST

Let's begin today's study by examining *thrust*, a very important force responsible for moving aircraft though the air.

What is *thrust*?

The *force* (a *push* or a *pull*) moving an aircraft forward through the air.

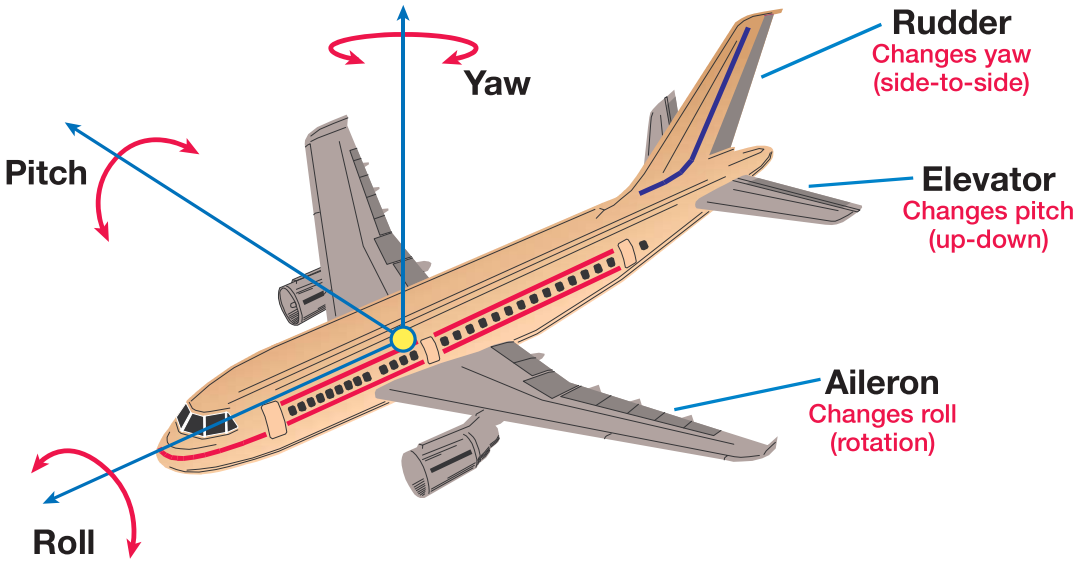
Aerospace engineers have created several systems for producing an aircraft's thrust (such as propellers, jet engines, and rockets).

Pilots use different terms to describe the particular ways an aircraft moves forward:

Pitch:	Aircraft nose moves up or down
Roll:	One wing of aircraft tips up while the other tips down
Yaw:	Nose of airplane moves left or right while remaining level with the ground

Pilots use several *control surfaces* (movable sections on the aircraft's surface) to better direct an aircraft's movement. These include:

Elevator:	Section on horizontal part of tail that controls pitch
Aileron:	Section at rear edge of wing near tip that controls roll
Rudder:	Section attached to vertical part of tail that controls yaw



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REPRODUCIBLE

Lab Activity

TO THE MOON (AND MARS) OR BUST

Introduction:

As you know, the force causing an aircraft to move forward through the air is called *thrust*. Propellers, jet engines, and rockets are all examples of systems used to create this force. *Control surfaces* such as ailerons, elevators, and rudders are also very important to pilots because they allow for better control of an aircraft's forward movement.

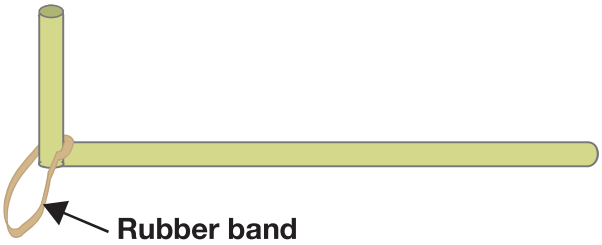
Your Assignment:

As aerospace engineers, you are expected to accomplish three tasks today:

1. create a model aircraft
2. use the model to test a new "thrust-generating" system
3. determine if changes in the control surfaces affect your aircraft's flight

Procedure (Use diagram below as reference when creating your aircraft):

1. Form teams of two; collect supplies and **Data Sheets** (each of you will be making a craft).
2. Begin construction by folding back top three centimeters of straw; insert a rubber band into fold; one team member will use a large rubber band and one will use a small rubber band.



3. Fold straw over rubber band and secure end with masking tape to create "launcher."

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Lab Activity (continued)

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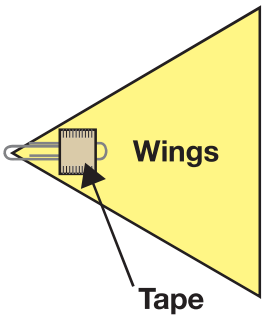
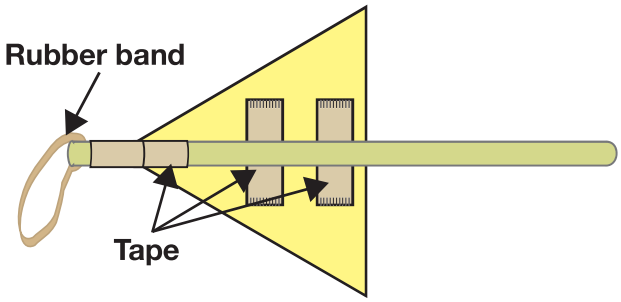
Procedure (continued):

4. Turn foam plate upside down.
5. Cut an equilateral triangle (13 cm x 13 cm x 13 cm) out of back side of plate.
6. Tape paper clip to top of foam wings; turn wings over and tape launcher to bottom of wings so top end of launcher extends slightly over tip.



Top view with paper clip



Bottom view with straw

7. When instructed to do so (and it is safe), team member using the small-rubber-band launcher will hook band around tip of thumb, pull back on opposite end of flyer until nose of aircraft is approximately half way to the elbow, and release.
8. Notice the distance and flight path taken.
9. Other team member repeats steps 7 and 8 on the aircraft with the large-rubber-band launcher.
10. Exchange aircraft; conduct a second trial of each.
11. If time permits, change control surfaces by adding foam pieces, folding wing edges, etc.; retest aircraft and record observations.

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Data Sheet

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Observations:

1. Which traveled a greater distance, the aircraft launched with the smaller rubber band or the one launched with the larger rubber band?

2. Was the aircraft's speed affected by the size of rubber band used? Explain.

Analysis:

1. What was responsible for creating the thrust that moved the aircraft?

   A. straw

   B. paper clip

   C. rubber band

   D. tape

2. Suppose you folded one aileron flap up and one flap down. How would the change in this control surface affect the aircraft's flight?

   A. nose of aircraft would go up

   B. aircraft would spin over and over

   C. aircraft would fly with one wing dropped lower than other

   D. aircraft would continue flying level but nose would turn either left or right

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Follow-Up

TO THE MOON (AND MARS) OR BUST

ORION

Background:

In Greek mythology, Orion was a great hunter who dearly loved Artemis, goddess of the wilderness. After accidentally causing Orion's death, the deeply distressed Artemis sent him into the sky forever to be seen as the constellation Orion. Today, along with the Big Dipper, Orion is one of the most recognized star systems in the northern sky! Through history, many explorers have relied on Orion when venturing into the unknown. Therefore, it came as no surprise when NASA announced in August 2006 that it had chosen *Orion* as the name of the new space vehicle to replace the *Space Shuttle* upon its retirement in 2010.

Making Comparisons:

As part of NASA's Constellation Program, *Orion* will carry crews on important missions back to the moon and later to Mars. Two new launch vehicles are also expected to play an important part in exploration: *Ares I* will be used to launch the piloted *Orion*, and the larger, unpiloted *Ares V* will be responsible for carrying heavy cargo.

Carefully examine the Data Table on different space vehicles below. After comparing the proposed space vehicles to earlier NASA space vehicles, complete the questions on the next page.

Data Table/Space Vehicles

	Height (m)	Payload[1] capacity (kg) (to Low Earth Orbit[2])	Primary Jobs
Saturn V Rocket	111	118,000	• Launch *Apollo* missions to moon • Launch *Skylab*
Space Shuttle	56	24,400	• Microgravity research • Hubble telescope launch and repair • *International Space Station* construction
Ares I (Proposed)	98	25,000	• Launch *Orion* and crew to *International Space Station*, moon, and Mars
Ares V (Proposed)	109	130,000	• Launch cargo for use by *International Space Station* and future missions to moon and Mars

[1]**Payload**: The total weight of cargo, passengers, and/or crew that an aircraft can carry.

[2]**Low Earth Orbit**: An orbit occurring above Earth's surface at an altitude of 2,000 km or less.

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Follow-Up (continued)

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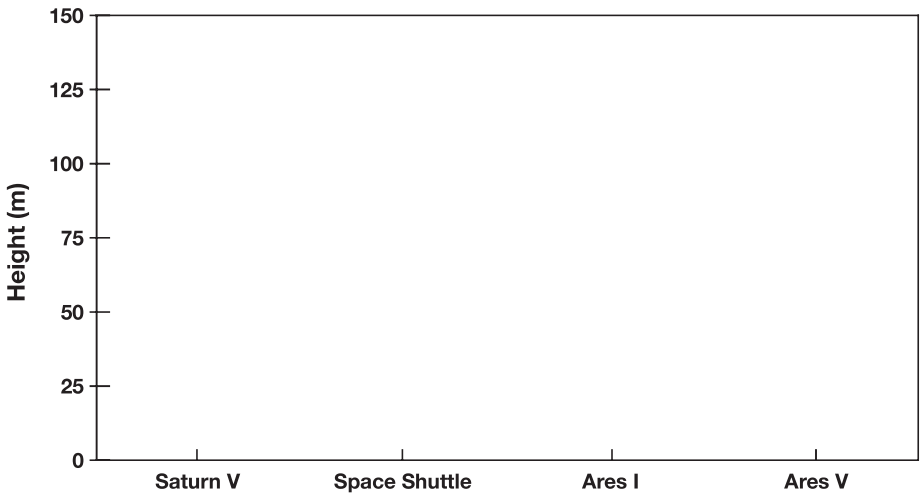
Questions (write your answers on the back of this page):

1. How does the payload capacity of the proposed *Ares V* compare to that of the *Space Shuttle*?
2. Considering what you know about thrust, which vehicle would require the greatest thrust? Explain your answer.
3. Suggest two reasons *Orion* is a good name for the vehicle NASA plans to use to return to the moon and later travel to Mars.
4. In the space provided below, use the information from the Data Table on the previous page to create a bar graph comparing the height of each space vehicle.



EXTEND YOUR KNOWLEDGE

- Read more about *Orion* at:

  www.lockheedmartin.com/orion
  www.nasa.gov/mission_pages/constellation/orion
  www.msnbc.msn.com/id/14594789

- Everything you ever wanted to know about NASA: student activities, A-V programs, photos, and more:

  www.quest.nasa.gov/about

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