Middle School

TEACHING GUIDE

LOCKHEED MARTIN

Space Day

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Space Day Tool Kit: Lessons Unit

Connects to National Science Education Standards

Inside:

- Five Lessons and Lab Activities
- Student Worksheets

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Space Day Tool Kit content developed in conjunction with Scholastic Inc.

Introduction

Dear Teacher:

Inspire your students with space activities and build science skills with the **Space Day Lessons Unit.**

Aligned with **National Science Education Standards**, the five lessons and lab activities inside provide teachers with important **terminology** and a variety of **hands-on experiences** to introduce students to the wonders of *space exploration* and *flight.*

All activities include turn-key **student reproducibles**, use **inexpensive**, **readily available supplies**, and require **little set-up**. Designed with flexibility in mind, they can be presented sequentially or independently, and can be easily incorporated elsewhere in the curriculum.

We hope you enjoy this unit!

Downloadable copies of this unit are available at www.spaceday.org (both PDF and Word formats)

Inside:

Lesson 1: Asteroids, Comets, and Meteoroids
This lesson examines three small bodies found in the solar system: *asteroids*, *comets*, and *meteoroids*. Students conduct a hands-on experiment that illustrates differences in size and structure among the three bodies.
- **Process skills:** Observation; Metric Measurement; Data Analysis and Application

Lesson 2: Tools of Astronomy
Students learn some key landmarks in the field of astronomy; the importance of such tools as lenses and telescopes; and the work of important scientists such as Galileo. Students create simple lenses out of water to understand how lenses bend light.
- **Process skills:** Observation; Data Analysis and Application

Lesson 3: Balloon Jet
After being introduced to the four important forces affecting an aircraft's flight—*thrust*, *drag*, *lift*, and *weight*—student teams study the effect of drag on the performance of balloon "jets."
- **Process skills:** Observation; Metric Measurement; Data Analysis and Application

Introduction *(continued)*

Lesson 4: To the Moon (and Mars) or Bust!
This lesson illuminates *thrust*—the force used to move an aircraft forward—and the effects of control surfaces on an aircraft's movement. Students create a model aircraft to determine if changes in the control surfaces affect the aircraft's flight.
• **Process skills:** Observation; Metric Measurement; Data Analysis and Application; Graphing

Lesson 5: Gravity Busters
This lesson demonstrates how the *lift* of helicopter rotors is used to overcome the opposing force of gravity, thus enabling a helicopter to fly.
• **Process skills:** Observation; Data Analysis and Application

Space Day in Your Neighborhood: www.spaceday.org

Space Day is an annual event sponsored by Lockheed Martin that uses space-related activities to build skills and inspire students in science, math, engineering, and technology.

For more information and ideas on **Space Day in Your Neighborhood**, visit **www.spaceday.org**. You'll find:

- **Space Day Event Organizer,** which includes:
  - Helpful suggestions for planning an event
  - Larger group activities
- **Additional Resources**
  - "Cosmic Chats": interviews with former astronauts
  - Links to related activities and Web sites
- **Information on:**
  - Student "Signatures in Space" program
  - Student competitions
- **Downloadable copies** of this *Lessons Unit*

See the next page for "Connections to *National Science Education Standards*"

Connections to *National Science Education Standards*

Connections to ***National Science Education Standards***, National Research Council

Content Standards, Grades 5–8	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Unifying Concepts and Processes					
Evidence, models, explanation	●	●	●	●	●
Change, constancy, and measurement	●	●	●	●	●
Form and function		●	●	●	●
Science as Inquiry					
Abilities necessary to do scientific inquiry		●	●	●	●
Understandings about scientific inquiry		●	●	●	●
Physical Science					
Properties and changes of properties in matter	●				
Motions and forces	●		●	●	●
Transfer of energy	●		●	●	●
Earth and Space Science					
Earth's history	●				
Earth in the solar system	●	●			
Science and Technology					
Abilities of technological design		●	●	●	●
Understandings about science and technology		●	●	●	●
Science in Personal and Social Perspectives					
Natural hazards	●				
Risks and benefits				●	
Science and technology in society		●	●	●	●
History and Nature of Science					
Science as a human endeavor		●	●	●	●
Nature of science		●	●	●	●
History of science		●			

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Lesson 1:
Asteroids, Comets, Meteoroids

TEACHER PAGES

Overview:

This lesson examines three types of small bodies found in the solar system: *asteroids*, *comets*, and *meteoroids*. Students learn important terminology and examine factors such as the size, origin, and composition of each. They also study the part these objects play in the formation of craters on larger bodies in the solar system. Students apply their knowledge in a hands-on activity that illustrates differences in size and structure among the three types of small bodies. Follow-up questions and lesson extensions are included.

Objectives:

- Upon completion of the lesson, students will state that *asteroids*, *comets*, and *meteoroids* are all examples of small bodies found within the solar system.
- Following class discussion, students will describe the size of *asteroids*, *comets*, and *meteoroids* as smaller than planets and moons, and less than 1,000 km in diameter.
- After being introduced to the similarities and differences among *asteroids*, *comets*, and *meteoroids*, students will create a simple scale model showing that the average asteroid is far larger than either meteoroids or even the largest comets.

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
- Students construct a scale model comparing selected physical properties of *asteroids*, *comets*, and *meteoroids*.
- Assign **Follow-Up** reproducible as homework.
- Use portion of following class period to discuss results and summarize lesson.

Materials Needed (for each student):

- metric ruler
- glue stick or white school glue
- scissors
- 2 paper clips
- unlined paper

Optional Materials:

- colored pencils
- sand
- cotton balls
- variety of seeds and spices for creating models (see next section for details)

Steps for Conducting Lab:

Day 1: Setup and Topic Introduction
- Carefully review student **Lab Activity** sheet to gauge amount of material each student will use; determine amount needed for all classes.
- Obtain a variety of inexpensive products that students can use to illustrate the three objects (things that represent rocks, ice, iron, dust, ammonia gas, carbon, comet tails, comets, etc.). Select items that will easily stick to paper when affixed with glue stick or white school glue. Most can be found as generics or in bulk at supermarkets.

Below are a few examples of items and how the students might choose to use them:

- powdered drink mix (comet tail, dust)
- salt crystals, sugar (ice of comet)
- whole oats (ice of comet)
- cotton balls (gas around comet)
- rice vermicelli noodles (comet tail)
- brown or red colored spices such as paprika and cinnamon (red iron)
- poppy seeds, tea leaves (carbon)
- sand, cinnamon (dust, rock)
- seasoned salts in different types and colors (variety of uses)

- Determine setup of supplies (for example, in baskets at various lab stations, to be shared by three to four students).
- Decide where to locate optional lab items.
  Before lab, give students copies of **Background** reproducible, discuss important terminology, and give brief overview of upcoming lab.
- Copy all required sheets.

Day 2: Lab Activity

- Before class, place required sheets in central location; set up lab supplies.
- As students enter, have them pick up required reproducibles.
- Tell class **Background** reproducible may be used as a reference.
- Review purpose of activity: to use information about *asteroids*, *comets*, and *meteoroids* to create models of each.
- Review important safety guidelines (for example, no tasting allowed in the laboratory).
- Point out supplies and discuss the maximum number of items and amount of each that can be used in creating each model.
- Instruct students to form teams that will share supplies, and begin.

Teacher Resources

Images of **asteroids** and more:
www.nasm.si.edu/ceps/etp/asteroids/

Related resources on **comets**:
http://stardust.jpl.nasa.gov/classroom/comets.html

Ancient beliefs about **comets**:
www.nasa.gov/mission_pages/deepimpact/media/f_ancient.html

More information about **meteoroids**:
www.solarsystem.nasa.gov/planets/profile.cfm?Object=Meteors&Display=Overview

Connections to *National Science Education Standards*

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

Physical Science
- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

Earth and Space Science
- Earth's history
- Earth in the solar system

Science in Personal and Social Perspectives
- Natural hazards

Source: National Research Council

Reproducible Answers:

Follow-Up: 1. comets and meteoroids; 2. all three can have rock and iron as part of their makeup; 3. answers will vary; most will probably suggest that larger craters are caused by asteroids, smaller ones by meteoroids.

Background

ASTEROIDS, COMETS, METEOROIDS

In today's lesson, you will be studying some very important parts of our solar system: *asteroids*, *comets*, and *meteoroids*. Even though today's scientists consider the three to be *small bodies*, you will soon see how very big and important they actually are. So, let's find out more about all three!

What is considered a small body?

- Any object in the sky that is smaller than a planet or a moon, such as an *asteroid*, a *comet*, or a *meteoroid*

What are some things scientists want to know about small bodies?

- Their *size* and *shape*
- Their *composition* (what substances they contain)
- Their *origin* (where and how they were formed)
- Their *location* (where to find them)

Asteroid:

Size and Shape:	Irregular, rocklike fragment; from a few meters up to 1,000 kilometers in diameter
Composition:	Rock containing carbon; a few have iron and other metals
Origin:	Leftover material from formation of solar system
Location:	Most found between orbit of Mars and Jupiter (*asteroid belt*)
Famous Example:	An asteroid's crashing to Earth formed Chicxulub crater in Mexico's Yucatan Peninsula; it is thought to be responsible for extinction of dinosaurs

Comet:

Size and Shape:	*Nucleus* (center) up to 20 kilometers in diameter; surrounded by gas (two tails, one *gas* and one *dust*, which are millions of kilometers long)
Composition:	Ice, rock, ammonia and other gases
Origin:	Leftover material from formation of solar system
Location:	They enter the solar system from deep space, orbit near sun, then move far out into space again
Famous Examples:	Comet Halley, Comet Hale-Bopp

Meteoroid:

Size and Shape:	Irregular, rocklike fragment; a few centimeters up to a few meters in diameter
Composition:	Rock, iron, or a combination of both
Origin:	Most are broken pieces of asteroids; a few are comet dust (called *meteors* if they enter Earth's atmosphere)
Location:	If they enter Earth's atmosphere and hit the ground, they are *meteorites*
Famous Example:	Iron meteorite found by *Mars Exploration Rover Opportunity* (first ever found on another planet)

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Lab Activity

ASTEROIDS, COMETS, METEOROIDS

Introduction:

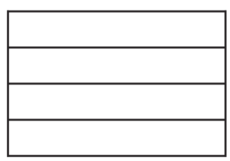
Astronomers consider *asteroids*, *comets*, and *meteoroids* to be examples of *small bodies* in our solar system. In many ways they are similar: They move at great speeds, they have helped scientists learn more about how our universe and solar system formed, and they have created fear and wonder in human beings through history. Today, however, you will be examining several *differences* in these groups. The **Background** sheet will be a useful reference for this activity.

Your Assignment:

Today, you will create a simple scale model that will demonstrate the average relative size, shape, and makeup of the three types of small bodies.

1. To compare *sizes*, you will measure and cut strips of paper so each length represents the diameter of one of the small bodies.
2. To compare *shapes*, you will create a sketch of one of the objects on each of the paper strips.
3. To compare *makeup*, you will select items to glue onto your drawings representing the substances in each.

Procedure (Creating Scale Model Strips):



1. Get a plain sheet of white paper and turn it sideways.
2. Measure four equal strips of paper, each 5 cm wide.
3. Cut strips (see diagram).
4. Select one of the paper strips; starting at end of strip, use metric ruler to measure 0.5 cm along length of strip.
5. Draw line on strip at 0.5 cm and cut off the 0.5 cm section; this represents the scaled size of a *meteoroid*; glue the strip to the **Data Sheet** in the space provided.
6. Starting at the end of strip where the cut was made, repeat the process, but this time measure 2 cm; again, draw a line at 2 cm and cut off the 2 cm section; this section represents the scaled size of a *comet*; glue it to the **Data Sheet** too.
7. Repeat the process, except this time measure a line that is 100 cm in length (you will need to measure more than one strip and add distances together)!
8. When done, cut at 100 cm; attach strips together by barely overlapping end of one strip to end of next and gluing overlapped ends together; these strips represent the scaled size of an *asteroid*.
9. Glue the *bottom* strip to the **Data Sheet** in the space provided; neatly fold remaining strips back and forth over the bottom strip; use a paper clip to hold remaining strips in place.

Creating Shapes and Makeup:

1. On each white strip, sketch the small body it represents (use the **Background** sheet as a reference); you may extend the comet's two *tails* beyond the strip if you want, but be sure that you only draw on the top strip for the asteroid).
2. Now, illustrate the composition of each (see **Background** sheet); decide which lab items would be good examples of the material (for example, a comet has an *icy* center; items that are white or look like ice would be good to use in the middle of your comet drawing).

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Data Sheet

ASTEROIDS, COMETS, METEOROIDS

Name: ______________________________

Meteoroid

← Glue here

Comet

← Glue here

Asteroid

← Glue *bottom* strip along here →

Fold remaining strips back and forth on top of glued strip and use paper clip to hold.

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Follow-Up

ASTEROIDS, COMETS, METEOROIDS

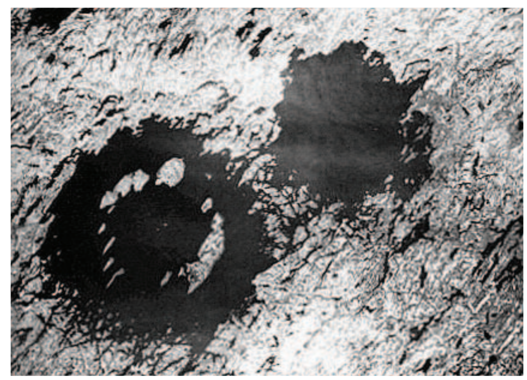
Name: ______________________________

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

1. Based on your scale model, which two small bodies are most similar in size?

2. Name two ways the compositions of *asteroids*, *comets*, and *meteoroids* are alike.

3. Throughout history, Earth's surface has been hit by *asteroids*, *comets*, and *meteorites*. When that happens, craters are often formed. Some, like Sudbury Crater in Ontario, Canada (image at right), are very large; others are not. Suggest how a scientist might be able to tell if the crater was caused by an *asteroid*, a *comet*, or a *meteorite*.



EXTEND YOUR KNOWLEDGE

- Learn more about NASA's Deep Impact Discovery Mission to look below the surface of Comet Temper 1:

  http://deepimpact.jpl.nasa.gov/mission/index.cfm

- Great information about small bodies and other interesting aspects of our solar system for student astronomers:

  http://starchild.gsfc.nasa.gov/docs/StarChild/StarChild.html

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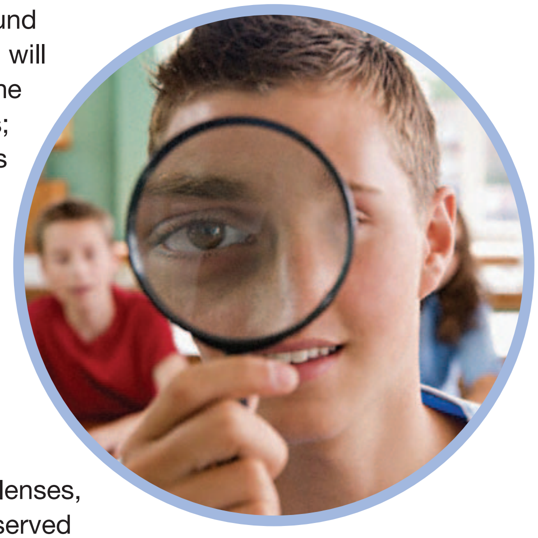
Lesson 2: Tools of Astronomy

Overview:

This lesson provides students with a background on the science of astronomy and its tools. Students will learn about some key landmarks in the field of astronomy; the importance of scientific tools such as lenses and telescopes; and the work of important scientists such as Galileo. Students will create a model of an early lens in a hands-on activity that allows them to apply what they've learned. Students will then use additional lenses in exploratory investigations. Follow-up questions and extensions are included.



Objectives:

- Upon completion of the lesson, students will identify a *lens* as any curved, transparent material that bends light waves.
- Upon completion of a lab activity investigating simple lenses, students will list two properties of spherical lenses observed during their experimentation.
- Following class discussion of Galileo's use of a telescope to study the moon and stars, students will describe the importance of scientific tools in our search for an understanding of the universe around us.

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

- Students construct a simple lens and conduct experiments with their model as well as with other models provided by the instructor.
- Observations are recorded and a class discussion follows.
- Assign **Follow-Up** reproducible as homework.
- Use portion of following class period to discuss results and summarize the lesson.

Materials Needed (for each student):

- 2 squares approximately 4 cm x 4 cm cut from clear plastic transparency
- eyedropper
- small container (beaker, etc.) for water
- 2 clear glass marbles

Steps for Conducting Lab:

Day 1: Setup and Topic Introduction

- Obtain clear glass marbles (2 per student).
- Precut segments of clear plastic (2 per student).
- Collect remaining lab supplies.
- Plan guidelines concerning marble use (for example, container at each lab station to hold marbles when not in use).
- Test lab activity to be prepared for questions.
- Copy all required sheets.
- Before lab activity, provide students with copies of **Background** reproducible; discuss important terminology and give brief overview of upcoming lab.

Day 2: Lab Activity

- Before class begins, place required sheets and supplies in central location.
- As students enter, have them pick up lesson sheets (**Lab Activity**, **Data Sheet**, and **Follow-Up** reproducibles).
- Tell class **Background** reproducible may be used as a reference.
- Review lab expectations.
- Tell students to begin.

Teacher Resources

Activities and readings on lenses and focal length:
http://acept.asu.edu/PiN/act/lenses/lenses.shtml

Learn more about Galileo's life and the impact of his discoveries:
http://galileo.rice.edu

Information on observational astronomy and general astronomy:
http://curious.astro.cornell.edu/index.php

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

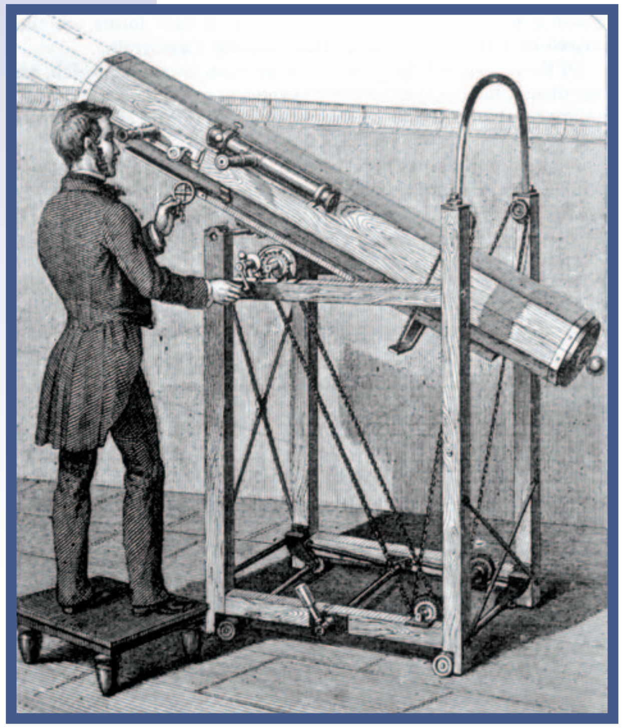
Earth and Space Science
- Earth in the solar system

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

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

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

Source: National Research Council

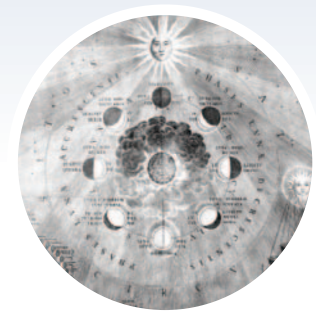


Reproducible Answers:
Follow-Up: 1. B, A, D, C; 2. answers will vary.

Background

Astronomy and the Study of Space

Throughout time, humans have strived to understand and explore the mysteries of the solar system. *Astronomy* refers to the branch of science devoted to the study of stars, planets, and space. *Astronomers* are scientists who rely upon observation and calculations in helping to interpret and explain space.



Throughout the history of astronomy, tools have been instrumental in helping to achieve breakthroughs in knowledge. A major achievement occurred with the development of *lenses* and *telescopes*, which allowed astronomers to observe space farther than ever before. Read on to find out more about these important tools of the modern astronomer, and some key events in the history of astronomy.

An Astronomy Timeline

c. 2500 BC: The Sumerians record the positions of planets and stars. They develop a 12-month calendar by following the cycles of the moon.

550 BC: Mayan priests in Central America use astronomy to develop a 365-day calendar. They develop another calendar to predict the cycles of the moon.

c. 400 BC: The first Chinese star catalogs are developed by scientists.

c. 290 BC: The Greek astronomer Aristarchus discovers that Earth and other planets circle the sun, though his discovery is not widely accepted.

c. 240 BC: Another Greek astronomer, Eratosthenes, determines that Earth is round.

c. 140 BC: The astrolabe, one of the first tools used to understand space, is believed to be invented by the Greek astronomer Hipparchus.

c. AD 150: Ptolemy, a Greek astronomer, theorizes that all bodies in space revolve around Earth. His theories are believed to be true for nearly 1,400 years.

c. AD 927: Muslim astronomers use astrolabes for telling time and mapping stars.

1400s: Scientists begin using *convex* and *concave* lenses in basic telescopes.

1543: A Polish astronomer named Nicolaus Copernicus states that Earth and all other planets revolve around the sun—an idea that challenges traditional thinking.

1600s: Scientists and inventors throughout Europe develop and patent designs for the first modern telescopes.

1632: Italian Galileo Galilei publishes a book supporting the idea of a sun-centered solar system. While his theories are accurate, many people in Europe do not believe or support them.

1705: Astronomer Edmond Halley discovers a comet that passes by Earth every 76 years; it is now known as Comet Halley.

1846: Johann Gottfried Galle, a German astronomer, becomes the first to view and identify the planet Neptune.

c. 1910: George Ritchey and Henri Chrétien invent the Ritchey-Chrétien Telescope, the design of which is used in telescopes today, including the Hubble Space Telescope.

Background (continued)

An Astronomy Timeline (continued)

1930: Pluto is discovered by an American astronomer named Clyde Tombaugh.

1957: The Soviet Union launches *Sputnik I*, the first ever man-made satellite to enter space. It is about the size of a basketball and weighs only 183 pounds.

1990: The Hubble Space Telescope, a 43-foot-long super-powered telescope, is launched. It is one of the greatest advancements in astronomy, allowing scientists to view objects up to 12 billion light years away.

1992: The first planetary system beyond our own solar system is discovered; it is located about 980 light years away.

2005: The Cassini spacecraft and Huygens Probe provide the first images of Saturn's moons.

A Closer Look: The Breakthrough of the Telescope

Key Facts

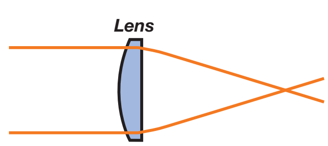
- The history of the telescope is mostly unknown; early Greek astronomers may have been the first to use the tool.
- Scientists during the 1400s–1500s used convex and concave lenses in basic telescopes.
- Major developments of the telescope occurred during the early 1600s.
- Astronomers began to use multiple lenses to view faraway objects.
- Early telescopes made objects appear larger and brighter than ever before.

Galileo: The Father of Astronomy

- Improved on early telescope; made a better one with powerful lenses that allowed him to see farther than anyone before
- First person to see Jupiter's moons and to describe the surface of Earth's moon

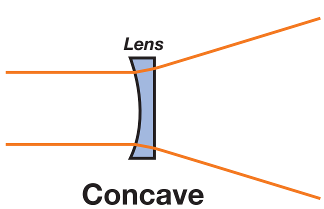
What are lenses *and how are they used?*

Lens: any *transparent* (clear) material that *refracts* (bends) the path of light rays; the name *lens* comes from a lens's resemblance to a lentil seed. Types of lenses include:



Convex

Convex lens:
- thicker at *center* than at edge
- curves outward like the outside of a bowl
- makes things appear *bigger* but also *blurrier*
- refracts (bends) light *inward*



Concave

Concave lens:
- thicker at *edge* than at center
- curves inward like the inside of a bowl
- makes things appear *smaller* but also *clearer*
- refracts (bends) light *outward*

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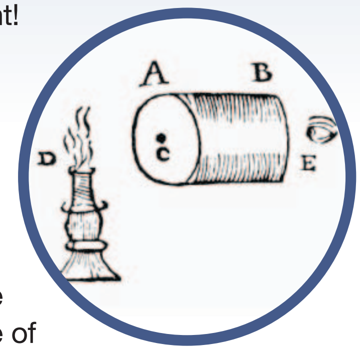
Lab Activity

TOOLS OF ASTRONOMY

Introduction:

You have already learned about lenses and how they help us see faraway objects through telescopes. But think of all the other ways they are used: eyeglasses, contact lenses, the lenses in your eyes, binoculars, cameras, radar systems, and microscopes. During the 1600s, lenses were even used for entertainment! In Galileo's time it became very common for wealthy people to pass out *spherical* (round) lenses—called "flea glasses"—at parties. Their guests would amuse themselves looking for fleas and other small critters in the folds of the other guests' clothing!



Your Assignment:

In today's activity, you will make a simple lens out of water and conduct investigations to see how it bends the light. Then you will create three experiments to observe how "flea glasses" change the appearance of objects that are viewed through them.

Procedure:

Creating a simple lens

1. Obtain two small squares of clear plastic from your teacher.
2. Place one square directly over the print at the top of this page, somewhere in the *Introduction* section.
3. Place one drop of water on the plastic so it covers some print; add a second drop of water directly on top of the first, making a single large droplet that will serve as your lens.
4. Compare the print *under* the water droplet with print that is not under the droplet. Look for differences in things such as print *size*, *sharpness* (clear or blurry), and letter *position* (upside down or right side up). Record your observations on the **Data Sheet**.
5. While observing the print through the water droplet, *very gently* lift the plastic square away from the page and notice any changes to the appearance of the print. Record your observations on the **Data Sheet**.
6. Lay the plastic sheet back down on the paper (if the droplet has moved, wipe off and redo).
7. Now make a *second* "two-drop" water lens on the *second* plastic sheet.
8. Lift the second plastic sheet gently and hold it 1–2 cm above the first droplet, so you are looking at the print through both droplets at the same time. Describe any changes in print size, sharpness, etc., on the **Data Sheet**.

Examining a flea glass

1. Obtain two flea glasses from your teacher.
2. Decide on experiments that you can do to learn more about how the lenses change the appearance of an object that is viewed through them. You may want to try putting one directly on the print, moving it slowly away, putting one on top of the other, etc. You decide!
3. Once you decide, use the **Data Sheet** to describe three experiments you plan to conduct.
4. Conduct your experiments and record your observations in the space provided on the **Data Sheet**.

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Data Sheet

TOOLS OF ASTRONOMY

Name: ______________________________

Questions:

1. Describe differences you observed when viewing the print through the water droplet.

2. Describe changes in the print when the water lens was lifted.

3. Describe changes in the print when you viewed the print through two water lenses at the same time.

4. List three experiments you conducted and your observations for each in the spaces below. Use the back of the page for additional space as necessary.

Experiment:	**Observations:**
A.	**A.**
B.	**B.**
C.	**C.**

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Follow-Up

TOOLS OF ASTRONOMY

Name: ____________________

Questions:

1. Look at the four moon images on the right. These images were created during the last 500 years. Read the descriptions below and see if you can put the images in order from oldest to most recent.

- The Italian artist and scientist Leonardo da Vinci sketched one of these images in the 1500s using only his sense of sight.
- Two images were sketched during the 1600s. The English scientist Thomas Harriot sketched one of the first images of the moon as seen through a telescope. The telescope he used magnified the moon to six times its original size. A few months after Harriot's sketch, the Italian scientist Galileo sketched the moon after he viewed it through a telescope that he had created himself. This telescope magnified the moon to 20 times its original size.
- The final image is a photograph of the moon taken during the 19th century.

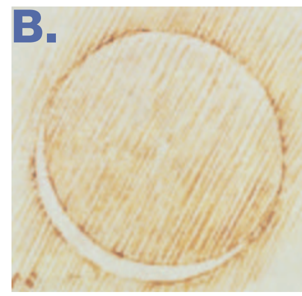
________ ________ ________ ________

(oldest) (most recent)

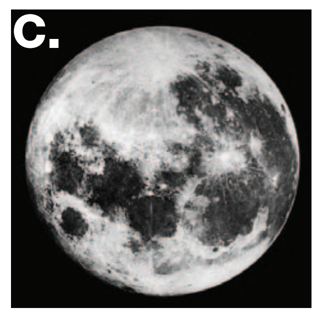
2. Along with lenses, what are some other examples of inventions that you believe have helped us learn more about our world? Explain your answer. Write your answer on the back of this page.

A.

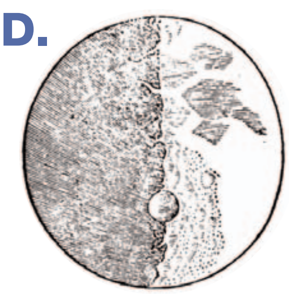
B.



C.



D.



EXTEND YOUR KNOWLEDGE

- Interesting information about the microscope; great pictures too:
  www.andrewlost.com/microscope_inventors_k3.htm
- Could Vikings have created the first lenses? See:
  http://news.bbc.co.uk/1/hi/sci/tech/702478.stm
- Learn more about the Hubble telescope and see images it has collected of the universe:
  www.space.com/hubblespacetelescope/

Did You Know?

After reading Galileo's book describing his observations of the moon through a telescope, the astronomer Johannes Kepler wrote *Somnium* ("The Dream"), a science fiction story about an early rocket voyage to the moon.

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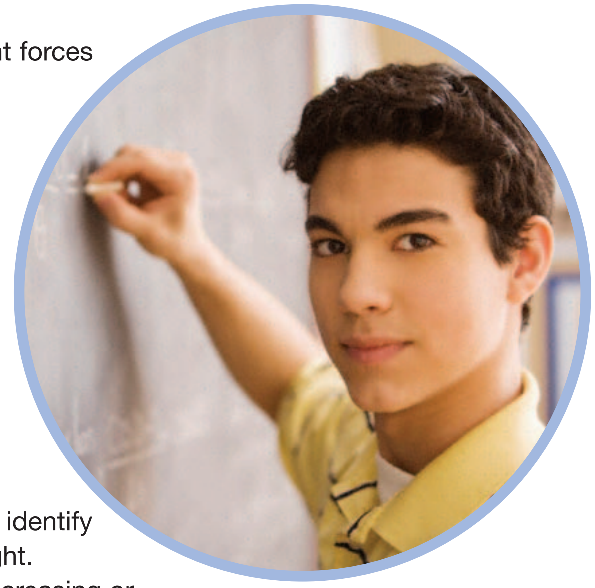
Lesson 3: Balloon Jet

Overview:

After being introduced to the four important forces affecting an aircraft's flight (*thrust*, *drag*, *lift*, and *weight*), student teams study the effect of drag on the performance of balloon "jets." Data is recorded and results discussed. Follow-up questions and lesson extensions are included.



Objectives:

- Following topic introduction and class discussion, students can identify the four important forces influencing an aircraft's flight.
- After conducting the activity and examining data, students can evaluate how landing gear position influences drag.
- Upon completion of activity, students can correctly identify the direction of each of the four forces affecting flight.
- When given examples, students can predict how increasing or decreasing each of the four forces will affect an aircraft's flight.

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 balloon jets, conduct experiments, and record data (use **Background**, **Lab Activity**, **Data Sheet**, and **Landing Gear Diagram** 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 3 to 4 students:

- 6 small rubber balloons (about 6 cm long when deflated); *note: use small balloons; large ones are expensive and difficult to inflate*
- 1 precut section of nylon thread/line (monofilament)
- scissors
- 1 roll of masking tape
- 3 non-flexible drinking straws, each precut in half
- landing gear diagram reproduced on card stock (see **Landing Gear Diagram** reproducible)
- metric ruler
- calculator (optional)

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Lesson 3: Balloon Jet *(continued)*

Steps for Conducting Lab:

Day 1: Setup and Topic Introduction

- Determine number of balloons needed for all classes (include extras, in case of mistakes).
- Use small balloons, about 6 cm long when deflated.
- Create two "jets": one to use as a model when introducing the lab, the other to try yourself beforehand.
- Decide where you want the lines attached (between chairs, to walls, etc.).
- Cut sections of the nylon line to length required (a small balloon travels approximately 4 m).
- Cut drinking straws in half (each segment will be about 12 cm long).
- Copy all required sheets (**Landing Gear Diagram** reproducible should be copied onto card stock).
- Copy extras diagrams in case students make mistakes.
- If time is too short, decide how to modify lab (reduce number of trials or have some groups run tests with landing gear up and others with landing gear down, then allow the groups to share results).
- 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 supplies and reproducibles in central location.
- As students enter, have them pick up required reproducibles (**Lab Activity**, **Data Sheet**, **Follow-Up**, and **Landing Gear Diagram**).
- Tell class **Background** reproducible may be used as a reference.
- Use model to illustrate how straw and landing gear card (up and down) are taped to balloon.
- Assign students to teams of three or four; instruct them to begin.

Teacher Resources

"How Things Fly": An exhibition at the National Air and Space Museum:
www.nasm.si.edu/exhibitions/gal109/gal109.html

"Understanding Flight": Includes descriptions and teaching transparencies on thrust, lift, weight, and drag (from the Web site 100 Years of Aviation, YES I Can! Science):
http://resources.yesican-science.ca/100_years/unit2_flight1g06.html

"How Planes Fly": An interesting Web page with lots of information (from the Web site Live Science):
www.livescience.com/technology/060828_how_planes_fly.html

"Your Own Flight": Descriptions and in-depth information (from the Web site Flights of Inspiration, Franklin Institute Science Museum):
www.fi.edu/flights/own2/forces.html

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
- Science and technology in society

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

Source: National Research Council

Reproducible Answers:

Follow-Up: 1. thrust and drag; 2. smooth surfaces, rounded noses, etc.; 3. smooth surface, rounded front, moves through the air, needs a system to make it move, etc.; 4. increasing payload would affect weight, not drag; however, some might suggest the mass of the pennies could cause the balloon to stretch out where they were located, creating a bumpy surface and therefore increasing drag; 5. a long, skinny jet would be more aerodynamic; drag would be reduced; 6. most birds carry their legs up near their body when they fly; this reduces the force of drag.

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Background

Do you know what planes, birds, bees, and even some fish and seeds have in common? They can *fly*! However, before you can understand how it happens, you must first learn about four very important *forces*.

What is a force?

A *push* or a *pull* affecting an object's movement.

What are the *forces* that influence an airplane's flight?

Lift: Force pushing a plane upward, away from Earth

Thrust: Force pushing a plane forward through the air

Weight: Force pulling a plane downward, caused by Earth's gravity

Drag: Force resisting a plane's forward motion; caused by air molecules hitting the plane

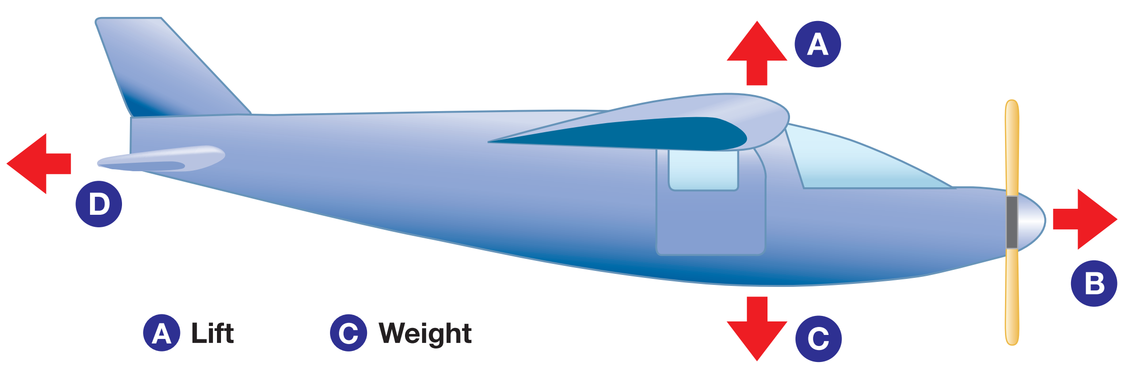
What affects the *strength* of each force?

Lift: The aircraft's wings (shape, size, and location)

Thrust: The system used to create the forward movement (propellers, jet engines, or rockets)

Weight: The aircraft's mass (a measurement of the material that makes up the aircraft and its contents)

Drag: The aircraft's design (shape, surface, and speed)

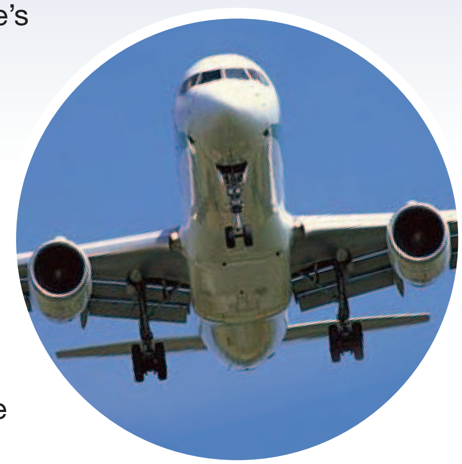


A Lift
B Thrust
C Weight
D Drag

Lab Activity

Introduction:

As you now know, a plane's forward motion (*thrust*) is slowed if *drag* (push of air against the plane) is too strong. To reduce *drag*, engineers design planes that are *aerodynamic* (streamlined). For example, a plane's smooth surface and rounded nose help reduce *drag*.



Your Assignment:

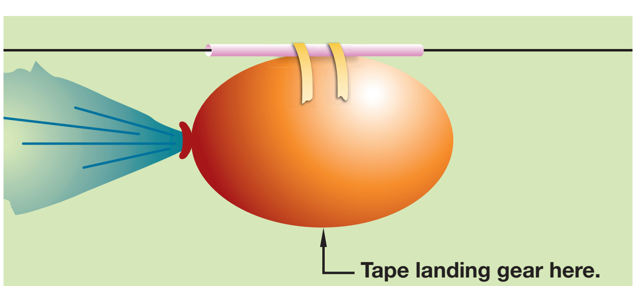
Today, a major aerospace corporation needs your assistance! Having heard of your expertise regarding the forces affecting aircraft flight, they have requested that you conduct experiments to help answer the following question:

> ***Does the position of a plane's landing gear during flight affect drag and, if so, how?***

Using the procedure below, your team of engineers will examine the drag produced when a jet's landing gear is *up* (retracted) or *down*. Once complete, your results and recommendations will be given to the corporation's representative. It's time to start, so don't *drag* your feet!

Procedure:

1. Form teams as instructed; collect needed supplies.
2. Attach nylon line as instructed.
3. Complete "Prediction" section of **Data Sheet**.
4. Inflate balloon jet, pinching end so no air escapes.
5. Record length of jet on data table provided.
6. Thread line through straw and securely attach to an anchor (e.g., a doorknob or chair), as directed by teacher.
7. Tightly tape balloon jet to straw as illustrated.
8. Prepare landing gear as directed. (Refer to the **Landing Gear Diagram** reproducible.)
9. To test with landing gear *up*, push all sections of folded card up against balloon.
10. Attach opposite end of nylon line to another anchor, ensuring it is stretched tightly.
11. Release end of jet, allowing air to escape; note speed of jet's movement.
12. Measure distance that jet traveled and record on data table.
13. Conduct two more tests, using same card but new balloons and straws.
14. Repeat entire process, but this time test with landing gear *down*, leaving bottom of card (wheels and middle section) hanging down from balloon.
15. Complete additional trials if time permits.



Data Sheet

BALLOON JET

Prediction:

Based on our understanding of *drag*, we believe the jet

will travel __________ cm when the landing gear is *up*.

will travel __________ cm when the landing gear is *down*.

Data Table:

	Distance Traveled (cm)							
	Trial 1		Trial 2		Trial 3		Avg. distance (cm)	
Jet length (cm)	Gear up	Gear down	Gear up	Gear down	Gear up	Gear down	Gear up	Gear down

Analysis:

Using the data shown above, describe how the position of the landing gear affected drag:

____

Name of our jet: ________________________________

Pilot names: ___________________________________

____

____

____

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Follow-Up

BALLOON JET

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

1. Name two forces affecting an airplane's flight that were studied in this activity.
2. Identify two ways engineers design planes to reduce drag.
3. Describe two ways the balloon jet was a model of a real jet airplane.
4. Suppose you added a payload (something being carried)—for example, you put several pennies inside the balloon before it was inflated. Would this have caused an increase in drag?
5. Suppose your balloon jet were longer and skinnier. How would this difference in shape have affected drag? Explain.
6. Where do birds hold their legs when flying? How does this position affect the force of drag on the bird's body?

EXTEND YOUR KNOWLEDGE

- Did you know the Lockheed Martin SR-71 Blackbird is still the highest-flying and fastest jet ever developed? Read more:

  www.lockheedmartin.com/SR-71

  www.nasa.gov/centers/dryden/news/FactSheets/FS-030-DFRC.html

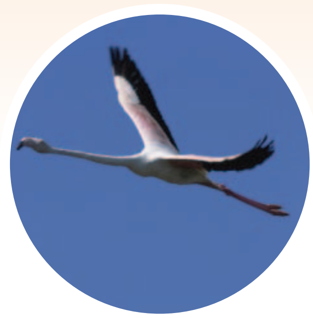
- Learn more about how thrust and drag affect movement of different animals:

  www.ucmp.berkeley.edu/vertebrates/flight/flightintro.html

- Discover what it takes to be a pilot! Check out:

  www.bls.gov/k12/science03.htm

- ***Now try this:*** Do research to find out how propellers, jet engines, and rockets are different in the ways they produce an aircraft's thrust.



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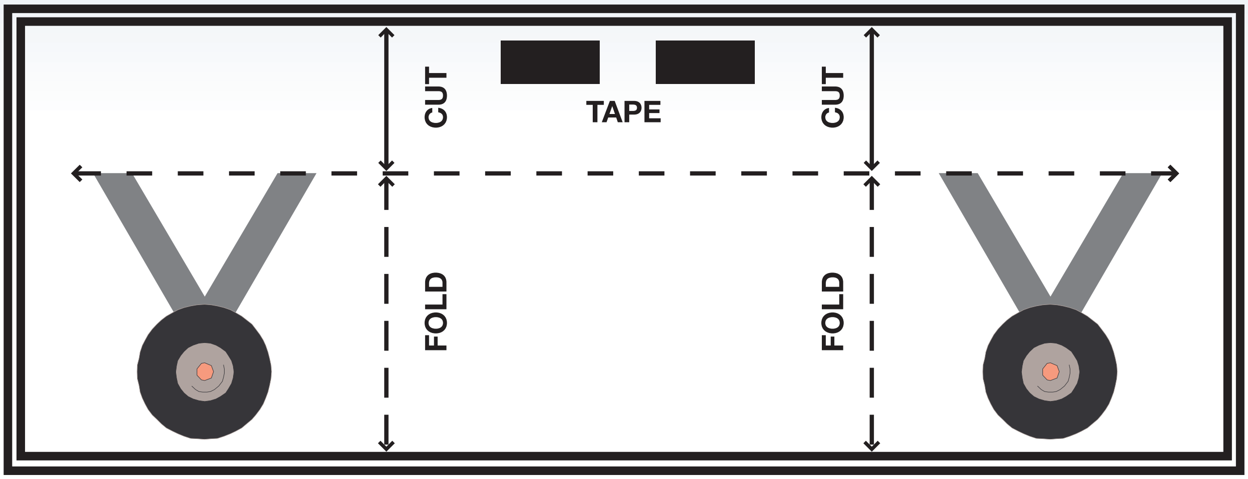
Landing Gear Diagram

BALLOON JET



Directions:

Step 1. Cut around rectangle on double line.

Step 2. At top of card, make 2 cuts as shown.

Step 3. Fold back 3 top sections along dotted line.

Step 4. Fold back 2 side sections along dotted line beside each wheel and crease.

Step 5. Attach landing gear to balloon by taping diagram (in area indicated) to the bottom of the balloon (directly opposite where the straw is attached). See visual on **Lab Activity** handout.

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

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)

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

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

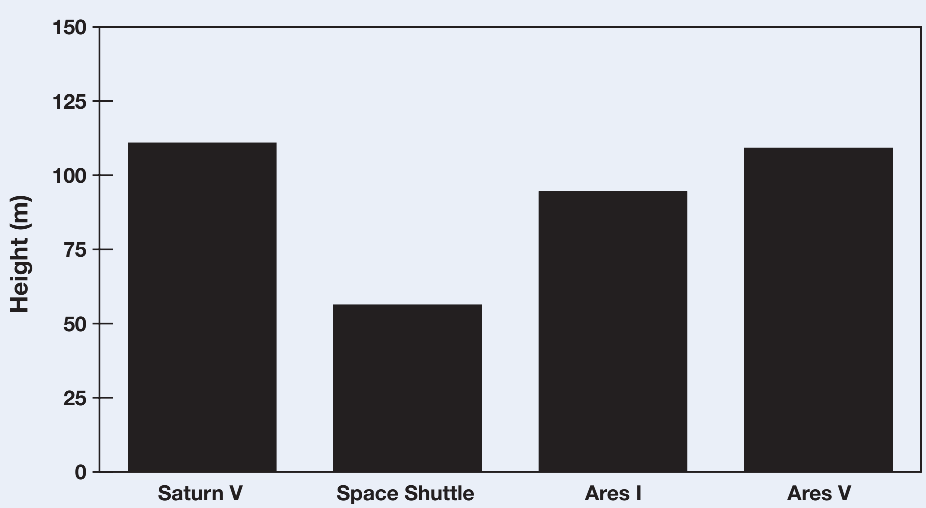
Science in Personal and Social Perspectives
- Risks and benefits
- Science and technology in society

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:



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

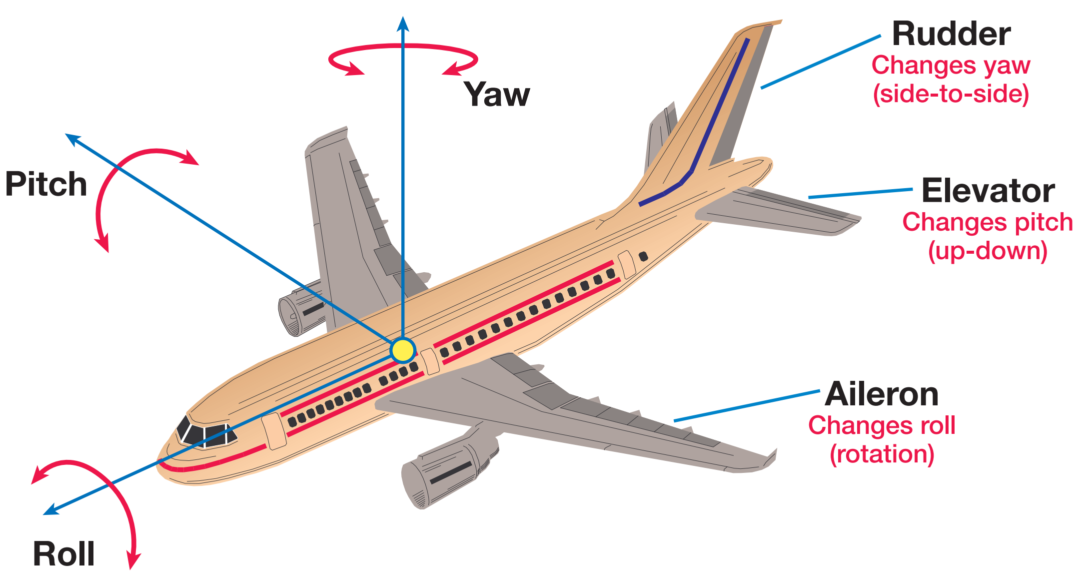
Yaw: Nose of airplane moves left or right while remaining level with the ground

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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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.

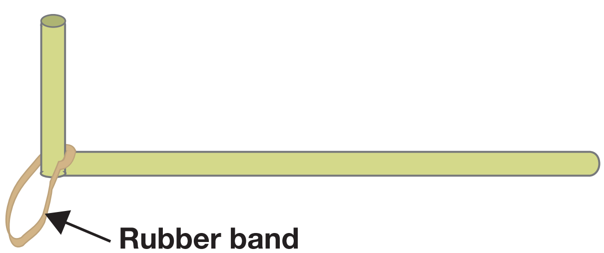
Your Assignment:

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.

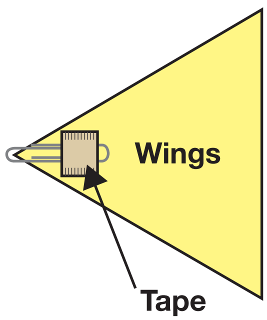


3. Fold straw over rubber band and secure end with masking tape to create "launcher."

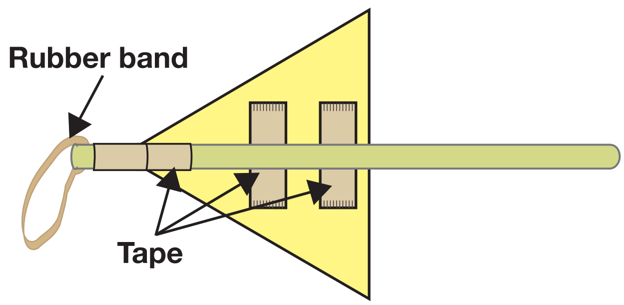
Lab Activity *(continued)*

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.

REPRODUCIBLE

Data Sheet

TO THE MOON (AND MARS) OR BUST

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.

Follow-Up *(continued)*

TO THE MOON (AND MARS) OR BUST

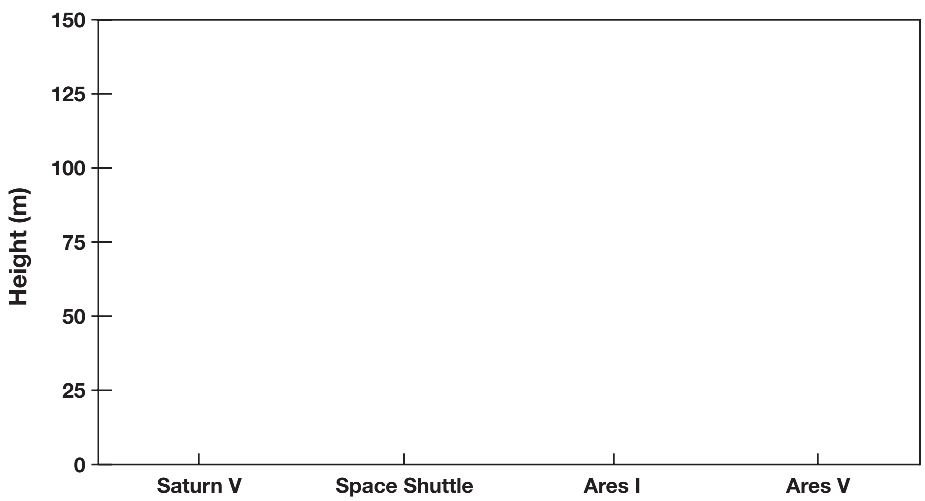
Questions (write your answers on the back of this page):

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:

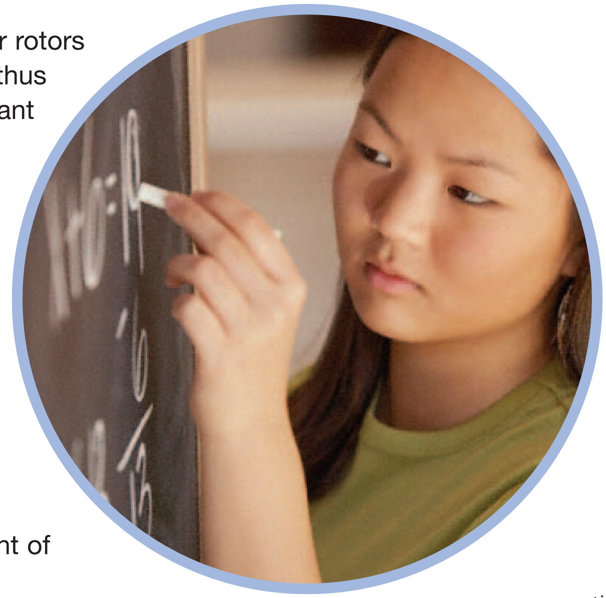
  www.lockheedmartin.com/orion
  www.nasa.gov/mission_pages/constellation/orion
  www.msnbc.msn.com/id/14594789

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

  www.quest.nasa.gov/about

Lesson 5:
Gravity Busters

TEACHER PAGES



Overview:

This lesson examines how the *lift* of helicopter rotors is used to overcome the opposing force of *gravity*, thus enabling a helicopter to fly. After being introduced to important terminology, students examine how *lift* is affected when the weight is increased. Follow-up questions and lesson extensions are included.

Objectives:

- Upon completion of lesson, students can identify the four forces affecting an aircraft's flight.
- Following class discussion of forces affecting helicopter flight, students will explain how rotor movement is responsible for creating the *lift* needed to overcome *gravity*.
- Upon completing the hands-on activity, students will state that increased *lift* is required for flight if the weight of an aircraft increases.
- Following experiments on rotor design, students will state that both rotor speed and blade angle will affect a helicopter's *lift*.

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
- Each student will construct a model of a helicopter rotor, run experiments to examine the effects of blade position and gravitational pull, and record data (use **Background**, **Lab Activity**, **Data Sheet**, and **Rotor Diagram** reproducibles).
- Assign **Follow-Up** reproducible as homework.
- Use portion of following class period to discuss results and summarize lesson.

Materials Needed (for each student):

- 2–3 copies of **Rotor Diagram**
- scissors
- 3–4 small paper clips
- timekeeping device (e.g., watch, wall clock, stopwatch)
- calculator (if available)

Steps for Conducting Lab:

Day 1: Setup and Topic Introduction
- Collect supplies.
- Copy all required sheets, making extra **Rotor Diagram** reproducibles.
- Decide where to conduct activity (the greater the drop distance, the better the results); consider stage, balcony, or top of outdoor bleachers.
- Create model of helicopter to show students when introducing lesson.
- Test your model to be prepared for questions.
- Before lab activity, provide students with copies of **Background** reproducible; discuss important terminology, and give brief overview of upcoming lab.

Day 2: Lab Activity
- Before class, place required sheets and supplies in central location.
- As students enter, have them pick up required sheets (**Lab Activity**, **Data Sheet**, **Follow-Up**, and **Rotor Diagram** reproducibles).
- Tell class **Background** reproducible may be used as a reference.
- Use your model to illustrate method of releasing model when testing ("drop," don't "toss").
- Review safety issues if appropriate (for example, if dropped from bleachers).
- Have students work in teams, with each student making a model.

Teacher Resources

"Helicopter Development in the Early Twentieth Century," U.S. Centennial of Flight Commission:
www.centennialofflight.gov/essay/Rotary/early_20th_century/HE2.htm

"History of Gravity," Adler Planetarium:
www.adlerplanetarium.org/education/resources/gravity/5-8_cb1-1.shtml

Rescue Mission Game:
www.bbc.co.uk/drama/rockface/game/main.swf

NASA Quest:
www.quest.nasa.gov/index.html

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
- Science and technology in society

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

Source: National Research Council

Reproducible Answers:

Follow-Up: 1. lift and gravity; 2. yes, the force of gravity increased. The lift time decreased as extra paper clips were added; 3. answers will vary; 4. there wouldn't be enough air molecules beneath the rotor blades to safely lift the helicopter.

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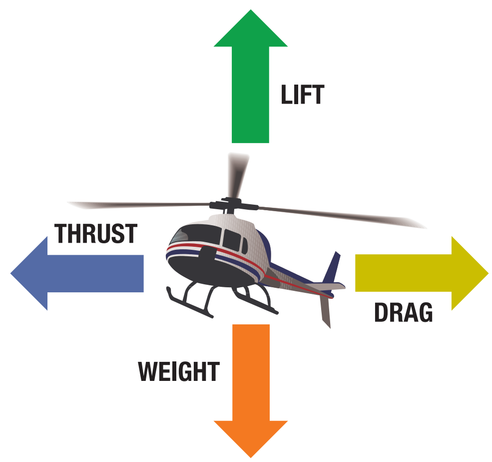
Background

GRAVITY BUSTERS

Can you guess how long helicopters have been around? For a long, long time! As far back as 1486, Leonardo da Vinci designed a very simple helicopter. Some scholars say his wasn't the first; around AD 320 in China, Ko Hung described a "Chinese Flying Top." Today, his design is thought to be the earliest known example of a helicopter. Now we know that four important *forces* (push or pull affecting an object's movement) influence a helicopter's flight. So, what are they? Just keep reading!

What *forces* affect a helicopter's flight?

FORCES IN HORIZONTAL FLIGHT



Lift: Force *pushing up* on a helicopter, caused by horizontal *rotor* and *blades*.

Weight: Force working against lift; caused by *gravity's downward pull* on helicopter; affected by kind and amount of *material* present

Thrust: Force *pushing* a helicopter forward through the air, caused by tail *rotor* and *blades*

Drag: Force working against *thrust*; caused when *air molecules* hit surface of helicopter, slowing it down

What are the differences in the way helicopters and airplanes fly?

Helicopters:

- Gain *lift* as moving air passes over *horizontal rotor*
- Gain *thrust* as air moves over *vertical* (tail) *rotor* blades
- Can *hover* (stay in one place) and rise and land *vertically* (up and down)
- Can take off and land in tight spaces
- Fly at slow speeds, compared with airplanes
- *Unstable* by nature; require constant pilot monitoring; can't easily correct course

Airplanes:

- Gain *lift* as moving air passes over fixed wings or propellers
- Receive *thrust* from jet engines, rockets, or propellers
- In most cases, can't hover or rise and land vertically
- Cannot take off and land in restricted spaces
- Fly at high speeds, compared with helicopters
- *Stable* by nature; do not require constant pilot monitoring; often correct course themselves

Lab Activity

Introduction:

As you now know, a helicopter uses *lift* to overcome *gravity*, which acts on a helicopter's *weight* by constantly pulling it downward. To create *lift*, a helicopter uses a horizontal *rotor* and attached *rotor blades* (usually two).

Because of a helicopter's unique properties (see **Background**), it is used in a variety of situations: search and rescue, firefighting, law enforcement, and medical evacuation, to name a few. One important consideration for engineers designing new helicopters is to examine the effect of *weight* on a helicopter's performance. The *rotor* must be able to create enough *lift* to overcome the downward pull of *gravity* on the combined *weight* of the cargo and helicopter.

Your Assignment:

The U.S. Coast Guard is planning to purchase a fleet of new helicopters sometime in the near future. First, however, they need you to run a series of tests to determine whether: (1) *increased weight* will affect the rotor's ability to lift the helicopter; (2) *cargo placement* inside the helicopter will affect the rotor's ability to create *lift*; and, if time permits, (3) *blade angle* of the rotor makes a difference in the *lift*.

Procedure:

1. Form teams of two. Collect supplies and **Data Sheets** as instructed. Each person on a team will make an individual "Gravity Buster." Partners will take turns testing and helping each other record lift time.
2. To create your "Gravity Buster" rotor and blades, refer to the **Rotor Diagram** sheet. Begin by using scissors to cut around the diagram along the solid black line.
3. Now make two additional cuts from the bottom of the "T" up to the "fold line."
4. Fold the left strip back behind the top of the "T"; fold the right strip forward toward the top of the "T." See illustration of folded rotor on the **Rotor Diagram** sheet.
5. Once finished, test your "Gravity Buster" as instructed by your teacher. In Part 1 on the **Data Sheet** you will record the affect of increased weight on lift. Begin by recording the "Gravity Buster's" lift time (how long it stays aloft) with no added weight (paper clips). Run three trials and then calculate the average lift time. Repeat the test but now increase the weight by adding one paper clip to the bottom. Record and average lift times for three trials. Finally, add additional weight by attaching a second paper clip to the bottom. Record and average lift times for three trials.
6. In Part 2 on the sheet, you will determine if the location of the weight (paper clips) affects the lift time. For example, what if the weight were positioned near the top of the rotor, or on the blades? How would that affect lift time? On each of the three diagrams, show the location of the paper clips during each test you conducted.
7. Optional: If time permits, run tests to learn more about how blade *angle* affects lift by changing the angle of the two folded blades. Record results on the back of the **Data Sheet**.

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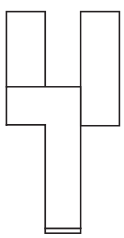
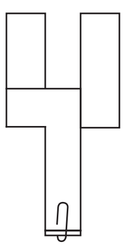
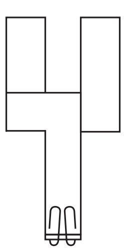
Data Sheet

GRAVITY BUSTERS

Name: ______________________________

Part 1: Study of Increased Weight

	Lift Time (seconds)			
	Trial 1	Trial 2	Trial 3	Average Lift Time
Weight 1: No weight added 				
Weight 2: One paper clip 				
Weight 3: Two paper clips 				

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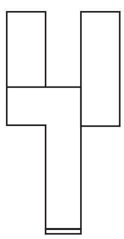
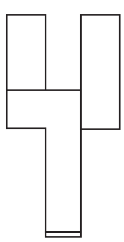
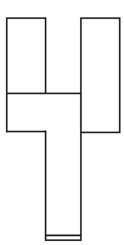
Data Sheet *(continued)*

Name: ______________________________

Part 2: Study of Weight Location—Placement on Rotor

Draw where you placed the paper clips.	Lift Time (seconds)			
	Trial 1	**Trial 2**	**Trial 3**	**Average Lift Time**
Weight Location 1 (sketch): 				
Weight Location 2 (sketch): 				
Weight Location 3 (sketch): 				

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Follow-Up

Name: ______________________________

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

1. Which two forces were being studied in this activity?
2. Based on your data, was the pull of gravity increased when extra weight was added? What was your evidence?
3. Based on your findings, was lift affected by the location of the paper clips? What was your evidence?
4. Sometimes it becomes difficult, or even impossible, to take a helicopter in for a high-altitude rescue operation. How might this difficulty be related to the force of lift? *Hint:* At higher altitudes (elevations above sea level), the number of air molecules decreases.

EXTEND YOUR KNOWLEDGE

- Did you know Lockheed Martin was selected by the U.S. Navy in January 2005 to build and equip the *Marine One* helicopter used by the president of the United States? Each of the twenty-three helicopters in the new fleet will have three 3,000-shaft-horsepower engines. Having three engines aboard will provide an extra margin of safety for the president's "Oval Office in the Sky." Find out more at:

  www.teamus101.com/333.cfm

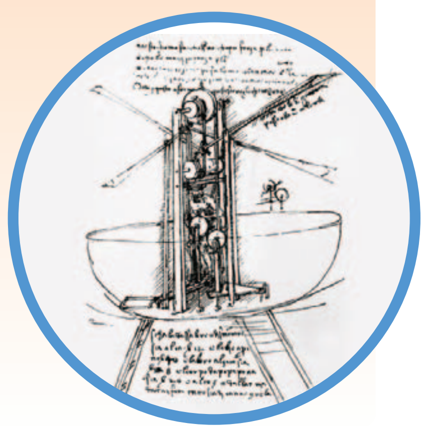
- See how Leonardo da Vinci's original helicopter design compares with the design of helicopters today, and learn more about his other inventions:

  www.mos.org/leonardo/qtvr3.html

  www.museoscienza.org/english/leonardo

- Play a helicopter rescue mission game:

  www.bbc.co.uk/drama/rockface/game/main.swf



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Rotor Diagram

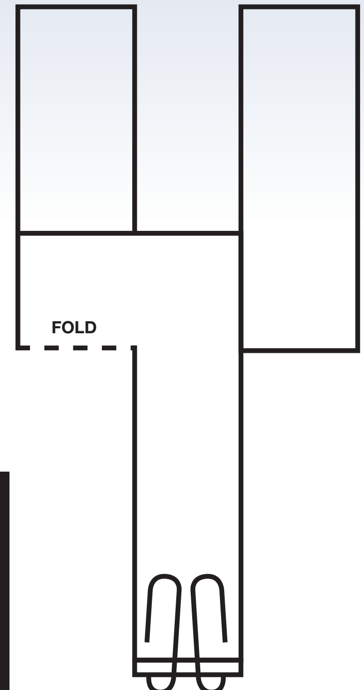
GRAVITY BUSTERS

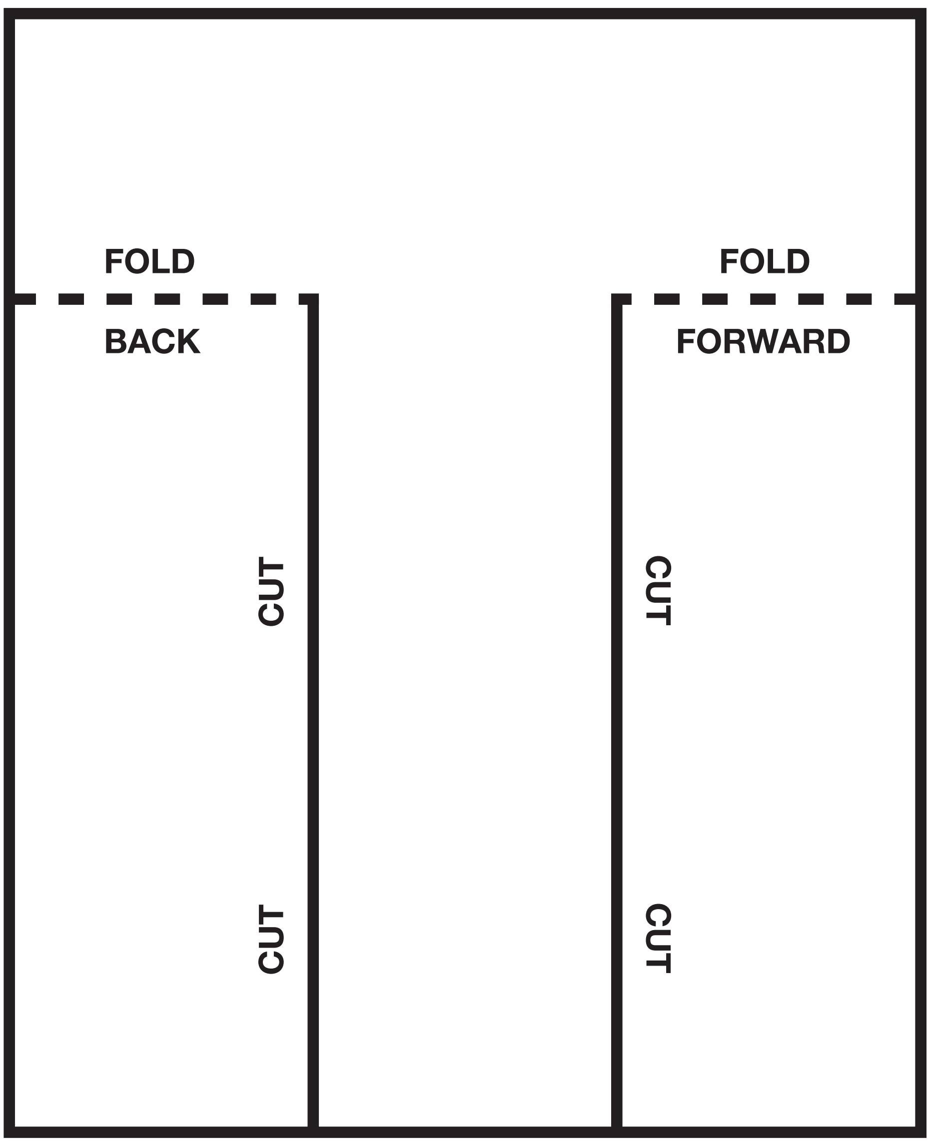
Directions:

Step 1. To create your "Gravity Buster" rotor and blades, begin by using scissors to cut around the diagram (below) along the solid black line.

Step 2. Now make two additional cuts from the bottom of the "T" up to the "fold line."

Step 3. Fold the left strip back behind the top of the "T"; fold the right strip forward toward the top of the "T." See illustration of folded rotor diagram (on the right).





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