National Aeronautics and
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Langley Research Center
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Educational Product	
Educators	Grades 3-5

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The NASA SCI Files™
The Case of the Radical Ride

A Lesson Guide with Activities in Mathematics, Science, and Technology

Please Note: Our name has changed! The NASA "Why" Files™ is now the NASA SCIence Files™ and is also known as the NASA SCI Files™.

http://scifiles.larc.nasa.gov

The Case of the Radical Ride lesson guide is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: **http://spacelink.nasa.gov/products**

A PDF version of the lesson guide for NASA SCI Files™ can be found at the NASA SCI Files™ web site: **http://scifiles.larc.nasa.gov**

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Segment 1

Segment 2

Segment 3

Segment 4

For additional information about the NASA SCI Files™, contact Shannon Ricles at (757) 864-5044 or **s.s.ricles@larc.nasa.gov**.

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Registered users of the NASA SCI Files™ may request a Society of Women Engineers (SWE) classroom mentor. For more information or to request a mentor, e-mail **kimlien.vu@swe.org**

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Program Overview

As Bianca and Kali arrive to meet the rest of the tree house detectives at the NASA auditorium for an awards ceremony, they learn that Dr. D, Jacob, and Katherine are having minor traffic problems. Convinced that they have plenty of time to get to the ceremony, and with not much else to do while they sit and wait, the detectives decide to work on their latest school project. The assignment is to come up with an idea for what transportation will look like in 100 years.

The detectives know that the best place to learn about the future is to visit the past, so they email Tony, who is visiting his aunt in Detroit, Michigan. They ask Tony if he can meet Barry Dressel at the Walter P. Chrysler Museum to learn about the history of transportation. Meanwhile, back in the van, Dr. D helps the tree house detectives understand that all future inventions and innovations must start with the engineering design process. The detectives get an email from two NASA SCI Files™ Kids' Club members, Wendy and Rosie, who are visiting Mr. Richard Storer at the Channel Tunnel in Folkestone, England. Mr. Storer helps the girls understand that once a problem is identified, a solution is sure to follow—eventually!

Tony's aunt also makes an appointment for him to visit Janet Goings at General Motors (GM) to learn about the importance of conducting research when using the engineering design process. Ms. Goings reveals some recent research as she shows Tony some really cool concept cars and explains how a fuel cell works. Back in the van, there seems to be no end to the traffic jam, so Dr. D makes good use of the time by explaining his research and model building experiences when he worked on his experimental hovercraft project. Wanting to know more about model building, the detectives email R.J. and ask him to visit Sam James at the Model Shop at NASA Langley Research Center. After learning how to make a model to scale, the detectives realize that testing is the next step in the engineering process. They join a videoconference in progress hosted by Mike Logan, NASA researcher, between students at Cooper Elementary School in Hampton, Virginia and King's Cross Education Action Zone in London, England. The students are competing in a mousetrap car contest and have just finished testing their model cars. They are analyzing their data so they can improve the distance the car travels. They realize that changes must be made!

Back in the car, Dr. D explains the iterative process and how engineers often have to test and redesign many times before achieving success. To learn more about the redesign process, R.J. sets off to visit Jeff Robinson at NASA Langley Research Center, who is working on the Hyper X, a new scramjet engine NASA is testing. Meanwhile, Bianca and Kali wait patiently for the tree house detectives to arrive, but they are beginning to get a little worried. Wishing that they had their own future form of transportation, they decide to learn more about maglev trains, and they contact a NASA SCI Files™ Kids' Club at Golightly Education Center in Detroit, Michigan. Mrs. Thomas's students are conducting experiments on magnetic force and have even built their own model maglev train.

Desperate to make the awards ceremony, the detectives decide it is time to get radical and come up with some really futuristic ideas for transportation that will help them avoid all future traffic problems. R.J. visits Andrew Hahn at NASA Langley Research Center, who explains all about a new concept for an airplane car. Mr. Hahn tells R.J. that the concept of the Personal Aerial Vehicle (PAV) is not that futuristic and that PAVs might be flying within the next decade. Fascinated by the possibility of having their very own personal airplane car and living in airport communities, the detectives are curious about what other radical things may happen in the future. They contact Terry Hertz at NASA Headquarters in Washington, DC to learn what cool things might be in the future for aeronautics. After dreaming about their next out-of-this-world tour to Mars, the detectives come back to Earth and are excited to learn that they are actually going to meet Frederick Gregory, the Deputy Administrator for NASA! Mr. Gregory encourages the detectives to stay in school and take lots of math, science, and technology courses to prepare for their future careers. He is also curious about where they do all their investigative work, so the tree house detectives invite Mr. Gregory to the tree house where no adult has been before!

National Science Standards (Grades K – 4)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Unifying Concepts and Processes				
• Systems, orders, and organization	✖	✖	✖	✖
• Evidence, models, and explanations	✖	✖	✖	✖
• Change, constancy, and measurement	✖	✖	✖	✖
• Form and function	✖	✖	✖	✖
Science and Inquiry (A)				
• Abilities necessary to do scientific inquiry	✖	✖	✖	✖
• Understandings about scientific inquiry	✖	✖	✖	✖
Physical Science (B)				
• Properties of objects and materials		✖		✖
• Position and motion of objects	✖			✖
• Light, heat, electricity, and magnetism			✖	
Life Science (C)				
• Organisms and their environments	✖	✖	✖	✖
Earth and Space Science (D)				
• Properties of Earth materials	✖			
• Changes in Earth and sky	✖			
Science and Technology (E)				
• Abilities of technological design	✖	✖	✖	✖
• Understandings about science and technology	✖	✖	✖	✖
• Abilities to distinguish between natural objects and man-made objects	✖	✖	✖	✖
Science in Personal and Social Perspective (F)				
• Characteristics and changes in population	✖	✖	✖	✖
• Types of resources	✖	✖	✖	✖
• Changes in environment	✖	✖	✖	✖
• Science and technology in local challenges	✖	✖	✖	✖
History and Nature of Science (G)				
• Science as a human endeavor	✖	✖	✖	✖

National Science Standards (Grades 5 – 8)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Unifying Concepts and Processes				
• Systems, order, and organization	✖	✖	✖	✖
• Evidence, models, and explanations	✖	✖	✖	✖
• Change, constancy, and measurement	✖	✖	✖	✖
• Form and function	✖	✖	✖	✖
Science as Inquiry (A)				
• Abilities necessary to do scientific inquiry	✖	✖	✖	✖
• Understandings about scientific inquiry	✖	✖	✖	✖
Physical Science (B)				
• Motion and forces	✖	✖	✖	✖
• Transfer of energy	✖	✖	✖	✖
Earth and Space Science (D)				
• Structure of the Earth system	✖			
• Earth's history	✖			
• Earth in the solar system				✖
Science and Technology (E)				
• Abilities of technological design	✖	✖	✖	✖
• Understanding science and technology	✖	✖	✖	✖
Science in Personal and Social Perspectives (F)				
• Science and technology in society	✖	✖	✖	✖
History and Nature of Science (G)				
• Science as a human endeavor	✖	✖	✖	✖
• Nature of science	✖	✖	✖	✖
• History of science	✖	✖	✖	✖

National Mathematics Standards (Grades 3 – 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Number and Operations				
Understand numbers, ways of representing numbers, relationships among numbers, and number systems.	✖	✖	✖	
Understand meanings of operations and how they relate to one another.	✖	✖	✖	
Compute fluently and make reasonable estimates.	✖	✖	✖	
Algebra				
Represent and analyze mathematical situations and structures using algebraic symbols.		✖		
Use mathematical models to represent and understand quantitative relationships.		✖		
Geometry				
Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.		✖	✖	
Use visualization, spatial reasoning, and geometric modeling to solve problems.		✖		
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement.	✖	✖	✖	✖
Apply appropriate techniques, tools, and formulas to determine measurements.	✖	✖	✖	✖
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.		✖	✖	
Problem Solving				
Build new mathematical knowledge through problem solving.	✖	✖	✖	✖
Solve problems that arise in mathematics and in other contexts.	✖	✖	✖	✖
Apply and adapt a variety of appropriate strategies to solve problems.	✖	✖	✖	✖
Monitor and reflect on the process of mathematical problem solving.	✖	✖	✖	✖
Communication				
Organize and consolidate mathematical thinking through communication.		✖	✖	
Communicate mathematical thinking coherently and clearly to peers, teachers, and others.		✖	✖	

National Educational Technology Standards
Performance Indicators for Technology-Literate Students (Grades 3–5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Basic Operations and Concepts				
Use keyboards and other common input and output devices efficiently and effectively.	✖	✖	✖	✖
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	✖	✖	✖	✖
Technology Productivity Tools				
Use general purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, and facilitate learning throughout the curriculum.	✖	✖	✖	✖
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	✖	✖	✖	✖
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	✖	✖	✖	✖
Use telecommunication efficiently and effectively to access remote information, to communicate with others in support of direct and independent learning, and to pursue personal interests.	✖	✖	✖	✖
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	✖	✖	✖	✖
Technology Research Tools				
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	✖	✖	✖	✖
Use technology resources for problem-solving, self-directed learning, and extended-learning activities.	✖	✖	✖	✖
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	✖	✖	✖	✖
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem-solving, self-directed learning, and extended-learning activities.	✖	✖	✖	✖
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	✖	✖	✖	✖
Evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources.	✖	✖	✖	✖

International Technology Education Association Standards for Technological Literacy (Grades 3–5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
The Nature of Technology				
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	✖	✖	✖	✖
Standard 2: Students will develop an understanding of the core concepts of technology.	✖	✖	✖	✖
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	✖	✖	✖	✖
Technology and Society				
Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.			✖	
Standard 6: Students will develop an understanding of the role of society in the development and use of technology.	✖	✖	✖	✖
Standard 7: Students will develop an understanding of the influence of technology on history.	✖	✖	✖	✖
Design				
Standard 8: Students will develop an understanding of the attributes of design.	✖	✖	✖	✖
Standard 9: Students will develop an understanding of engineering design.	✖	✖	✖	✖
Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	✖	✖	✖	✖
Abilities for a Technological World				
Standard 11: Students will develop the abilities to apply the design process.	✖	✖	✖	✖
Standard 12: Students will develop abilities to use and maintain technological products and systems.	✖	✖	✖	✖
The Designed World				
Standard 18: Students will develop an understanding of and be able to select and use transportation technology.	✖	✖	✖	✖
Standard 19: Students will develop an understanding of and be able to select and use manufacturing technologies.	✖	✖	✖	✖
Standard 20: Students will develop an understanding of and be able to select and use construction technology.	✖			

National Geography Standards, (Grades 3 - 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire process and report information from a spatial perspective	✖		✖	✖
How to use mental maps to organize information about people, places, and environments in a spatial context	✖		✖	✖
How to analyze the spatial organizations of people, places, and environments on Earth's surface	✖		✖	✖
Places and Regions				
How culture and experience influence people's perceptions of places and regions	✖	✖	✖	✖
Physical Systems				
The physical processes that shape the patterns of Earth's surface	✖			
Human Systems				
The characteristics, distribution, and migration of human populations on Earth's surface	✖	✖	✖	✖
The processes patterns, and functions of human settlement	✖	✖	✖	✖
Environment and Society				
How human actions modify the physical environment	✖			
How physical systems affect human systems	✖			
The changes that occur in the meaning, use, distribution, and importance of resources	✖			
The Uses of Geography				
How to apply geography to interpret the past	✖	✖	✖	✖
How to apply geography to interpret the present and plan for the future	✖	✖	✖	✖

The NASA SCI Files™
The Case of the
Radical Ride

Segment 1

On their way to an important awards ceremony, the tree house detectives and Dr. D run into traffic problems. After sitting in traffic, they conclude that there isn't anything they can do but wait, and they decide to begin investigating their next project. The project is to hypothesize what transportation will be like in 100 years. While wishing they had something futuristic to get them out of the traffic jam, the detectives decide that the best place to learn about the future is to look at the past. Tony sets off to learn about the history of transportation with Mr. Barry Dressel at the Walter P. Chrysler Museum in Detroit, Michigan. Meanwhile, back in the van, Dr. D helps the tree house detectives understand that all future inventions and innovations must start with the engineering design process. After learning that the design process begins with identifying a problem and then formulating solutions, they check in with two members of the NASA SCI Files™ Kids' Club, Wendy and Rosie, who are visiting Mr. Richard Storer, with Eurotunnel, at the Channel Tunnel in Folkestone, England.

Objectives

The student will

- create a time line of technology innovations in transportation.
- examine the engineering design process.
- demonstrate the brainstorming process.
- understand the concept of a natural land bridge and its effects on human and animal populations
- understand the challenges in constructing a tunnel.

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Vocabulary

Channel Tunnel—31 miles of railway tunnel with three interconnected tubes that run under the English Channel and connect the United Kingdom and France (continental Europe)

cycle—a series of regularly repeated events or operations that usually lead back to their starting point

design—to think up and draw the plans for something (e.g., design an airplane)

engineer—a person who is trained in or follows a branch of engineering as a profession

engineering—the science or profession of developing and using nature's power and resources in ways that are useful to people (e.g., designing and building roads, bridges, dams, or machines and creating new products)

iteration—a process in which a series of operations is repeated a number of times

problem—something to be worked out or solved; something that is hard to understand, deal with, or correct

solution—act or process of solving; an answer to a problem

time line—a schedule of events and procedures; a table listing important events for successive years within a certain historical period; a presentation of a chronological sequence of events enabling a viewer to understand temporal relationships at a glance

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Before viewing Segment 1 of *The Case of the Radical Ride*, read the program overview to the students. List and discuss questions and preconceptions that students may have about engineering and past, present, and future transportation.
2. Record a list of issues and questions that the students want answered in the program. Determine why it is important to define the problem before beginning. From this list, guide students to create a class or team list of three issues and four questions that will help them better understand the problem. To locate the following tools on the NASA SCI Files™ web site, select **Educators** from the menu bar, click on **Tools**, and then select **Instructional Tools**. You will find them listed under the **Problem-Based Learning** tab.

a. **Problem Board**—Printable form to create student or class K-W-L chart

b. **Guiding Questions for Problem Solving**—Questions for students to use while conducting research

c. **Problem Log and Rubric**—Students' printable log with the stages of the problem-solving process

d. **Brainstorming Map**—Graphic representation of key concepts and their relationships

e. **The Scientific Method and Flowchart**—Chart that describes the scientific method process

3. **Focus Questions**—These questions at the beginning of each segment help students focus on a reason for viewing. They can be printed ahead of time from the **Educators** area of the web site in the **Activities/Worksheet** section under **Worksheets** for the current episode. Students should copy these questions into their science journals prior to viewing the program. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.
4. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed by selecting Educators on the web site in the Activities/Worksheet section under Worksheets for the current episode.

View Segment 1 of the Video

For optimal educational benefit, view *The Case of the Radical Ride* in 15-minute segments and not in its entirety. If you are watching a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Students should work in groups or as a class to discuss and list what they know about transportation, engineering, and problem solving. Have the students conduct research on transportation and the engineering process to learn about transportation of the past and to begin brainstorming for ideas of what transportation might look like in a 100 years. As a class, reach a consensus on what additional information is needed. Have the students conduct independent research or provide them with the information needed.
4. Have the students complete **Action Plans**, which can be printed from the **Educators** area or the tree house **Problem Board** area in the **Problem-Solving Tools** section of the web site for the current online investigation. Students should then conduct independent or group research by using books and Internet sites noted in the **Research Rack** section of the **Problem Board** in the **Tree House**. Educators can also search for resources by topic, episode, and media type under the **Educators** main menu option **Resources**.
5. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. The variety of activities is designed to enrich and enhance your curriculum. Activities may also be used to help students "solve" the problem along with the tree house detectives.
6. Have the students work individually, in pairs, or in small groups on the problem-based learning (PBL) activity on the NASA SCI Files™ web site. To locate the PBL activity, click on **Tree House** and then the **Problem Board**. Choose the 2003–2004 Season and click on **Spacecraft Design Lab.**

a. To begin the PBL activity, read the scenario (Here's the Situation) to the students.

b. Read and discuss the various roles involved in the investigation.

c. Print the criteria for the investigation and distribute.

d. Have students begin their investigation by using the **Research Rack** and the **Problem-Solving Tools** located on the bottom menu bar for the PBL activity. The **Research Rack** is also located in the **Tree House**.

Careers

aeronautical engineer
inventor
mechanical engineer
museum curator

7. Having students reflect in their journals what they have learned from this segment and from their own experimentation and research is one way to assess student progress. In the beginning, students may have difficulty reflecting. To help them, ask specific questions that are related to the concepts.
8. Have students complete a **Reflection Journal**, which can be found in the **Problem-Solving Tools** section of the online PBL investigation or in the **Instructional Tools** section under **Educators**.
9. The NASA SCI Files™ web site provides educators with general and specific evaluation tools for cooperative learning, scientific investigation, and the problem-solving process.

Resources (additional resources located on web site)

Books

Bender, Lionel: *Eyewitness: Invention*. DK Publishing, Inc., 2000, ISBN: 0789457687.

Brown, Don: *Alice Ramsey's Grand Adventure*. Houghton Mifflin Company, 2000, ISBN: 0618073167.

Diaz, James R.; and Carter, David A.: *Elements of Pop Up: A Pop Up Book for Aspiring Paper Engineers*. Simon and Schuster, 1999, ISBN: 0689822243.

Daimler-Chrysler: *The American Heritage of Daimler Chrysler*. DaimlerChrysler Corporation, 2002, ISBN: 090995202.

Heap, Christine: *The DK Big Book of Trains*. DK Publishing, Inc., 1998, ISBN: 0789434369.

Hewett, Joan: *Tunnels, Tracks, and Trains: Building a Subway*. Lodestar Books, 1995, ISBN: 0525674667.

Kassinger, Ruth: *Reinvent the Wheel: Make Classic Inventions, Discover Your Problem-Solving Genius, and Take the Inventors' Challenge*. Wiley, John and Sons, Inc., 2001, ISBN: 0471395390.

Kulling, Monica: *Eat My Dust! Henry Ford's First Race*. Bantam Doubleday Dell Books for Young Readers, 2004, ISBN: 0375815104.

Parker, Steven: *I Wonder Why Tunnels Are Round and Other Questions About Building*. Houghton Mifflin Company, 1995, ISBN: 1856975800.

Smith, Albert Gary; and Mason, Randy: *History of the American Automobile Coloring Book*. Dover Publications, Inc., 1990, ISBN: 0486263150.

Sullivan, Lee: *Tunnels Go Underground*. Lerner Publishing Group, 2000, ISBN: 1575054299.

Sutton, Richard: *Eyewitness: Car*. DK Publishing, 2000, ISBN: 0789458020.

Vanderwarker, Peter: *Big Dig: Reshaping an American City*. Little, Brown Children's Book, 2001, ISBN: 0316605980.

Resources (additional resources located on web site)

Video

Building Big—Tunnels. WGBH Boston Video, 2000, ASIN: B00004U2N4.

Web Sites

Walter P. Chrysler Museum
Take a virtual tour of the museum and see many of the cars created by Chrysler.
http://www.chryslerheritage.com/index.htm

Kids Design Network—Dupage Children's Museum
With Kids' Design Network, you'll investigate a challenge, dream up a design, and draw your plans on the computer; then, using the Internet, you can show your design to a real engineer, who'll help with your design so you can build it! Best of all, it's free!
http://www.dupagechildrensmuseum.org/kdn2/

The ASEE Engineering K–12 Center
On this great web site, you can find almost everything you need to learn about teaching engineering to K–12 students. The site has a wealth of great resources and links to wonderful engineering activities.
http://www.engineeringk12.org/

What You Need To Know About™—Automobile History
Visit this web site for everything from A–Z on the history of the automobile. See a time line, learn more about famous carmakers and inventors, and find out who invented the various components of a car, such as cruise control!
http://inventors.about.com/library/inventors/blcar.htm

How the English Channel Was Formed
Learn about the geology of England and France and how the English Channel was formed during the last ice age.
http://www.theotherside.co.uk/tm-heritage/background/channelform.htm

The Channel Tunnel
Learn the history of the Channel Tunnel and how it was built.
http://www.theotherside.co.uk/tmheritage/background/tunnel.htm

Eurotunnel
Home page of the company that runs high-speed car, coach, and freight shuttles linking the United Kingdom and France.
http://www3.eurotunnel.com/rcs/etun/pb_english/en_wp_home/en_pg_home_gateway_1/index.jsp

PBS—Building Big: Tunnels
This web site has all the tunnel basics. Students can learn about the tools and techniques used to build tunnels of the past and present, and they can learn more about various tunnels around the world. Read about the engineers who build tunnels and much more. Great teacher resources too, with educator guide!
http://www.pbs.org/wgbh/buildingbig/tunnel/index.html

Activities and Worksheets

Transportation on the Move

Purpose

To create a time line depicting the history of transportation

Note: Make your own paper tape by cutting and pasting together several strips of paper.

If using the Internet, try these suggested sites or conduct a web search of your own by using a search engine.

Fact Monster™ from Information Please™
http://www.factmonster.com/ipka/A0873323.html

Nationmaster
http://www.nationmaster.com/encyclopedia/Timeline-of-transportation-technology

What You Need To Know About Transportation
http://inventors.about.com/library/inventors/bl_history_of_transportation.htm

Materials

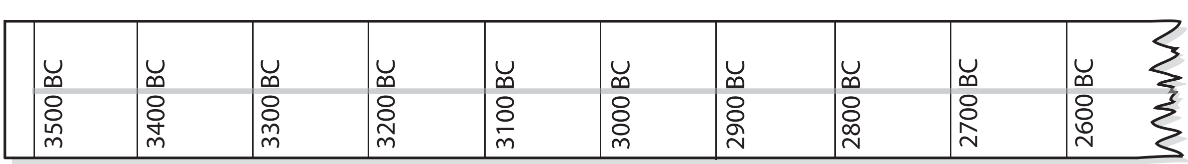
adding machine tape
pencils
markers
glue or tape
meter stick
reference books
Internet (optional)
science journal

Procedure

1. Research the history of transportation and determine the major milestones that you would like to include on your time line. Be sure to include the invention of the wheel.
2. In your science journal, list each milestone and the date in history that it occurred.
3. Draw, copy, or print small pictures for each milestone.
4. Determine the length of paper tape needed to span 6,000 years by deciding what increment will be used for each 100 years (i.e., centimeters, meters).
5. Use a meter stick to measure and cut the paper to the length you determined.
6. Divide the paper into equal 100-year sections using the increment you decided upon.
7. Use a meter stick to draw a line across the center of the paper to make one continuous line from beginning to end.
8. Write in the beginning year of each century. Mark the separation between BC and AD. Remember to count forward from the separation for AD and backward for BC.
9. Use glue or tape to attach the pictures above or below the year.
10. Display your time line in a hallway or on a wall in the classroom.

Extensions

1. Choose one invention or innovation and research its origins and history. Create a poster or report about your findings and present it to the class.
2. After watching the entire show, extend the time line 500 years into the future and add pictures of what you think future transportation inventions and innovations will look like.
3. Have each student or group of students research a 100- or 500-year time span and create a mini time line for just that segment of time. Connect all the time lines together to create a class time line that spans at least 6,000 years.



Let's Go Engineering

Engineering is fun and exciting, but did you know that most people don't have a clue what an engineer does? Almost everything in society is linked to engineering. If it weren't for engineers, we would not have cars, computers, televisions, and the many other conveniences that we take for granted each day. So just what is an engineer? An engineer is someone who is creative and thinks of new ways to solve problems by using math, science, and technology. Many people think that an engineer is a scientist, but even though they may use science, engineers are not usually scientists. Theodore Von Karman, an aerospace engineer, put it nicely when he said, "Scientists discover the world that exists; engineers create the world that never was." There are many different types of engineers, such as electrical, mechanical, civil, chemical, aerospace, biomedical, agricultural, computer, and many more. There is an engineer for almost every area that might be interesting to you!

When engineers have ideas, they usually follow a few simple steps to help them as they search for the solution. Use the checklist below to help you as you design your solution to the challenge.

- ❑ Keep a design log. Engineers keep a log to record their work and ideas.
- ❑ Use your imagination. Think wild and crazy thoughts. Remember that no idea is too silly. Everyone laughed at the Wright brothers and said that man would never fly. Good thing they didn't get discouraged!
- ❑ Plan and design your idea. Careful design is important. Now is the time to brainstorm for ideas and evaluate them.
- ❑ Research. Conduct research to verify that your design is based on sound science and math principles.
- ❑ Draw your design. Make a detailed drawing of your idea so others will understand how your design works.
- ❑ Make a model of your design.
- ❑ Test your design. Test your model to see if it works as planned.
- ❑ Evaluate your test results. Use data collected from testing to determine whether your design performs as it was meant to perform.
- ❑ Redesign. If your design did not work as planned, do more research, redesign it, and test it again. This procedure is called an iterative process.
- ❑ Patent your design. Engineers often have unique designs that others might want, so they apply for a patent from the U.S. Patent Office to protect their ideas from being claimed by others.

Designer's Log

Keeping a log is very important. It can prove that you had an idea first. It can also help you plan your design and help you explain your design to others when you are finished. Follow the suggestions below to help you keep a detailed and accurate log and become a true engineer!

- Every time you work on your design, take notes and record when and where you were when you had the thought. Also record the results of the work. Date and initial your notes.
- Describe all your ideas, plans, designs, models, tests, and results in great detail. Details are very important because they help others understand your design.
- When possible, make a drawing of your ideas and your design. Be sure to label all the parts clearly and correctly so that others will be able to understand how your design works.
- If you need to buy items to build your model, describe the materials and keep a list of the costs.
- Photos can be included in your log because they are excellent proof of your design.
- Be sure to have an adult sign your log. He/she will be a witness to prove that the idea and work are your own.

Sample Log

Name: Wilbur Wright **Date:** February 12, 1902

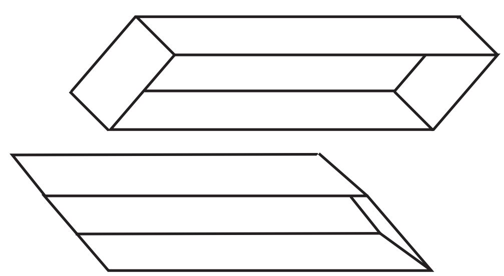
Witness: Orville Wright **Time:** 10:02 AM

Location: Wright Bicycle Shop, Dayton, OH

Details

Discussed with Orville the problem of control. After observing the bicycle tube box, an idea came to me – Wing warping.

Drawings or photos



Designer's Log

Name: ______________________ **Date:** ______________________

Witness: ______________________ **Time:** ______________________

Location: ____

Details	Drawings or photos

What a Plan!

Use this worksheet to help plan your design, but don't forget to record your plans in your designer's log!

Challenge ______________________________

Solutions

List the top 5 solutions from your brainstorming:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

Criteria

Develop a list of criteria to aid in evaluating your ideas.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

Questions

1. Ask yourself what makes a good design. ______________________________
____
2. Is my design easy to construct?______________________________
3. Do I have the materials needed for my design?______________________________
4. Does my design meet the criteria for the challenge? ______________________________

Identify the Best Solution

After evaluating each solution or design, choose the best one to solve the problem.

Verification

Write a brief summary of why this design is best and how it will meet the criteria for the challenge or problem.

____
____
____
____
____
____

A Stormy Brain

Materials

pencils
markers
large sheet of paper

Purpose

To learn how to link ideas and questions together to form a relationship

Background

Brainstorming is fun and can be helpful when trying to solve problems. It is a process of spontaneously thinking and sharing as many ideas as possible about a topic without being judgmental. Brainstorming is an important part of the problem-solving process, and there are a few suggested guidelines to follow when you brainstorm. Remember that everyone is welcome and that all ideas are valuable. Don't be critical and focus on sharing lots of ideas because the more the better. Also welcome hitchhiking or piggybacking where one idea will spark another similar idea or enhance one already given. The sky is the limit, so even outrageous and humorous ideas are accepted.

To learn more about brainstorming, visit our web site for these tools:
Brainstorming Rules
http://scifiles.larc.nasa.gov/educators/tools/pbl/brainstorming_rules.html

Brainstorming Map
http://scifiles.larc.nasa.gov/educators/tools/pbl/brainstorming_map.html

Procedure

1. Read the challenges below and, as a group, choose one to work on.
2. Brainstorm for ideas about how to solve the challenge. Be sure to record all ideas.
3. Create a brainstorm map or web of your ideas. It might help to use different colored markers for the various solutions placed in the web.
4. Discuss your web and all the possible solutions.
5. Reach a consensus for the one solution that best solves your challenge.
6. Write a short description of your solution and defend why it is the best one.
7. Present your solution to your class.

Challenges

1. You just finished your soccer game and are ready to head home when you notice that your bike has a flat tire. You look around to see if you can catch a ride with one of your friends, but they have already left. You have 50 cents in your pocket, but there aren't any pay phones close by. The dark clouds in the sky indicate an approaching thunderstorm. You need to do something quickly. What should you do?
2. When astronauts go to Mars, they will be gone for about 2 years. A lot of their food will need to be preserved. Preserved food is often high in sodium (salt), but sodium counteracts the calcium your body needs to maintain strong and healthy bones. When working in a microgravity environment, an astronaut's muscles can deteriorate (atrophy) over time. Also, in a microgravity environment, the human skeleton supports less weight and will begin to decrease in size (lose bone mass). NASA needs your help to solve this problem: What should NASA scientists and researchers recommend to overcome the problems of muscle and bone loss in a microgravity environment?

Extension

1. Conduct a survey of parents, friends, and other family members to see if they think your solution is the best answer to the challenge.

Tunneling Through

Purpose

To understand the challenges involved in constructing a tunnel

Materials

copy-paper box
large, plastic bag
soil and sand to fill box
large, shallow pan
water
metric ruler
marker
tunnel supplies

Teacher Note

Have students bring in various items for constructing their tunnels. These items might include spoons (for digging), popsicle sticks, paper tubes, tape, glue, aluminum foil, wax paper, tissue boxes, and so on.

If you have Internet access, check out PBS's web site, **Building Big: Tunnels—Tools and Techniques**, to learn more about tunnels and the tools used to build them. *http://www.pbs.org/wgbh/buildingbig/tunnel/challenge/tools/index.html*

Have the students try the activity from PBS's web site, "Meeting in the Middle," prior to digging their tunnel. With this activity, discover what it takes to align a tunnel that is being constructed from two different directions and have both sections meet in the middle. *http://www.pbs.org/wgbh/buildingbig/educator/act_middle_ho.html*

Procedure

1. Label one end of the copy-paper box "North" and one end "South."
2. Line the copy-paper box with a large, plastic bag.
3. Fill the box 3/4 full with a mixture of soil and sand.
4. Add water to the mixture until it is slightly wet. See diagram 1.
5. Scoop out some of the soil mixture and place the shallow pan in the soil. Arrange soil mixture so that it meets the edges of the pan. Fill the pan with water, forming a small "lake." See diagram 2.
6. Let the box sit overnight to dry and harden the soil mixture.
7. To begin your tunnel, you will need two crews. One crew will begin to dig from the North end and the other will dig from the South end.
8. Hold a planning meeting with both crews and determine the construction constraints of your tunnel.
9. Identify the diameter and depth of the tunnel and anything else that might be important.

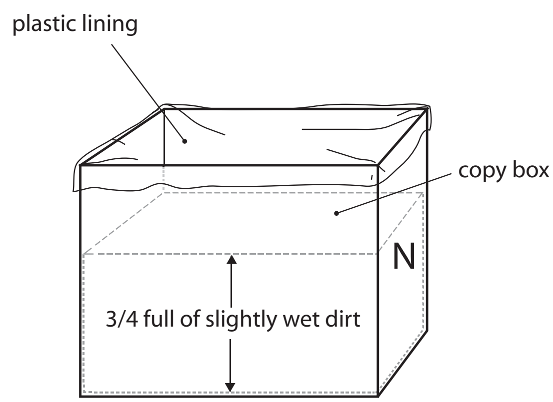


Diagram 1

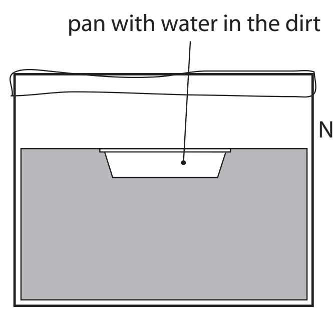


Diagram 2

Tunneling Through

10. The tunnel must be at least 15 cm below the lake bed.
11. Remember that both tunnels must meet in the middle at exactly the same spot. Discuss and brainstorm for ideas on how you will successfully build each tunnel so that they will line up properly and fit together exactly when the two tunnel halves meet in the middle.
12. Draw a design plan of your tunnel.

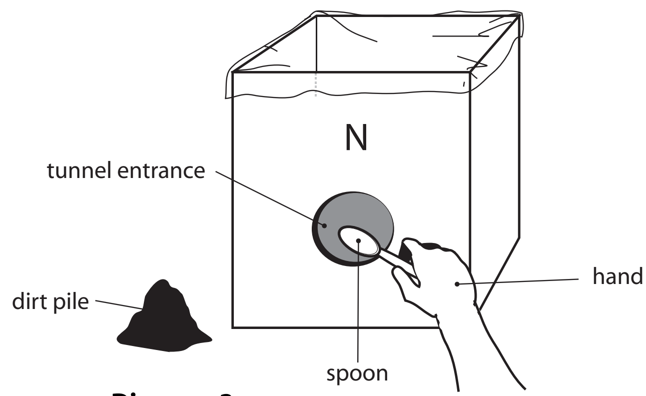


Diagram 3

13. When you're ready, begin construction on your tunnel and continue until one continuous tunnel is formed. See diagram 3.
14. If it's available, add train track and send a train through your tunnel for its inaugural tunnel crossing.

Conclusions

1. What difficulties did you encounter as you dug your tunnel from opposite ends of the lake?
2. What would you do differently next time?
3. What are some benefits of digging two separate tunnels?
4. Which crew dug the longest distance and why?

Extensions

1. For a math lesson on budgeting, give each team a budget for building a tunnel and a set of specific equipment for the project, attaching a cost to each item (i.e., spoon: $50,000; paper tube: $500,000). If they break the equipment or need additional supplies, the team is charged accordingly. Set a project deadline and charge by the minute or hour if they don't meet the deadline. The teams must keep track of their budget and expenses to show a profit or a loss. The team that comes in closest to budget wins.
2. Build two tunnels, one for northbound traffic and one for southbound traffic. Justify the need for two tunnels and the benefits gained.
3. Add pebbles, large rocks, and other items to the soil mixture to create obstacles for the team to overcome while digging the tunnel

Answer Key

Tunneling Through

1. Answers will vary, but might include that it was difficult to keep the tunnel level, going straight, and many other obstacles that could have occurred.
2. Answers will vary.
3. Answers will vary, but some benefits are that two separate tunnels would allow traffic to go in only one direction in each tunnel, which might help stem accidents. Two tunnels would also be beneficial because if a disaster occurred in one tunnel, the other tunnel could be used. Also, in case of an emergency evacuation for such things as hurricanes, both tunnels could be opened for traffic to go in the same direction.
4. Answers will vary.

Segment 2

As Bianca and Kali wait outside the auditorium for Dr. D and the other tree house detectives, they receive Tony's report. He has just finished his visit with Janet Goings at General Motors (GM) in Detroit, Michigan where she explained the importance of research. Ms. Goings also showed Tony some cool concept cars and explained the new fascinating technology of the fuel cell. Back in the van, the tree house detectives are beginning to worry that they won't make the awards ceremony. It looks as if there is no end to the traffic jam. To make good use of their downtime, Dr. D describes his research and model building experiences when he worked on his hovercraft. The detectives decide to email R.J. to ask him to talk to Sam James and check out the model shop at NASA Langley Research Center in Hampton, Virginia. Realizing that the next step is to test the model, the detectives join a videoconference hosted by Mike Logan with students from Cooper Elementary Magnet School in Hampton, Virginia and King's Cross Education Action Zone in London, England. The students are involved in a mousetrap car competition, and they have just finished the testing phase of the engineering design process.

Objectives

Students will

- conduct research to make informed decisions.
- understand how a fuel cell works.
- build models to scale.
- conduct tests by using models to collect data for analysis.
- learn about the blended wing body design.
- participate in a mousetrap car competition.

Vocabulary

concept car—a prototype of a car designed for the future

fuel cell—a device that continuously changes the chemical energy of a fuel (such as hydrogen) into electrical energy

model—a small object built to scale that represents, in detail, another often larger object; a small exact copy of something

mousetrap—a trap for catching mice

prototype—first full-size functional model to be manufactured

research—careful study and investigation for the purpose of discovering and explaining new knowledge

scale—a ratio representing the size of a picture, plan, or model of something compared to the size of the real thing

test—a trial run-through of a process or equipment to find out if it works

videoconference—a meeting in which participants are in different places, connected by audio and video links

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of the Radical Ride*, discuss the previous segment to review the problem and reaffirm what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 1.
5. Read the Overview for Segment 2 and have students add to their lists any questions that will help them better understand the problem.
6. Focus Questions—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.
7. "What's Up?" Questions—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed from the web site ahead of time for students to copy into their science journals.

View Segment 2 on the Video

For optimal educational benefit, view *The Case of the Radical Ride* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about transportation, the engineering design process, identifying a problem, and finding a solution to the problem.
4. Organize the information and determine whether any of the students' questions from the previous segments were answered.
5. Decide what additional information is needed for the tree house detectives to better understand engineering design and the future of transportation. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
6. Choose activities from the **Educator Guide** and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
7. For related activities from previous programs, download the **Educator Guide** for *The Case of the "Wright" Invention*, select **Educators**, and click on **Activities/Worksheets** in the menu bar at the top. Scroll down to the 2002–2003 Season and click on *The Case of the "Wright" Invention*.

a. In the **Educator Guide** you will find

a. **Segment 1**—*Let's Go Inventing, Inventor's Log, Imagination Station, Bugging Out the Bugs, The Wright Brothers*

b. **Segment 2**—*Who Invented That?; Brain Brewing Storms; What a Plan!; Criteria; Research, Research, and More Research*

c. **Segment 3**—*Dazzling Doggie Designs, The Iterative Process, Spaghetti Anyone?, Model Making*

d. **Segment 4**—*3, 2, 1…Crash! Testing a Model, Trademarks, Copy Cat or Copyright?, Naming Your Invention*

b. On the web site in the **Activities/Worksheet** section, you will find

a. *Creations of the Imagination*

b. *Is It a Thingamajig or Thingamabob?*

c. *Would You Buy This Invention?*

d. *Testing the "Wright" Weather*

e. *Testing 1, 2, 3*

8. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under **After Viewing** on page 15 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

- **Research Rack**—books, Internet sites, and research tools
- **Problem-Solving Tools**—tools and strategies to help guide the problem-solving process
- **Dr. D's Lab**—interactive activities and simulations
- **Media Zone**—interviews with experts from this segment
- **Expert's Corner**—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

Careers

auto design engineer
mechanic
model maker
test pilot

9. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the **PBL Facilitator Prompting Questions** instructional tool found by selecting **Educators** on the web site.

10. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. For more assessment ideas and tools, go to **Educators** and click on **Instructional Tools** in the menu bar.

Resources (additional resources located on web site)

Books

Balmer, Alden J.: *Doc Fizzix's Mousetrap Powered Cars and Boats*. Doc Fizzix Publishing Company, 2002, ISBN: 0965667413.

Coughlan, John: *Experimental and Concept Cars*. Capstone Press, 1994, ISBN: 1560652101.

Levy, Matthys and Panchyk, Richard: *Engineering the City*. Chicago Review Press, Inc., 2000, ISBN: 1556524196.

Rees, Chris: *Concept Cars: An A–Z Guide to the World's Most Fabulous Futuristic Cars*. Barnes and Noble Books, 2000, ISBN: 0760721688.

Sutherland, Martha: *Model Making: A Basic Guide*. W. W. Norton and Company, 1999, ISBN: 0393730425.

Taylor, Thom; Berghoff, Kathy; and Hallett, Lisa: *How To Draw Cars Like a Pro*. Motorbooks, 1996, ISBN: 0760300100.

Resources (additional resources located on web site)

Web Sites

StatPac, Inc.—Designing Surveys and Questions
A great resource for educators and other adults to learn how to design surveys and questions.
http://www.statpac.com/surveys/

NASA Langley Research Center—Blended Wing Body
Visit this site to learn all about one of the newest concepts in flight—the blended wing body (BWB). The BWB is a hybrid shape that resembles a flying wing, but it also incorporates features from conventional transport aircraft. This new shape helps increase fuel economy and creates a larger payload (cargo or passenger) area.
http://oea.larc.nasa.gov/PAIS/FS-2003-11-81-LaRC.html

National Academy of Engineering—Engineer Girl!
A web site devoted to inspiring young girls to become engineers.
http://www.engineergirl.org/nae/cwe/egmain.nsf/?OpenDatabase

PBS Kids Cyberchase—Jigsaw Puzzle Size-Up
Sure, you're great at solving jigsaw puzzles, but here are some puzzles with a twist. Some of the pieces have been changed to different sizes, and you have to get them back again. When you finish, visit "Games Central" for lots of other exciting and fun games!
http://pbskids.org/cyberchase/games/sizeandscale/sizeandscale.html

Ratio and Scaled Figures
Visit this site for an easy to understand explanation of ratio and scale for teachers and upper elementary students.
http://richardbowles.tripod.com/maths/ratio/ratio.htm

Young Inventors' Awards Program
Craftsman and the National Science Teachers Association (NSTA) challenge students in grades 2–8 to use creativity and imagination, along with science, technology, and mechanical ability, to invent or modify a tool. Awards include $250 to $10,000 in Series EE savings bonds for students and various merchandise rewards for teachers. Every student who enters receives a craftsman tool. Deadline for entry is mid-March of each year.
http://www.nsta.org/programs/craftsman.asp

How Stuff Works: Fuel Cells
Great explanation of how a fuel cell works, problems with a fuel cell, and much more.
http://science.howstuffworks.com/fuel-cell.htm

U.S. Department of Energy—Hydrogen and Fuel Cells
This web site is a great resource for learning more about hydrogen, fuel cells, future technology, and how it will all benefit society. The U.S. Department of Energy also offers a FREE CD that contains a 104-page middle school activity guide. Just call 1-877-337-3463 to request a copy.
http://www.eere.energy.gov/hydrogenandfuelcells/

The Online Fuel Cell Information Center
This web site is a great online resource for educators. Learn how a fuel cell works, types of fuels cells, applications and benefits of fuel cells, and much more. This comprehensive web site also offers photos, diagrams, books, and other reference sources.
http://www.fuelcells.org

Doc Fizzix—Mousetrap Powered Vehicles and More
This site is a great resource for mousetrap car kits, construction tips, mouse physics demonstrations, and more.
http://www.mousetrap-cars.com/mousetrap/doc_fizzix_site.htm

Discover Engineering
As you dig into this site, you will discover a wealth of information on engineering and careers. There are also games and some really "cool stuff."
http://www.discoverengineering.org/home.asp

Lemelson-MIT Program—Inventor of the Week
Each week learn about an inventor and the invention(s) that made him or her famous.
http://web.mit.edu/invent/i-main.html

The University of Sydney—Model Making and Paper Craft
This site contains dozens of links to great models that can be made from paper and paper products.
http://science.uniserve.edu.au/school/k_6/model_paper.html

Activities and Worksheets

Fueling With H_2O

Purpose

To demonstrate how a fuel cell works by splitting water into hydrogen and oxygen.

Materials

6-volt battery
tap water
aluminum foil
2 wire test leads *(insulated copper wire)*
4 double-ended alligator clips
salt
large, clear glass or plastic tub
scissors
science journal

Background

Fuel cells use hydrogen and oxygen to create electricity, with only water and heat as by-products. Hydrogen is abundant, clean, and efficient, and it is available from many different resources such as natural gas and water. Hydrogen fuel cell technology offers the promise of a world in which energy is abundant, clean, reliable, and affordable.

A molecule of water has two atoms of hydrogen and one atom of oxygen. You can split a water molecule into its hydrogen and oxygen parts by passing an electrical current through the water between two electrodes (a negative cathode and positive anode). An electrode is a conductor (metal or carbon) used to make electrical contact with a part of an electrical circuit that is not metallic.

Procedure

1. To make the electrodes, cut two pieces of aluminum foil 6 cm x 10 cm.
2. Fold each piece lengthwise (accordion style) so that each pleat is approximately 1 cm wide. Be sure to firmly press the foil together as if making a small paper fan.
3. Attach an alligator clip to each end of both lead wires.
4. Fill the clear container 3/4 full of tap water.
5. Attach one of the alligator clips from each wire to the battery.
6. Attach the other end of the wire with the alligator clip to one short end of each electrode. See diagram 1.
7. In your science journal, predict what will happen when you place both electrodes in the water.
8. Place the electrodes in the water at opposite ends from each other. Do not let the electrodes touch. Secure them in place either by bending the aluminum foil over the sides of the container or by using additional alligator clips. Label or identify each electrode as either "+" or "–" according to which battery terminal it is connected. See diagram 2.
9. Observe and record your observations.
10. In your science journal, write your prediction as to what will happen when you add salt to the water. Note: Salt is a catalyst, a substance that changes the rate of a chemical reaction but is not changed itself.
11. Add salt until the water becomes cloudy.
12. Observe the water and the electrodes for a short period of time (3–5 minutes) and record your observations. Note any differences in the water near each electrode.

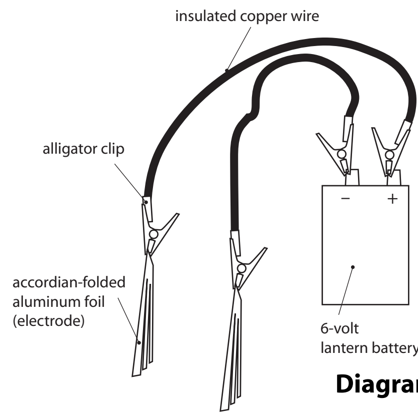


Diagram 1

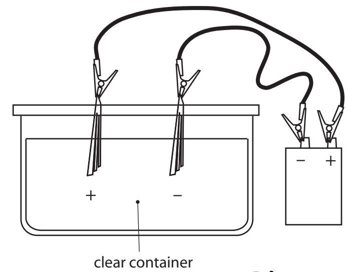


Diagram 2

Fueling With H_2O (concluded)

Conclusion

1. The electrodes in the water produced two different gases. What are they?
2. How did you know that gases were being produced?
3. Which gas did the positive electrode produce? How do you know?
4. What gas did the negative electrode produce? How do you know?
5. Why did you add salt to the water? Hint: Think about when electricity can flow through a circuit.
6. Discuss and describe ways that fuel cell technology might improve our lifestyles.

Extension

1. Collect the gases that are created by the electrodes. To collect the gases, submerge two test tubes in the water so that each is completely filled. Turn each test tube upside down. Lift the tubes slightly out of the water, making sure to keep them upside down so that no air leaks into the tube. Insert an electrode into each tube and wait for them to fill with gas. One will fill more quickly than the other. Explain why. See diagram 3.
2. Test for hydrogen by having an adult light a candle and carefully set it beside the water container. Pull the tube filled with hydrogen out of the water, keep it upside down, and hold it over the candle. See diagram 5. This procedure must be done quickly because the hydrogen will escape very fast once it is out of the water. Listen for a "puff." Move the tube away from the candle for a few seconds and repeat. This time you shouldn't hear anything. **CAUTION**: Do not try this with the oxygen.

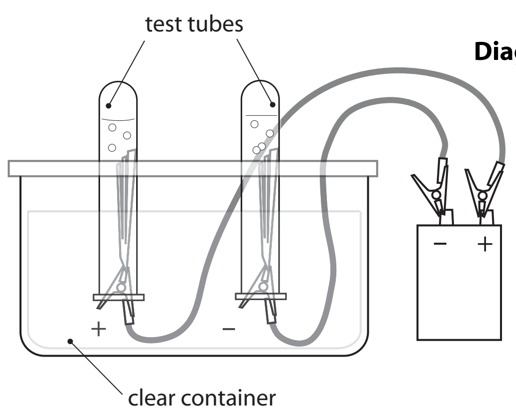


Diagram 3

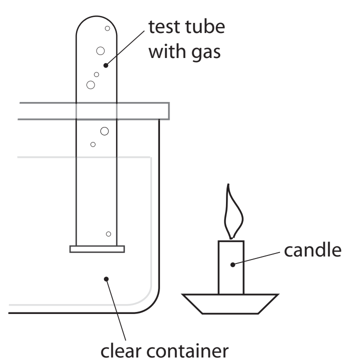


Diagram 4

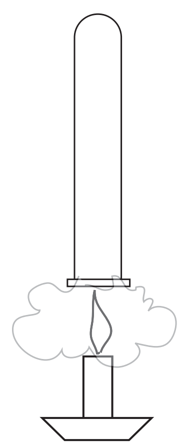


Diagram 5

Model Making

It is time to make a model of your design! Use the suggested list of ideas to help you make your model.

Before making a model, research model making. Visit the library for books on model making or conduct an Internet search.

Think about the materials that you will need to make the model. What supplies will you need? How much will they cost? Be imaginative and creative in making your model. List the supplies needed below:

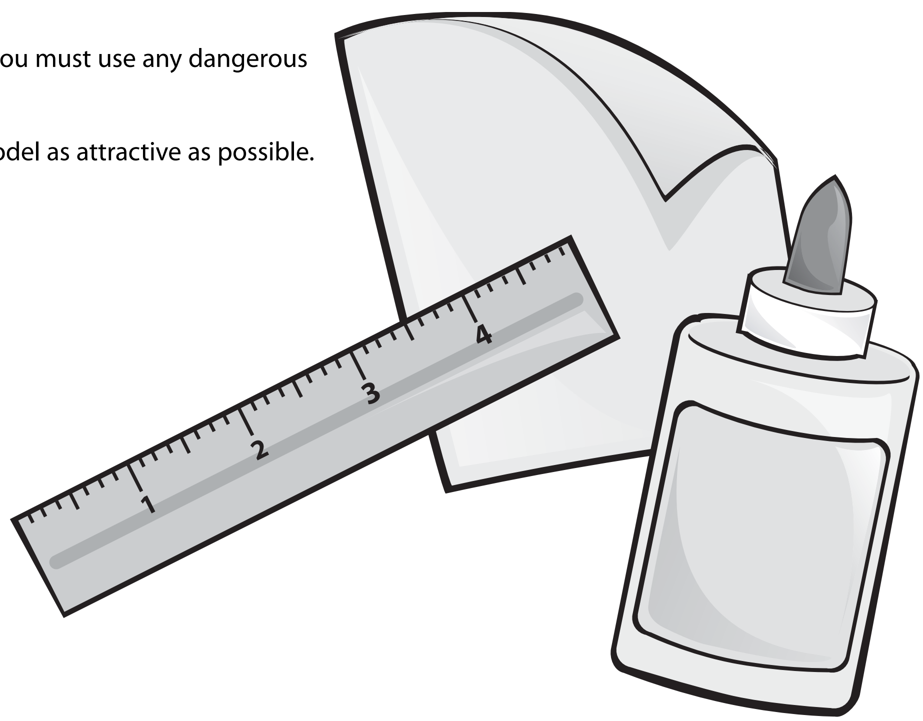
1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________
11. ______________________
12. ______________________
13. ______________________
14. ______________________

Look at your design carefully and in your Designer's Log, write in detail the steps that you will follow to build your model. Writing out the steps will help you work out problems before you start the actual building process. This step will help save you time and money as it may prevent you from having to throw out the model and start over!

Solicit help from an adult if you must use any dangerous items.

Try to make your finished model as attractive as possible.

Good luck!



Modeling With Scale

Problem

To understand how to use scale to create a model

Materials

ruler
MatchBox® cars
modeling clay
science journal

Teachers Note

MatchBox® cars are usually on a scale of 1:64. Check the package of each car for more details to verify the scale. Have the students use either a standard or metric ruler to measure the cars, depending on the model of car. Most American cars are not built using metrics.

Background

A model is usually a smaller copy of an object such as a car or an airplane that helps us look at objects that are too large or too small to be built in actual size. When making a model, scientists use scale or ratio. A ratio is a comparison of two or more measurements. The scale gives the ratio of the model measurements to the measurements of the actual object. For example, if you had a model car that was built using the ratio 1:2 (1 to 2), the model would be one-half the size of the original car. The model looks like the actual object, only smaller. A ratio is a fraction used to compare the size of two numbers to each other. Scale models are useful in many fields, including architecture, automobile design, and airplane engineering. Many people have made a hobby of building or collecting models of a variety of objects such as cars, airplanes, ships, lighthouses, and dollhouses. Some toys are actually scale models of real or imagined objects.

Procedure

1. Use a ruler to measure the length, width, and height of your model car.
2. Use a scale of 1:64 to determine the length, width, and height of the actual car. Remember that the scale means that for every unit of the model, the real car would be 64 times that amount.
3. Calculate the dimensions in feet and inches and record them in your science journal.
4. Use the actual dimensions of a real car to create a model by first deciding upon a scale such as 40:1. Note: The larger number is now first because you decreased the size of the actual car to a smaller size. Divide the actual measurements by the number used in the scale (40).
5. Record your measurements in your science journal.
6. Use the scaled dimensions to create a clay model of the car.

Conclusion

1. Why did you multiply when increasing the size of the model to the actual size?
2. Why did you divide when decreasing the size of the actual car to a model?
3. When creating the clay model, did you need to take additional measurements other than length, width, and height?
4. List other ways that models are used.

Extension

1. Create a scale model of a model. Use the dimensions of a Matchbox® car to make a model that is larger, but not full-size.

The Blended Wing Body (BWB)

Purpose

To demonstrate the great opportunity there is for aeronautics innovation

Materials

8.5- x 11-inch paper

Teacher Note

You can find this activity on a NASA bookmark that can be printed from
http://spacelink.nasa.gov/products/Blended.Wing.Body.Bookmark/

Background

NASA's Aerospace Research and Technology Base program is developing technologies for a new type of aircraft that will be more economical and efficient than today's airliners. This revolutionary flying wing configuration, called the BWB, has a thick, airfoil-shaped fuselage section that combines the engines, wings, and body into a single lifting surface. The BWB can carry as many as 800 passengers over 7,000 miles at an approximate cruise speed of 560 mph. Compared to today's airliners, it would reduce fuel consumption, harmful emissions, operating cost, and noise levels. NASA is developing high-payoff technologies for a new generation of safe, environmentally compatible, and highly productive aircraft. Airplanes of the future may look very different from those of today. In the activity below, be an engineer and experiment with a possible new wing type.

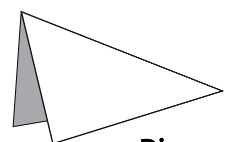


Diagram 1

Procedure

1. Fold a piece of 8.5- x 11-inch paper diagonally as shown in diagram 1.
2. Make a 1/2-inch fold along the previously folded edge. See diagram 2.
3. Make a second 1/2-inch fold. See diagram 3.
4. Curl the ends of the paper to make a ring and tuck one end into the fold of the other. See diagram 4.
5. Gently grasp the "V" between the two "crown points" with your thumb and index finger.
6. Toss the glider lightly forward. Note: The folds in the paper make the airplane's front end heavy and the back end light. Curling the ends to make a ring changes the shape of the wing and improves the wing's flight performance.

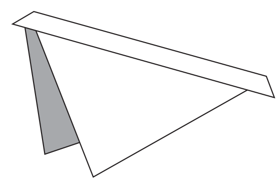


Diagram 2

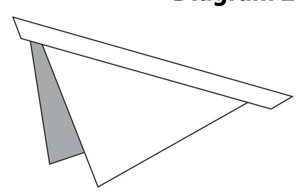


Diagram 3

Conclusion

1. How did the flight characteristics change with each ring change?

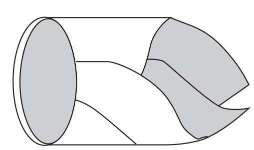


Diagram 4

Extension

1. Conduct trial tests to find the average distance your wing glider can fly.
2. Hold competitions between gliders.
3. Make modifications to the glider and conduct trial tests to compete against other modified gliders.

Mousetrap Car

Problem

To design and engineer a car solely powered by one standard-sized mousetrap that will travel the greatest distance

Materials

Design Log (p. 22)
1 standard mousetrap
string
rubber bands
material for axles (dowel rods, skewers, straws)
wheels (lids, compact disks, butter tub lids)
glue
low temperature glue gun (optional)
scissors
graph paper
meter stick
masking tape
other**

Teachers Note

- Before starting the design challenge, students should have a good understanding of simple machines, force and motion, and the design process. To learn more about these topics, check out *The Case of the Powerful Pulleys* and *The Case of the Wright Invention* on the NASA SCI Files™ web site **http://scifiles.larc.nasa.gov** Students can also conduct a web search to research other mousetrap car designs.

- Rubrics for assessment can be found on the NASA SCI Files™ web site in the **Educators** area by clicking on **Tools** in the menu bar and then choosing **Instructional Tools**.

- Check out NASA LIVE™ **http://live.larc.nasa.gov** to learn more about FREE videoconferencing programs that connect your students with NASA engineers, scientists, and specialists.

The time required varies, depending on how much of the project is assigned for homework. If done completely in class, it should take about six 45-minute class periods.

** *To be determined by teacher and/or student. Various objects such as foam material meat trays, Legos®, modified toy cars, balsa wood, washers, and other objects can be brought from home and used to build a mousetrap car. Be creative! To make the competition fair, provide multiple items in a pool of resources from which students can choose.*

Design Rules

1. All teams must use the same type of mousetrap.
2. Only the team members can construct the mousetrap car. (No help from parents or other adults!)
3. The mousetrap must be the sole source of propulsion, and it must move forward with the vehicle.
4. The cars must have a minimum of three wheels that remain on the ground at all times.
5. A mousetrap's spring may be removed only to adjust the length of the lever arm.
6. Vehicles must be self-starting and steer themselves.

Procedure

1. In your group, discuss the design challenge and brainstorm for various mousetrap car design ideas. List your ideas in the Design Log.
2. Reach a consensus about which design is the best.
3. Draw a diagram of the chosen design and be sure to label all parts.
4. Discuss the design and conduct research to answer any design questions.
5. Make a list of materials and collect the ones necessary for your design.
6. Work as a group to construct your vehicle.
7. Test your vehicle and make any necessary design changes.
8. Repeat step 7 until your vehicle is ready for its first race.

Mousetrap Car (concluded)

Test Track

1. In a large, open, flat area set up the test track by placing a 2-m strip of masking tape lengthwise along the floor to mark the "start" line.
2. Place a 20-m strip of masking tape perpendicular to one corner of the start line. See diagram 1.
3. Using a marker and a meter stick, mark the meters along the edge of the masking tape, starting with "0" at the start line and continuing to 20 m.
4. When measuring the distance the car traveled, use a meter stick to determine the final measurement in centimeters (cm).

Competition

1. Place the front end of the vehicle at the edge of the start line.
2. Engage and release your vehicle so it can propel itself down the track.
3. Use a meter stick or other straight, flat object to line up the front end of the vehicle to the masking tape measure. See diagram 2.
4. Measure and record the distance the vehicle traveled.
5. Repeat steps 1–5 for two more trials.
6. Find the average distance the vehicle traveled and enter it on the class chart.
7. The winner will be the vehicle that traveled the farthest.
8. The teacher or facilitator will determine other rules and criteria.

Conclusion

1. Were there any special features designed into your car that gave it a competitive edge?
2. Identify at least five physical principles that affect the operation of your car.
3. Describe how your design choices either maximized or minimized its effects.
4. Identify any particularly difficult steps in construction. What would you do differently next time?

Extension

1. Test the vehicles for speed and determine which is the fastest mousetrap car.
2. Identify science and math concepts used in the design process and explain how they helped you build the car.
3. Give awards for the most creative design, the lightest design, and so on.

Diagram 1

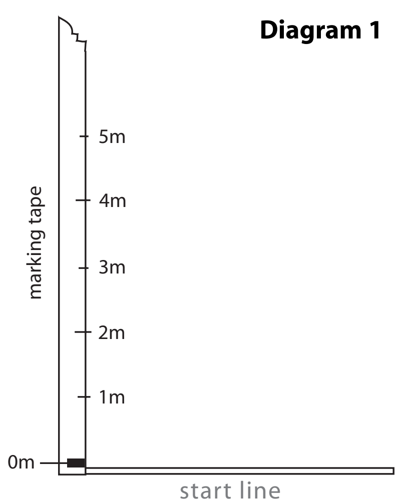
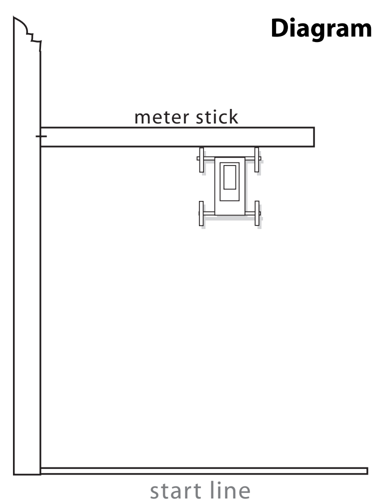


Diagram 2



Testing, 1, 2, 3…

Purpose

To test various models of airplanes and analyze the test data

This activity has been adapted from the Educational Brief for *X-Gliders: Exploring Flight Research With Experimental Gliders*. To download a complete copy with additional background information, please visit *http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/X.Gliders/.index.html*

Materials

- foam meat trays 28 cm x 23 cm
- X-glider templates (pages 44-45)
- tape
- paper clips
- binder clips
- pen
- scissors
- meter stick(s)
- masking tape
- marker
- toothpicks
- sandpaper or emery board

Teacher Note

Cut plastic foam meat trays with scissors, a razor knife, or a serrated plastic knife. Let younger students cut the parts out by using a sharp pencil or a round toothpick to punch a series of holes approximately 2 mm apart around the outside edge of the airplane part. The part can then be pushed out from the tray.

There are 12 different wing and stabilizer combinations. Each group should choose 4 combinations to test. For better test results, have multiple groups test the same combinations.

Procedure

1. Tape the glider template to the foam meat tray.
2. Cut or punch along the solid lines of each airplane part on the template.
3. Use sandpaper or an emery board to smooth out any rough edges.
4. On the fuselage, carefully cut the slot as shown on the template.
5. Choose a wing and stabilizer design and insert them into the fuselage. See diagram 1.
6. A designer must properly balance an airplane's weight for it to fly safely. Determine the proper weight and balance for your model airplane by attaching a paper clip or binder clip to the fuselage as shown in diagram 2.
7. Vary the position of the clip until the glider flies the greatest distance in a straight line. Additional clips may be needed.
8. In a large, open area (preferably inside), set up a test track by placing a strip of masking tape on the floor to create a "start" line from which to launch the planes.
9. Run another piece of masking tape perpendicular to one end of the start line.

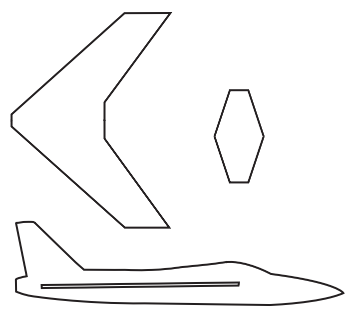


Diagram 1

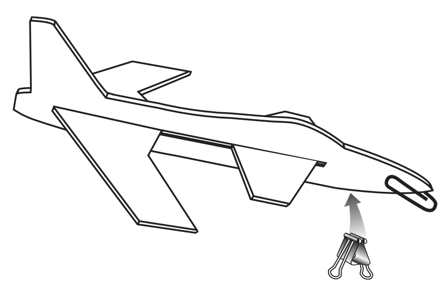


Diagram 2

Testing, 1, 2, 3…

10. Using a meter stick and a marker, place marks on the masking tape every meter for about 10 m. See diagram 3.
11. Conduct at least 3 test trials for 4 different wing and stabilizer combinations.
12. Record the test results for each in the Data Chart. Be sure to include number and placement of clips used for each trial.
13. Find the average distance that each combination flew.
14. After all test trials of all combinations have been completed, analyze your data to determine which combination flew the greatest distance.
15. Compare your results with other teams.
16. Discuss all results and determine which wing and stabilizer combination flew the best overall for the class.

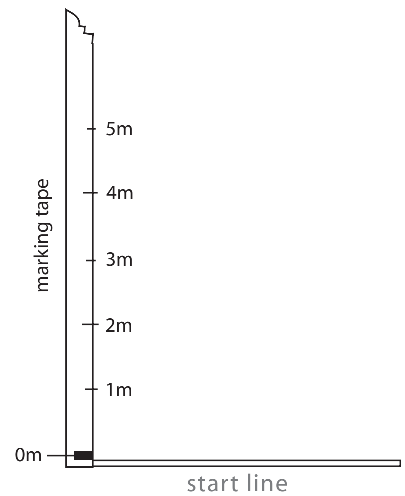
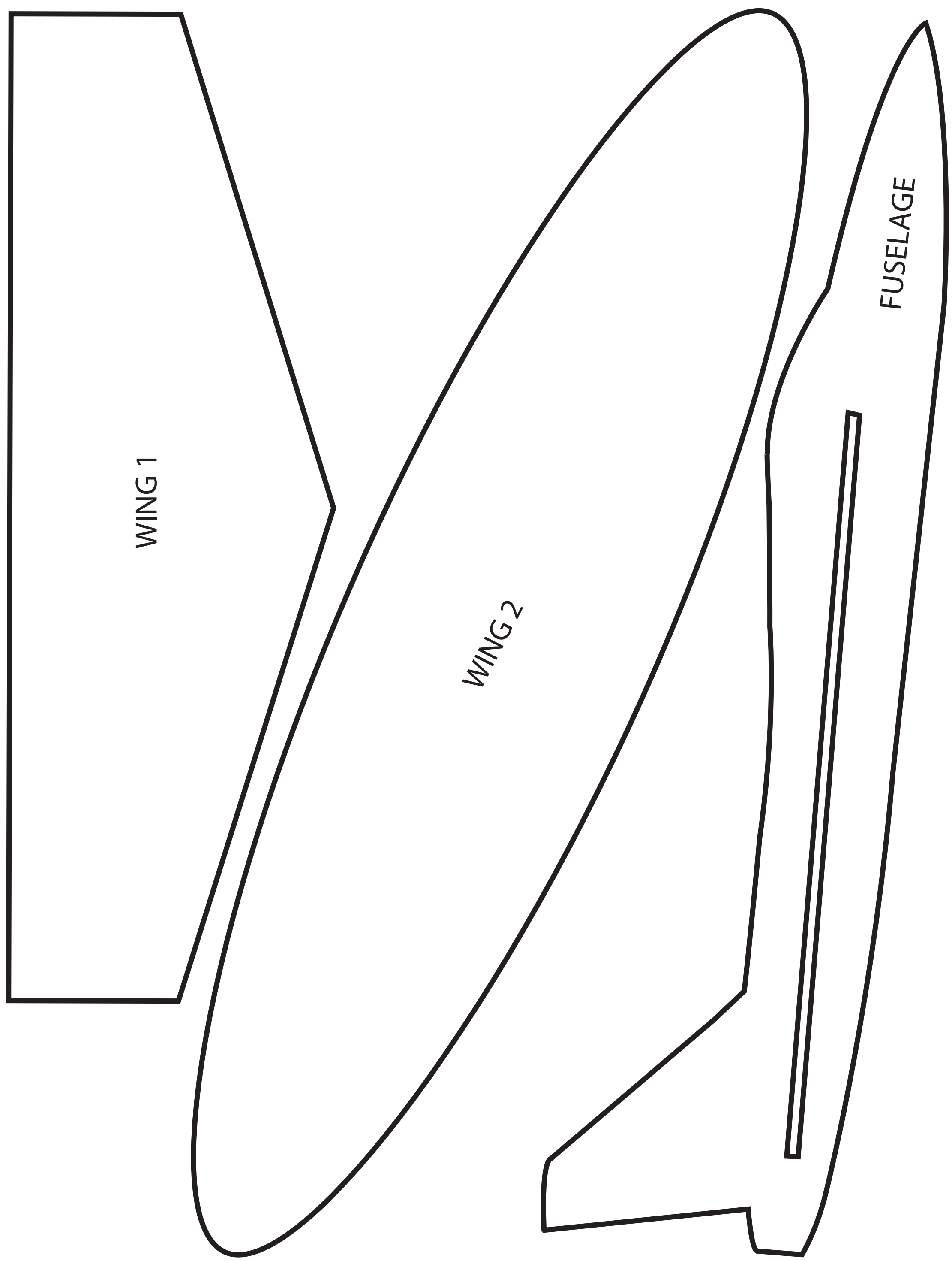


Diagram 3

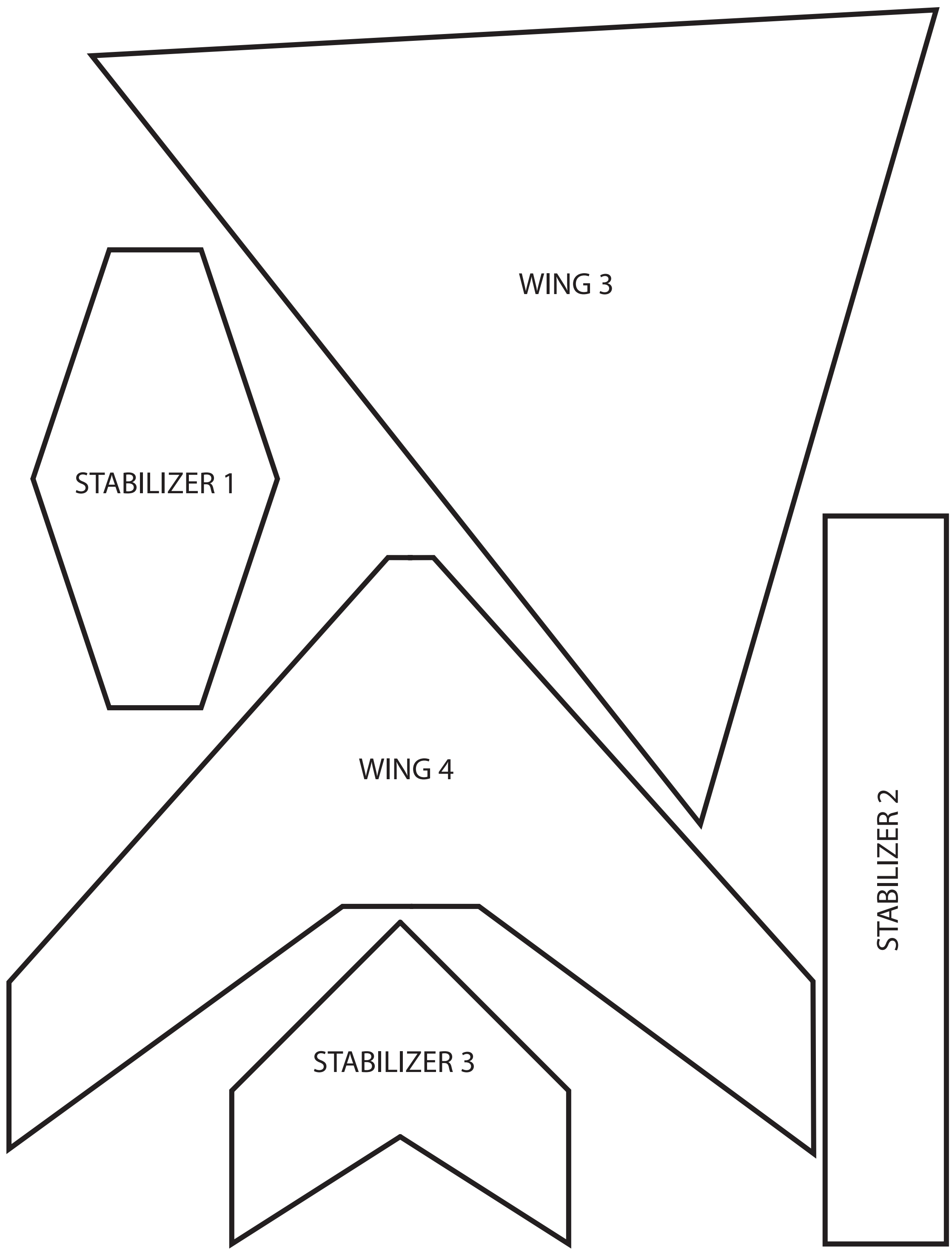
DATA CHART

Combination	Number of Clips	Trial 1	Trial 2	Trial 3	Average Distance flown
EXAMPLE: Wing 1 and Stabilzer 1	2 paper clips on nose and 1 binder clip 2 cm from nose	2 m	2.3 m	2.5 m	2.3 m

Testing, 1, 2, 3... X-Glider Templates



Testing, 1, 2, 3… X-Glider Templates



Answer Key

Fueling With H_2O

1. Hydrogen and oxygen.
2. Bubbles were created when the gases formed.
3. Oxygen. It was the smaller amount of gas produced. The chemical formula for water is H_2O, which means there are 2 hydrogen atoms for every oxygen atom. Atoms are about the same size and take up the same amount of space. Therefore, the electrode producing the least amount of gas has to be producing oxygen.
4. Hydrogen. It was the greatest amount of gas produced. See answer to question 3.
5. An electrical current can only flow when a circuit is closed. Tap water does not readily conduct an electric current. Dissolving salt in the water increases conductivity. The sodium and chloride atoms (ions) in salt make the water more conductive.
6. Answers will vary but might include that the consumption and burning of fossil fuels such as oil might be reduced, which will have an impact on our oil dependency and possibly reduce any global warming. Air pollutants will also be reduced.

Modeling With Scale

1. You had to multiply because the scale model is smaller than the actual size. Therefore, you had to increase the measurement of the model by the scale. To do that you have to multiply.
2. When you are decreasing from actual size to a model, you have to divide the measurements by the scale to get the size of the model.
3. Answers will vary, but depending on the type of model being created, it may have been necessary to take additional measurements to accurately make the model.
4. Answers will vary but might include toys, designing houses, showcase of new playground, dollhouse, model home, and so on.

Blended Wing Body

1. Answers will vary.

Mousetrap Car

1–4. Answers will vary.

The NASA SCI Files™
The Case of the
Radical Ride

Segment 3

The tree house detectives and Dr. D are STILL stuck in traffic. Things are looking grim, and they might miss the awards ceremony after all. To stay focused on the positive side of being stuck, the detectives continue to work on their project from the van. While waiting, Dr. D explains the importance of redesign, the next step in the engineering design process, by explaining how he redesigned his personal hovercraft. In the meantime, R.J. visits Jeff Robinson at NASA Langley Research Center to learn more about the redesign process involving the Hyper X project, and Bianca and Kali continue to wait patiently outside the auditorium. Bianca begins to think that they need to learn more about future transportation, and she decides to dial-up the NASA SCI Files™ Kids' Club members at Golightly Educational Center in Detroit, Michigan. After reading Wendy's and Rosie's report from the Channel Tunnel about a possible transatlantic tunnel, the students decide to conduct magnetic experiments with their mentors from the Society of Women Engineers (SWE) to learn more about how a maglev train operates. Wishing they had their own maglev train, the detectives and Dr. D continue to move at a snail's pace while Bianca and Kali determine that more research is needed.

Objectives

The students will

- build a model hovercraft and conduct tests for optimal size and placement of air holes.
- understand the importance of the iterative (redesign) process in engineering.
- learn how a fault tree is used in the engineering design process.
- conduct an experiment to understand magnetic force.
- understand how improved travel impacts society and the world.
- create a maglev train to understand magnetic force.

Vocabulary

fault tree—a graphical representation of the chain of events in the engineering design process that is used by engineers to analyze their designs from a top-down approach to avoid problems or find solutions

Hyper-X Program—a series of small, experimental research aircraft designed to test a new propulsion system called a scramjet.

maglev—an electrically operated high-speed train that glides above a track by means of a magnetic field (magnetic levitation)

magnetic field—a region of magnetic forces around a magnet

magnetism—a force of attraction or repulsion caused by an arrangement of moving electrons producing a magnetic field

scramjet—a new type of propulsion system that uses the speed of the aircraft to compress incoming air to mix and burn it much like in a car engine. The burned fuel-air mix then expands out the back of the engine and propels the vehicle forward.

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 3 of *The Case of the Radical Ride*, discuss the previous segment to review the problem and assess what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on **Tools**. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use this section of the web site to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 2 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during previous segments. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 2.
5. Read the overview for Segment 3 and have students add any questions to their list that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the **Educators** area of the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program so they will be able to answer the questions. An icon will appear when the answer is near.

7. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed from the **Educators** area of the web site ahead of time for students to copy into their science journals.

View Segment 3 of the Video

For optimal educational benefit, view *The Case of the Radical Ride* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about transportation, the engineering design process, identifying a problem, finding a solution to the problem, making a model, testing the model, and analyzing the test data. Organize the information, place it on the Problem Board, and determine whether any of the students' questions from the previous segments were answered.
4. Decide what additional information is needed for the tree house detectives to better understand engineering design and the future of transportation. Have students conduct independent research or provide them with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
5. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
6. If time did not permit you to begin the web activity at the conclusion of Segments 1 or 2, refer to number 6 under After Viewing on page 15 and begin the PBL activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, PBL activity:

   Research Rack—books, Internet sites, and research tools

   Problem-Solving Tools—tools and strategies to help guide the problem-solving process.

   Dr. D's Lab—interactive activities and simulations

   Media Zone—interviews with experts from this segment

   Expert's Corner—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

7. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the **PBL Facilitator Prompting Questions** instructional tool found by selecting **Educators** on the web site.
8. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the **Research Rack** in the **Tree House** and find the online PBL investigation main menu section, **Problem-Solving Tools**, and the **Tools** section of the **Educators** area for more assessment ideas and tools.

Careers

aerospace engineer
materials engineer
computer engineer
wind tunnel technician
physicist

Resources (additional resources located on web site)

Books

Haslam, Andrew (Designer) and Glover, David: *Building (Make it Work! Science Series: The Hands-On Approach to Science)*. Two-Can Publishing, LLC, 2000.
ISBN: 1587283514.

Haslam, Andrew (Designer) and Glover, David: *Machines (Make it Work! Science Series: The Hands-On Approach to Science)*. Two-Can Publishing, LLC, 2000.
ISBN: 1587283573.

McCormack, Alan J.: *Inventor's Workshop*. Fearon Teacher Aids, 1981.
ISBN: 0822497832

Rinard, Judith E.: *The Book of Flight: The Smithsonian National Air and Space Museum*. Firefly Books, LTD, 2001. ISBN: 1552095991.

Thomes, Joann F.: *How To Do Inventions for Science Fair Projects*. Frank Schaffer Publications, 1997. ISBN: 0764701061.

Yolen, Jane: *My Brothers' Flying Machine.* Little, Brown Children's Books, 2003.
ISBN: 0315971596.

Web Sites

What You Need To Know About: Hovercraft
Visit this web site to learn how a hovercraft works and to read about the man who invented it. Great links are provided for further research.
http://inventors.about.com/library/inventors/blhovercraft.htm

NASA Langley Research Center—Aeronautics
Visit this web site to learn how NASA Langley Research Center is helping change the way the world flies. Find more information on flight simulators, the 757 aircraft, aviation safety and security, and much more.
http://www.larc.nasa.gov/research/inside_pages/aeronautics.htm

Federal Aviation Administration—Careers in Aviation
If you're thinking about a career in aviation, this site is a must. Learn all about aviation careers from skycaps to test pilots.
http://www.faa.gov/education/rlib/career.htm

NASAexplores: Hyper X: Greased Lightning
Read an engaging article written for K–4 students about the fastest plane in the world, the X-43. There are also student activities and an educator guide.
http://www.nasaexplores.com/show2_k_4a.php?id=02-031&gl=k4

Nova Site: Faster Than Sound
It has been 50 years since test pilot Chuck Yeager broke the sound barrier. Visit this site to hear Yeager and others describe those early days and to discover what creates a sonic boom, or to find out about the latest attempts to beat speed records on land, water, and in the air. Student activities and a teacher guide are included.
http://www.pbs.org/wgbh/nova/barrier/

NASAexplores: Lowering the Boom
Read an exciting article about how NASA is working with government and industry partners to find ways to reduce the noise and shock waves associated with supersonic flights. Student activities and an educator guide are included.
http://nasaexplores.com/show2_articlea.php?id=04-017

Howstuffworks: How Maglev Trains Work
Visit this web site to find out about electromagnetic propulsion, future development of the maglev train, and much more.
http://travel.howstuffworks.com/maglev-train.htm

Fundamentals of Maglev
Learn, in simple terms, the basic principles of how a maglev train works. Also find out about the various types of maglev trains, how they float, and other related issues.
http://www.calpoly.edu/~cm/studpage/clottich/fund.html

New Scientist: First Passenger Maglev Train Set for Liftoff
Read an article and find out all the details about the first magnetic levitation passenger train that began operations in January 2003 in Shanghai, China. The train will carry passengers at a top speed of more than 400 km (250 mph)!
http://www.newscientist.com/news/news.jsp?id=ns99993153

Popular Science: Transatlantic Maglev
Catch a train in New York and arrive in London just an hour later! Read about the proposed neutrally buoyant vacuum tunnel submerged 150 ft to 300 ft beneath the Atlantic Ocean's surface and anchored to the sea floor, in which trains zip along at speeds up to 4,000 mph.
http://www.popsci.com/popsci/science/article/0,12543,599827-2,00.html

Activities and Worksheets

In the Guide

On the Web

Faster and Faster We Go!

Compare speeds of various modes of transportation from the past and present.

Riding on Air

Construct a maglev train and track to learn more about magnetic forces.

Just Hovering Around

Problem

To design and build a model hovercraft

Background

In *The Case of the Radical Ride*, Dr. D is building his own personal hovercraft by using the engineering design process to design, build, test, and redesign (as necessary) a model hovercraft. To get maximum lift, Dr. D needs to optimally place holes in the plastic on the bottom of the hovercraft, but he needs your help to determine the size, placement, and number of holes.

Remember to make sure that there are vent holes near the plastic lid attached to the bottom. Also, leave space between the holes so there is plenty of plastic between each of them. If the holes are too far away from the center, they will become plugged when the plastic sheet lies flat against the floor. If the space between holes is too narrow, the plastic will tear. Consider using duct tape to reinforce any thin, narrow necks of plastic between the holes.

Materials

- heavy cardboard
- scissors or razor knife
- compass
- metric ruler
- heavy plastic
- duct tape
- marker
- shop vacuum
- small plastic lid
- brad
- weights of various masses

Procedure

1. In your group, discuss the basic design of a hovercraft. Conduct research if necessary.
2. On a piece of cardboard, draw a circle with a 20-cm diameter.
3. Carefully cut along the drawn line.
4. Place the cardboard circle on top of the heavy plastic and use a marker to trace a circle about 3–4 cm larger than the cardboard (26–28 cm in diameter).
5. Find the center of the cardboard circle and mark it with a small dot.
6. Use a ruler and draw a solid line from the center dot to anywhere on the outer edge of the disk. See diagram 1.
7. Measure the length of the line and mark a dot in the middle.
8. Center the hose of the shop vacuum over the dot mark and trace around the outer edges of the hose.
9. Cut a hole along the line traced.
10. Lay the disk in the center of the plastic circle and fold up the edges over the cardboard circle and tape. See diagram 2.
11. Use duct tape to secure the plastic to the top of the cardboard. Make sure that the plastic is drawn tight and that all edges are sealed.
12. With adult supervision, punch a hole through both the center of the cardboard circle and the plastic bottom.
13. With adult supervision, punch a hole in the center of the small plastic lid.
14. Place the plastic lid on the plastic side of the circle and secure with a brad. See diagram 3 on page 53.
15. From your discussion and research, determine the placement, size, and number of holes you should place in the plastic to produce optimal lift of the hovercraft.

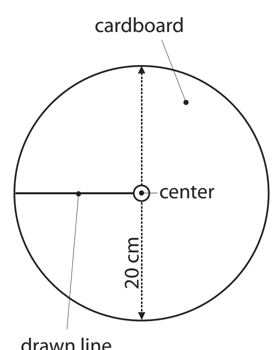


Diagram 1

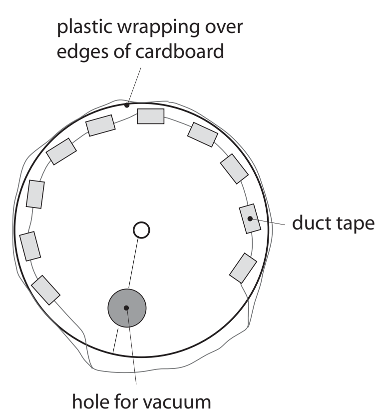


Diagram 2

Just Hovering Around (concluded)

16. Use a compass to draw a place for each hole and cut them out. Note (Optional): To avoid mistakes, design a paper template with circles where the holes should be. Once all group members agree to the template, cut out the places where you want holes on the template. Place the template on top of the plastic and trace the areas where the holes should be. Cut holes in the designated areas of the plastic. See diagram 4.
17. Connect the shop vacuum to the cardboard circle and test your hovercraft. See diagram 5.
18. Devise a series of tests by using various amounts of weights to measure the distance the hovercraft lifts off the tabletop.
19. Record your test data in a chart to share with the class.
20. In your class, determine which group's design lifted the most weight to the highest level.

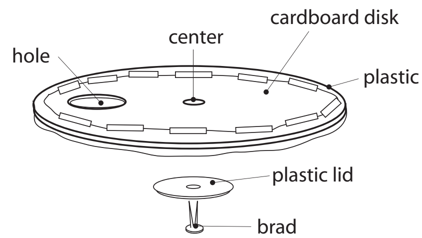


Diagram 3

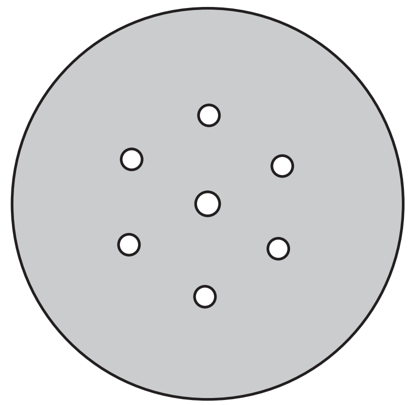


Diagram 4

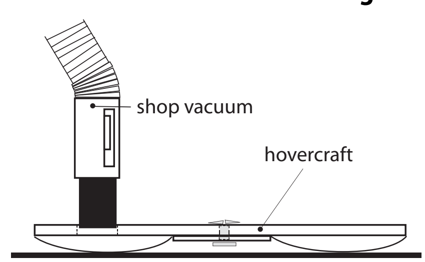


Diagram 5

Conclusion

1. Which design lifted the most weight? Why do you think it was the best?
2. How would you change your design next time?
3. Are there any other changes in the hovercraft design that you would like to make?
4. Dr. D's next problem is how to control the hovercraft. What do you recommend he try?

Extension

To build a large-scale model of Dr. D's hovercraft, visit *http://www.amasci.com/amateur/hovercft.html*

The Iterative Process

The tree house detectives learned that designing is an iterative process. Iterative means that first you design something, build it, test it, and then you analyze the data from the tests. From the data, the design is modified over and over again until it is correct. To begin the iterative process for your chosen solution, carefully plan and draw your design. Remember to draw your design in detail and label it clearly, neatly, and correctly so that others will understand how it works. In your Designer's Log, draw a final copy and write a detailed description of your design.

Draw your design here:

Description of your design: ______________________________

Redesign, Redesign, Redesign

Purpose

To understand the importance of redesign in the engineering design process

Look around and you will see many different products—radios, televisions, cell phones, soda cans, pencils, bookcases, computers, paper clips, and so on. Everything you see began as an idea in someone's mind. Designers take their ideas and after much work, turn them into reality, but have you ever thought that something could be better? Have you ever had an idea about how to improve a product?

Dr. D explains to the tree house detectives that the engineering design process is actually an iterative process, which just means that you go through all the steps in the process again and again until you are happy with the final product. Dr. D also told the detectives that the product would probably never be "perfect" but that eventually an engineer decides that it is good enough for the purposes intended and stops the process. Sometimes, however, an engineer or inventor can decide much later that the product could be even better and will redesign it one more time. That is the beauty of the engineering design process—it is never really finished!

Procedure

1. Look around the room again and choose a product that you think could be improved. Write the product's name in the line provided.
2. Brainstorm a list of ways to make the product better and draw a web to display your ideas.
3. Choose one of the ideas and describe how you would redesign the product.
4. Share your idea for redesign with the class. Ask for comments and feedback.

Product Name: ____________________________________

Web of Ideas:

Redesign Ideas:

To a Fault

Purpose

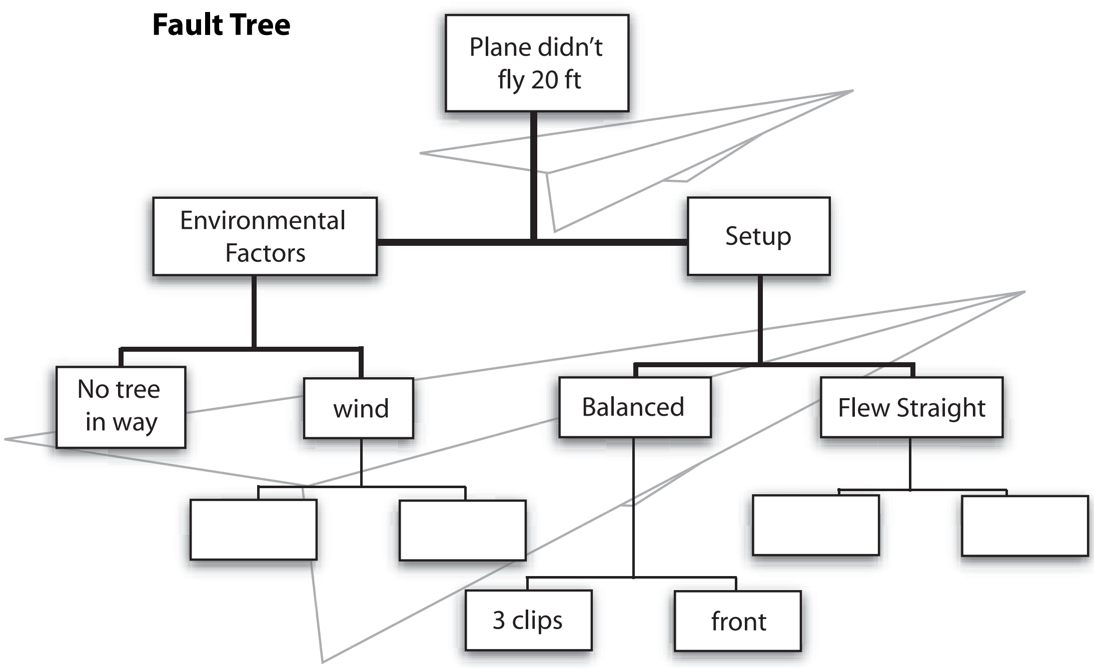
To learn how to analyze a design to determine problems

Fault tree analysis is a logical, structured process that can help designers identify potential problems. Fault trees are powerful design tools that can help engineers ensure that their designs successfully meet their objectives. Fault tree analyses are performed from a top-down approach. You begin by determining a top-level event and then work down to evaluate all the contributing factors that may lead to the top-level event's occurrence. It is a graphical representation of the chain of events in the design process.

For example, if you designed a paper airplane to fly 20 m and it only flew 5 m, the top-level event would be that the airplane did not fly 20 m. Also, the fault tree might be built to include, among other things, the manufacturing process and materials, the setup (plane is balanced and flies straight), the test procedure (throwing techniques), and any environmental impacts (strong wind blowing or trees in the way). You would need to take a look at each event in the fault tree and decide which, if any, contributed to the unsuccessful flight. Once you identify the factor(s) that led to the unsuccessful flight, you would decide if any changes should be made. If no factors contributed, then you should consider the possibility that the current design of the plane is not capable of flying that distance. Either way, it is back to the drawing board for another redesign!

When using the engineering design process, include a fault tree to help create a successful design. Use or copy a diagram like the one shown to help you design your own fault tree.

Fault Tree



A Levitating Idea

Problem

To understand magnetic forces and how they are used to create a maglev train

Background

Magnetism, like gravity, is a force that cannot be seen. Every magnet, however, has an area in which it exerts its force. This area or space is called the magnetic force field. The size of this field depends upon the strength and size of the magnet. All parts of a magnet do not show equal strength. The areas of greatest strength or attraction on a magnet are called the poles. If you suspend a bar magnet horizontally by a loop of thread, you will find that when the magnet stops swinging, one end will point north. This end is the north-seeking pole, or simply north pole. The other end is the south-seeking, or south pole. Magnets are usually marked with an N for north pole and an S for south pole. If you place similar poles together (N-N or S-S), the magnets will repel each other. If you place opposite poles together (N-S), the magnets will attract and stick to each other.

Materials

26 5/16-in. flat washers
ceramic magnets:
powerful 1 1/8-in. size
12-cm (3/8-in. diameter) wooden dowel
metric ruler
science journal
*Note: These magnets are often hard to find but can be purchased at Radio Shack®.

Procedure

1. Place four magnets on the wooden dowel with opposite ends together so that they attract and stick together.
2. Place the fifth magnet on the dowel with similar poles together so that it repels the other magnets. See diagram 1.
3. Lightly tap the top magnet a couple of times.
4. Using a metric ruler, measure in millimeters (mm) the distance between the bottom of the top magnet and the top of the magnet right below it. See diagram 2.
5. Record the distance in your science journal.
6. Place two washers on top of the upper magnet. See diagram 3.
7. Lightly tap the magnet and washer so that they bounce slightly.
8. Measure and record the distance between the magnets.
9. Repeat steps 6–8 by adding two washers at a time until you have a total of ten washers.
10. Repeat steps 6–8 by using four washers at a time until all the washers are placed on the dowel.
11. Create a graph of your results.
12. Share your results with the class and create a class graph.

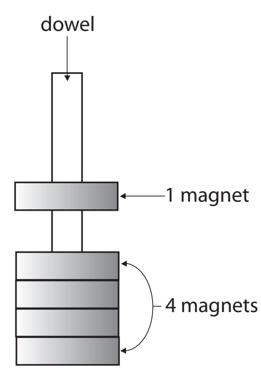


Diagram 1

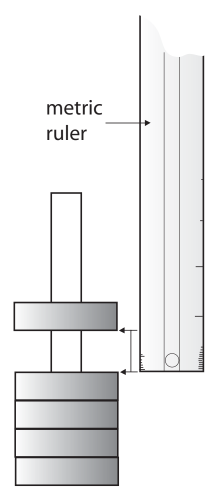


Diagram 2

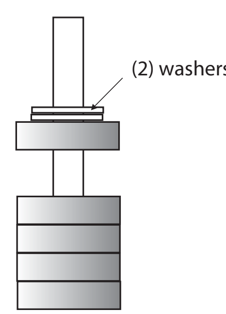
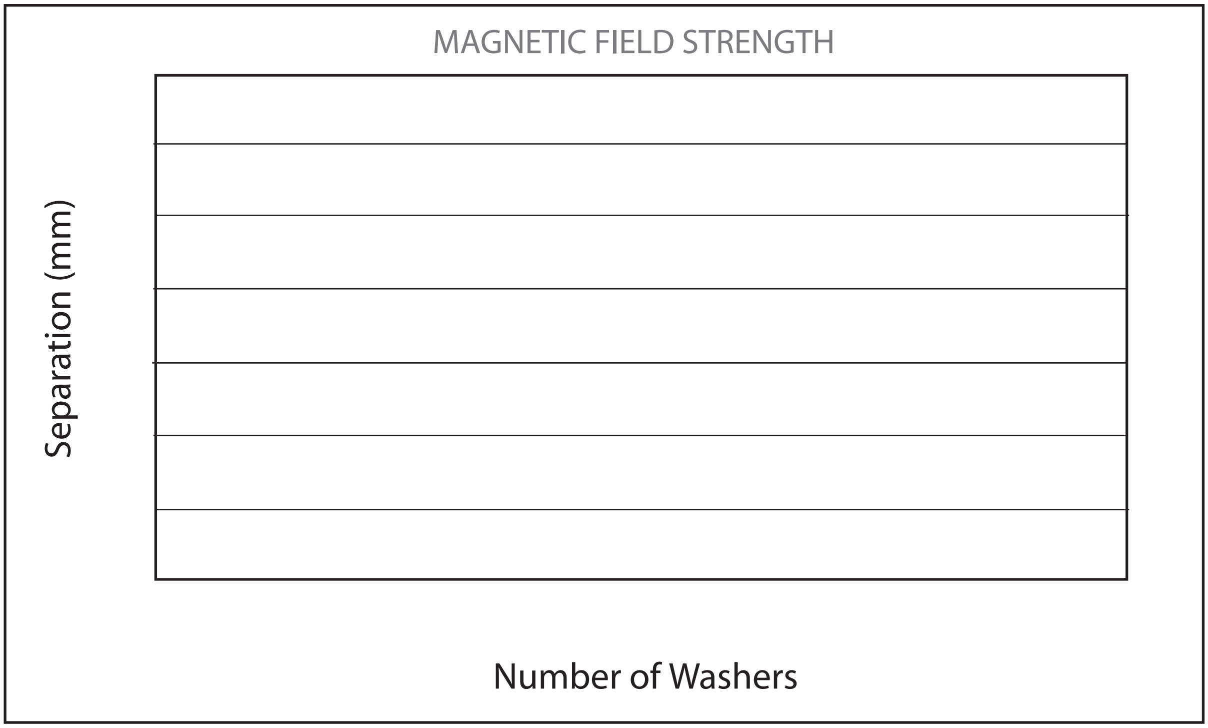


Diagram 3

A Levitating Idea (concluded)

Graph



Conclusion

1. What happened as you added washers to the top magnet? Why?
2. Why was it necessary to add four washers at a time after adding ten washers?
3. How is magnetic force used to create a maglev train?

Extension

1. Conduct the same experiment by using only one magnet on the bottom instead of four. Repeat the experiment with two magnets on the bottom, then three magnets.
2. Conduct an experiment measuring the distance between two repelling magnets. Repeat with two magnets on the bottom and then with three magnets. How did the distance between magnets change as you increased the number of magnets on the bottom?

Answer Key

Just Hovering Around

1–4. Answers will vary.

A Levitating Idea

1. As washers were added to the top of the magnet, the distance between the two magnets decreased because when the masses were first added to the top magnet, the increased weight caused the top magnet to begin dropping. Magnetic force is stronger when magnets are closer together; therefore, the magnet stopped dropping when the increased magnetic force equaled the weight.
2. The graph flattens as the mass increases, showing that it takes a lot of mass to make a little change in separation once the two magnets get very close together. Remember that the magnetic field strength increases rapidly when magnets are close together. When there are 10 washers up top, the change in separation with only 2 additional washers would be so small it would be difficult to measure accurately. Therefore, it was necessary to add washers 4 at a time.
3. Magnetic force is used the same way in this experiment as it would be in the actual building of a maglev train except that the magnetic force would have to be much more powerful to levitate the train and passengers above the "tracks."

On the Web

Faster and Faster We Go!

1. Answers will vary, but students should be able to see that the time it takes people to go long distances has drastically decreased over the last 200 years.
2. Answers will vary but might include that our world has become "smaller," and we travel more frequently and to places farther away.
3. Answers will vary but might include that our world will become even smaller and we will travel farther and faster. With new technology, someday we might go to the Moon for a vacation or to Tokyo for lunch.

Riding on Air!

1. Opposite poles repel and create a magnetic force field between them. If it is strong enough, the force field separates any objects above and below it.
2. No, regular magnets would not create a force field strong enough to support the weight of a train and its passengers. For a better understanding conduct the activity, A Levitating Idea, on page 57-58 in the educator guide.
3. Answers will vary but might include that it is a cleaner form of transportation and that the trains have the potential of traveling at great speeds.

Segment 4

Although Dr. D and the detectives continue to move slowly in traffic, their wireless Internet connection is holding up, so they hope that they will at least be able to see the awards ceremony by web cast. The detectives still don't think they have enough information about what transportation of the future will look like, so R.J. sets off to visit Mr. Andrew Hahn at NASA Langley Research Center to learn about Personal Air Vehicles (PAVs). Mr. Hahn tells R.J. that someday in the not so distant future, we might have our own airplane cars and live in airport communities! Bianca and Kali also contact Mr. Terry Hertz at NASA Headquarters. As NASA's Director of Aeronautics Technology, Mr. Hertz gives the detectives a glimpse into a few of the unlimited possibilities for the future of transportation. Finally, it is time for the awards ceremony, but Dr. D, Jacob, and Katherine don't make it in time. In the meantime, Bianca and Kali are surprised when they get the chance to meet Mr. Frederick Gregory, Deputy Administrator of NASA! Not long after the awards ceremony, Dr. D and the other detectives arrive, and they all talk with Mr. Gregory about the importance of education and what NASA is doing to inspire the next generation of explorers as only NASA can!

Objectives

The students will

- learn about personal air vehicles (PAVs) and how they will affect our society.
- envision the future of space and air travel.
- explore various careers in aeronautics and space.

Vocabulary

airport community—a community that centers around a small airport where the houses have hangars instead of garages so that people can fly to and from their destinations instead of driving

intermodal delay—time spent going from one mode of transportation to another

Personal Air Vehicle (PAV)—concept for a future transportation vehicle that would fly like a plane but operate like a car

Small Aircraft Transportation System (SATS)—a proposed system of over 5,000 small airports across the U.S. using low-cost electronics that will make the airports safe for anyone to use

sonic boom—a sound like that of an explosion produced when a shock wave formed at the nose of an aircraft traveling at supersonic speed reaches the ground

supersonic—moving at a speed that is faster than the speed at which sound travels through the air

vision—a vivid picture created by the imagination

Video Component

Implementation Stratey

The NASA SCI Files™ is designed to enhance and enrich the existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 4 of *The Case of the Radical Ride*, discuss the previous segment to review the problem and what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** can also be found in the **Problem-Solving** Tools section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 3 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 3. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 3.
5. Read the overview for Segment 4 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.

View Segment 4 of the Video

For optimal educational benefit, view *The Case of the Radical Ride* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. At the end of Segment 4, lead students in a discussion of the Focus Questions for Segment 4.
2. Have students discuss and reflect upon what they have learned about the engineering design process and the future of transportation. The following instructional tools located in the **Educators** area of the web site may aid in the discussion: **Experimental Inquiry Process Flowchart** and/or **Scientific Method Flowchart**.
3. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
4. Wrap up the featured online PBL investigation. Evaluate the students' or teams' final product, generated to represent the online PBL investigation. Sample evaluation tools can be found in the **Educators** area of the web site under the main menu topic **Tools** by clicking on **Instructional Tools**.
5. Have students write in their journals what they have learned about the engineering design process and the future of transportation so that they can share their entry with a partner or the class.

Careers

administrator
air traffic controller
civil engineer
electrical engineer
industrial engineer
manufacturing engineer

Resources (additional resources located on web site)

Books

Adler, David A.: *A Picture Book of Benjamin Franklin*. Holiday House, Inc., 1991, ISBN: 0823408825.

Baker, David: *Scientific American: Inventions from Outer Space—Everyday Uses for NASA Technology*. Random House, 2000, ISBN: 0375409793.

Bankston, John: *Henry Ford and the Assembly Line*. Mitchell Lane Publishers, Inc., 2003, ISBN: 1584151730.

Greenblatt, Jacquelyn A.: *Women Scientists and Inventors: A Science Puzzle Book*. Good Year Books, 1999, ISBN: 0673577287.

Parker, Steven and West, David: *53 1/2 Things That Changed the World and Some That Didn't*. Millbrook Press, 1995, ISBN: 156294603X.

Romanek, Trudee: *The Technology Book for Girls and Other Advanced Beings*. Kids Can Press, 2001. ISBN: 1550749366.

Simon, Seymour and Fauteux, Nicole: *Let's Try It Out with Towers and Bridges: Hands-On Early Learning Activities*. Simon and Schuster, 2003, ISBN: 068982923X.

Web Sites

NASA—Aerospace Vehicle Systems Technology Office
Visit this site to learn about exciting new research such as the Personal Air Vehicle (PAV) that is being conducted at NASA Langley to help shape the future of aviation.
http://avst.larc.nasa.gov/news.html

NASA—Small Aircraft Transportation System (SATS)
NASA, in partnership with other government, state, and local aviation airport authorities, is developing technology that will bring new, safe, and affordable operating capabilities to any runway in the nation and in most weather conditions. The new operating capabilities rely on onboard computing, advanced flight controls, Highway-in-the-Sky displays, and automated air traffic separation and sequencing technologies.
http://sats.larc.nasa.gov/main.html

Federal Aviation Administration (FAA): Education
Visit this web site for activities, games, and career information. Teacher resources are also available.
http://www.faa.gov/education/

AirSafe.com®: Aviation Safety
Visit this web site to view critical information for the traveling public, featuring both airport and airline *security.http://airsafe.com/*

NASA—Virtual Skies
Explore the exciting worlds of aviation technology, air traffic management, and current research on this web site. Become a meteorologist and try your hand at cloud identification and weather forecasting. Design your own airport, become an air traffic controller, and much more. This site is a great aviation resource for older students and adults.
http://virtualskies.arc.nasa.gov/

NASAexplores: Lowering the Boom
Read an exciting article about how NASA is working with other government agencies and industry partners to find ways to reduce the noise and shock waves associated with supersonic flights. Student activities and an educator guide are included.
http://nasaexplores.com/show2_articlea.php?id=04-017

NASAexplores: The Future of Supersonic Jets Read all about NASA's High-Speed Research (HSR)
Program and the new technology that is being discovered to help change the future of transportation. Student activities and an educator guide are included.
http://nasaexplores.com/show2_articlea.php?id=03-049

Activities and Worksheets

In the Safety Zone

Problem

To understand how air traffic is monitored and safely controlled
To plot coordinates, measure distance, and apply ratios

Teacher Prep

1. Copy one game board (p. 75-78) per group and assemble using clear tape. Tape or glue the game board to the cardboard.
2. Cut out the Aircraft and Storm Game Pieces (p. 74).

Teacher Note

1. Before beginning this game, students should have a basic understanding of how to plot coordinates on a grid.
2. One person in the class should be designated as the announcer. The teacher, another adult, or a student can play this role.
3. Depending on students' ability, this game can be played with one, two, or three aircraft in each quadrant. The more airplanes, the more difficult the game.
4. The aircraft on page 74 are grouped by quadrants and at least one airplane from each group needs to be selected.
5. At the beginning of the game, draw the airport layout located in the top left corner of the game board on the chalkboard or overhead projector and explain the landing procedures.

Procedure

1. Distribute game boards and other necessary materials to each group: (1) Flight Plan (p. 71) to record landing times, (2) Tracking Chart (p. 72) to track the progress of the assigned plane(s), (3) Safety Rating Card (SRC) (p. 73) to keep track of the total points earned, and (4) Game Constraints (p. 73).
2. Explain the goals of the game to the students.
3. Have each student in the group choose a quadrant on the game board and select one or more aircraft for the quadrant chosen.
4. Have students choose a colored pencil and color each aircraft game piece the same color for the quadrant to ensure correct tracking.
5. Have the students work together to plot the aircrafts' initial positions on the game board by using the initial aircraft flight coordinates provided in the Flight Plan. Students will use a pushpin or sewing pin, along with the correct aircraft game piece, to mark the location.
6. Point out to the students that each aircraft is marked with the flight number and the runway where it is to land.
7. Use the answer key (Figure 1) to award 1 point for each correctly plotted aircraft. Record the total point value on each group's Safety Rating Card (SRC) (p. 73).
8. Have each student measure the direct distance from each of the assigned aircraft to the airport.
9. Have the students calculate the direct distance in km by using the scale: 2 cm : 5 km by rounding results to the nearest km and record on the Tracking Chart (p. 72).
10. Have announcer read the Safety Zone Scenario (p. 67-68) as students play the game.
11. Score the game and determine the Air Safety Travel Index (ASTI).
12. The team with the highest ASTI percentage wins.
13. Discuss conclusion questions (p. 70).

Materials

Student Materials
(*per group of 4*)
game board (p. 75-78)
cardboard (size of game board)
clear tape
4 metric rulers
4 different colored pencils
20 pushpins or sewing pins
4 calculators
4 Flight Plans (p. 71)
4 Tracking Charts (p. 72)
4 Safety Rating Cards (SRC)/Game Constraint Cards (p. 73)
Aircraft and Storm Game Pieces (p. 74)

Teacher Materials
stopwatch or timer

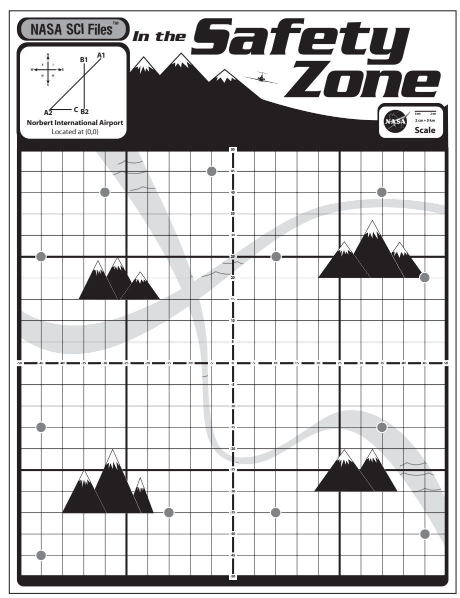


Figure 1

In the Safety Zone (continued)

Scoring the game

Score 10 points for aircraft landed on time, subtract 1 point for each minute ahead or behind schedule, and subtract 5 penalty points for each aircraft coming in on the wrong runway.

Distance and Accuracy Calculations

1. Have students determine the ASTI by calculating the percentage and using the ratio of team points divided by total possible points for the number of aircraft you directed (1 aircraft = 44 total points, 2 aircraft = 88 total points, 3 aircraft = 132 total points). Write the percentage on the SRC.
2. Have students complete the Tracking Chart by calculating the actual linear distance traveled from the aircraft's initial coordinates to the airport by using this equation: 5 (km/min) multiplied by landing time (min).
3. Calculate the difference between the direct distance traveled versus the actual distance traveled, and record the values on the Tracking Chart.

Safety Zone Scenario

Announcer Reads the Following:

1. Each air traffic controller (ATC) is responsible for the aircraft in his or her quadrant. Record the flight number, aircraft type, and runway information on the Tracking Chart.
2. For each minute of play, all aircraft must make 1 move. One move equals 2 cm of linear travel (5 km). Use your metric ruler to verify 2 cm of movement. Remember, an aircraft cannot move backwards.
3. During each minute of play, each ATC must keep track of his/her aircraft's flight paths by using a colored pencil and metric ruler. In addition, after all flight paths have been updated, place a check mark on the Tracking Chart to indicate completion of your aircraft's move.
4. Familiarize yourself with the airport layout located at the top of the game board. The entire airport is located on the origin (0, 0). Please see game constraints for final approach guidelines.
5. Study the Flight Plan and pay particular attention to the arrival times and runway locations and develop a landing strategy.
6. Work quickly, efficiently, and collaboratively during the game. You are working as a team and not playing against each other.
7. We are now ready to begin the game. (Start timer.)
8. Minute 1. Each group has 1 minute to move each aircraft on the game board 2 cm.
9. Minute 2. You have 1 minute to move each aircraft on the game board 2 cm.
10. Minute 3. Continue to move aircraft 2 cm.
11. Minute 4. Continue to move aircraft 2 cm. (After minute 4, stop timer.)

In the Safety Zone (concluded)

12. A thunderstorm is approaching the airport and traveling due east at 5 km/min. The leading edge of the storm is located at (–35, 5) and (–35, –5). Minute 5 (start timer). Continue moving each aircraft 2 cm. (Stop timer after minute 5 has expired.)
13. The storm continues to move east at 5 km/min. Move the storm pieces.
14. Minute 6 (start timer). Continue moving aircraft 2 cm. (Stop timer after minute 6 has expired.)
15. A 737's right (starboard) engine has caught on fire and caused runway B1 to be temporarily closed to incoming aircraft. The storm continues to move east at 5 km/min. Move storm pieces.
16. Minute 7 (start timer). Continue moving aircraft 2 cm.
17. Minute 8: The storm is still moving east at 5 km/min. Move storm pieces. Continue moving aircraft 2 cm.
18. Minute 9. Runway B1 has been cleared for takeoffs and landings. The storm continues to advance east at 5 km/min. Move storm pieces. Continue moving each aircraft 2 cm. (Stop timer after minute 9 has expired.)
19. Flight 1130 is experiencing leaking fuel. Please clear the flight path for an emergency landing. Flight 1130 must land.
20. Minute 10. Continue moving each aircraft 2 cm. (Start the timer again.)
21. Minute 11. The storm is still moving east at 5 km/min. Continue moving each aircraft 2 cm.
22. Minute 12. The storm is crossing the airport and all takeoffs and landings are delayed until the storm clears. Continue moving each aircraft 2 cm.
23. Minute 13. The storm continues to cross over the airport at 5 km/min and is producing heavy downpours and severe lightning. Airport is still temporarily closed. Continue moving each aircraft 2 cm.
24. Minute 14. The storm continues to cross east over the airport at 5 km/min. Airport is still temporarily closed as the storm moves through the area. Continue moving each aircraft 2 cm.
25. Minute 15. The storm continues to cross east over the airport at 5 km/min. Airport is still temporarily closed as the storm heads out of the area. Continue moving each aircraft 2 cm.
26. Minute 16. The storm has dissipated and the airport is now clear for takeoffs and landings. Continue moving each aircraft 2 cm.
27. Minute 17. Continue moving each aircraft 2 cm.
28. Minute 18. Mechanical problems have caused runways B1 and B2 to be closed for the next 3 minutes. Continue moving each aircraft 2 cm.
29. Minute 19. Continue moving each aircraft 2 cm.
30. Minute 20. Continue moving each aircraft 2 cm.
31. Minute 21. Runways B1 and B2 are open for takeoffs and landings. Continue moving each aircraft 2 cm. (Continue to announce each minute until all aircraft have landed.)

In the Safety Zone: Student Page

Background

The Federal Aviation Administration (FAA), an agency of the U. S. Department of Transportation (DOT), runs the Air Traffic Control (ATC) System. The system was developed primarily to maintain safe separation of aircraft throughout the U.S. and to keep air traffic flowing in an orderly manner and as efficiently as possible.

Air traffic controllers coordinate the movement of aircraft to make certain that air traffic stays a safe distance apart. Their immediate concern is safety, but controllers must direct aircraft efficiently to minimize delays. Controllers also keep pilots informed about changes in weather conditions.

Goals of the Game

In this game, you are an ATC responsible for safely and efficiently guiding one aircraft to its destination. Your primary goal is to land the aircraft safely and on time. Points will be rewarded for plotting the plane correctly, landing on time, and landing on the correct runway.

Procedure

1. Choose a quadrant and an aircraft designated for that quadrant.
2. Color the aircraft and retain the colored pencil for tracking.
3. Work together to plot the initial positions of all aircraft on the game board by using the initial aircraft flight coordinates provided in the Flight Plan. Use a pushpin or sewing pin, along with the correct aircraft game piece, to mark the location.
4. On the Safety Rating Card (p. 73), record points awarded for each correctly plotted aircraft.
5. Measure the direct distance from each of the assigned aircraft to the airport.
6. Calculate the direct distance in km using the scale: 2 cm : 5 km. Round results to the nearest km and record them on the Tracking Chart. (p.72)
7. Listen as the announcer reads the Safety Zone Scenario and follow directions.
8. After the game is completed, score your game by giving 10 points for aircraft that landed on time, subtract 1 point for each minute ahead or behind schedule, and subtract 5 penalty points for each aircraft coming in on the wrong runway.
9. Determine the Air Safety Travel Index (ASTI) by calculating the percentage using the ratio of team points divided by total possible points for the number of aircraft you directed (1 aircraft = 44 total points, 2 aircraft = 88 total points, 3 aircraft = 132 total points).
10. Multiply by 100 and write the percentage on the Safety Rating Card (SRC).

In the Safety Zone: Student Page (concluded)

11. Complete the Tracking Chart by calculating the actual linear distance traveled from the aircraft's initial coordinates to the airport by using the equation 5 (km/min) x landing time (min)
12. Calculate the difference in the direct distance traveled versus the actual distance traveled, and record the values on the Tracking Chart.

Conclusion

1. Analyze the difference between the direct distance traveled versus the actual distance traveled. What conclusions can you draw from this discrepancy?
2. Analyze your calculated Air Safety Travel Index. The optimum ASTI value is 100 percent. If your ASTI value is not 100 percent, what are some variables that affected your ASTI value?
3. Why is communication vital to an air traffic controller?
4. Research indicates that air traffic control is one of the most challenging and stressful jobs. After having limited experience with directing aircraft, write a paragraph or two commenting on this statement.
5. Air traffic is expected to increase in the future. What challenges will face the next generation of air traffic controllers?

Extensions

1. Invite an air traffic controller to participate in the game. After the game is played, have the ATC lead a discussion on the qualities of a successful ATC.
2. Design your own script and game board for the game.

In the Safety Zone: Student Page

Name:________________________________

Date:________________________________

Flight Plan

	Aircraft Type	Flight No.	Airline	Departure Point	Flight Coordinates	Arrival Time	Runway	Landing Time	Difference in Times
Quadrant 1	757	125	Aspen Air	Denver	(10,25)	+7 min.	B1		
	MD-80	711	Gamble Air	Las Vegas	(45,20)	+12 min.	B1		
	737	625	Cub Tran	Chicago	(35, 40)	+25 min.	B2		
Quadrant 2	767	780	Green Air	Seattle	(-30, 40)	+18 min.	A1		
	Cessna	615	Green Tran	San Francisco	(-45, 25)	+20 min.	C		
	DC-9	1058	WWA	Portland	(-5, 45)	+10 min.	B1		
Quadrant 3	747	239	Dar-Mills Air	Hawaii	(-45, -45)	+27 min.	A2		
	777	1214	Fuji	Tokyo	(-40, -15)	+11 min.	A2		
	MD-80	1130	Tex-Mex	Mexico	(-15, -35)	+15 min.	B2		
Quadrant 4	737	347	Saint Airway	New Orleans	(45, -40)	+23 min.	B2		
	757	432	Tri-Alpha	Atlanta	(35, -15)	+13 min.	A1		
	757	222	Tex-Mex	Houston	(10, -35)	+8 min.	B2		

In the Safety Zone: Student Page

Tracking Chart

Flight Number			
Aircraft Type			
Runway			
Direct Distance From Airport			
Actual Distance Traveled			
Difference in Kilometers			

Use this grid to help yourself remember if you've moved all your planes! After each minute, check off each plane you have moved.

Minute	Individual Plane Check-Off		
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			

Tracking Chart

Flight Number			
Aircraft Type			
Runway			
Direct Distance From Airport			
Actual Distance Traveled			
Difference in Kilometers			

Use this grid to help yourself remember if you've moved all your planes! After each minute, check off each plane you have moved.

Minute	Individual Plane Check-Off		
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26			
27			
28			
29			
30			

Tracking Chart

Flight Number			
Aircraft Type			
Runway			
Direct Distance From Airport			
Actual Distance Traveled			
Difference in Kilometers			

Use this grid to help yourself remember if you've moved all your planes! After each minute, check off each plane you have moved.

Minute	Individual Plane Check-Off		
1			
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27			
28			
29			
30			

In the Safety Zone: Student Page

ATC: ______________________________

Quadrant: _________________________

Safety Rating Card

Individual ATC Score	ATC's Points	Max. Points (Number of Aircraft) 1	2	3
Initial Aircraft Setup 1 point for each correctly plotted aircraft	________	1	2	3
Landing Aircraft 10 points possible for each aircraft landed. Subtract 1 point for every minute early or late. Subtract 5 points for a wrong runway landing.	________	10	20	30
Total →	________	11	22	33

Team Score	Points	Max. Points (Number of Aircraft) 1	2	3
Quadrant I	________			
Quadrant II	________			
Quadrant III	________			
Quadrant IV	________			
		44	88	132
Total →	________			

Air Safety Travel Index x (ASTI) Formula

(A/B) ∗ 100 = ASTI

A = Team's Total Points   B = Maxium Points

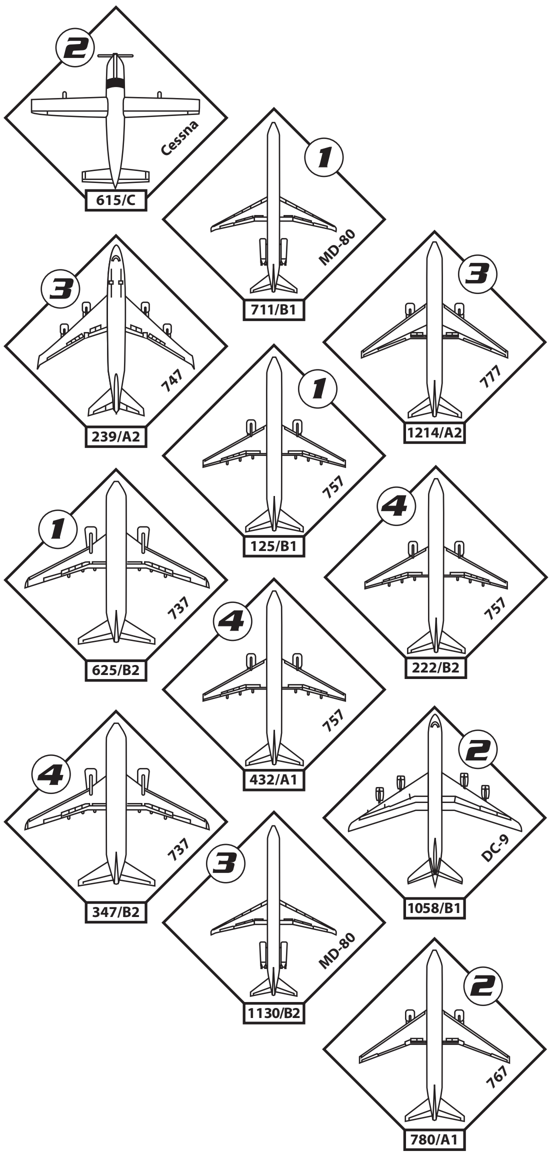
(______/______) ∗ 100 =

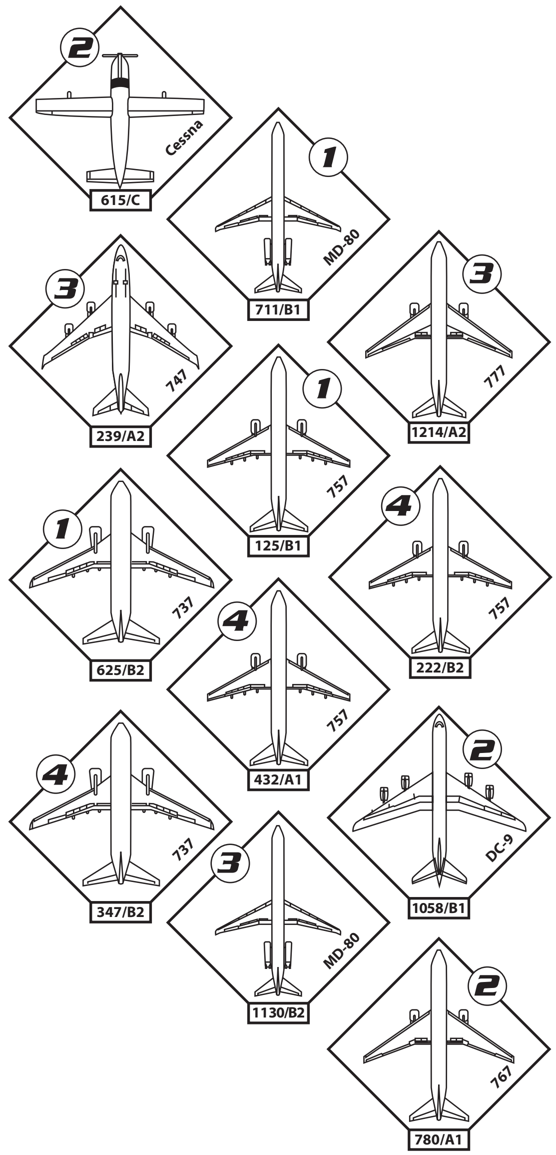
Team Points   Max Points

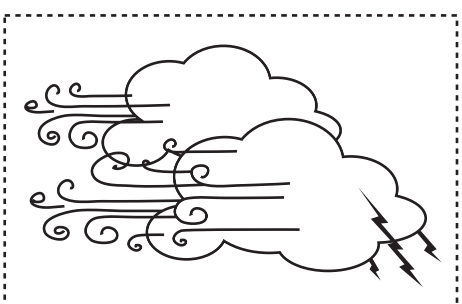
Game Constraints

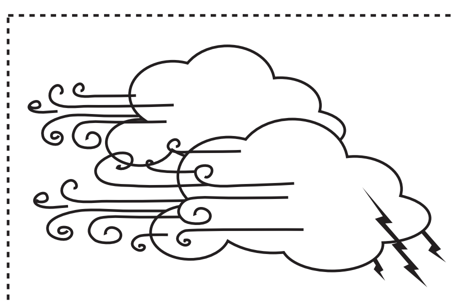
1. For each minute of play, aircraft can move 2 cm in any direction except backwards.
2. Aircraft cannot be closer to each other than 2 cm (5 km).
3. To land on Runway C, aircraft must be on the coordinates (1,0).
4. Runway C is reserved strictly for the Cessna aircraft.
5. To land on Runway B1, aircraft must be on the coordinates (0,1) and for Runway B2 on the coordinates (0,-1).
6. To land on Runway A1, aircraft must land from the northeast from (5,5) and on Runway A2, from the southwest from (-5, -5).
7. Landing an aircraft on the wrong runway results in a 5-point penalty.
8. No two aircraft can land on the same runway at the same time.
9. Within three minutes of landing, the ATC must announce his intention of landing an aircraft by identifying the flight number and runway.
10. Aircraft flight path must avoid mountains and storms.

In the Safety Zone: Student Page



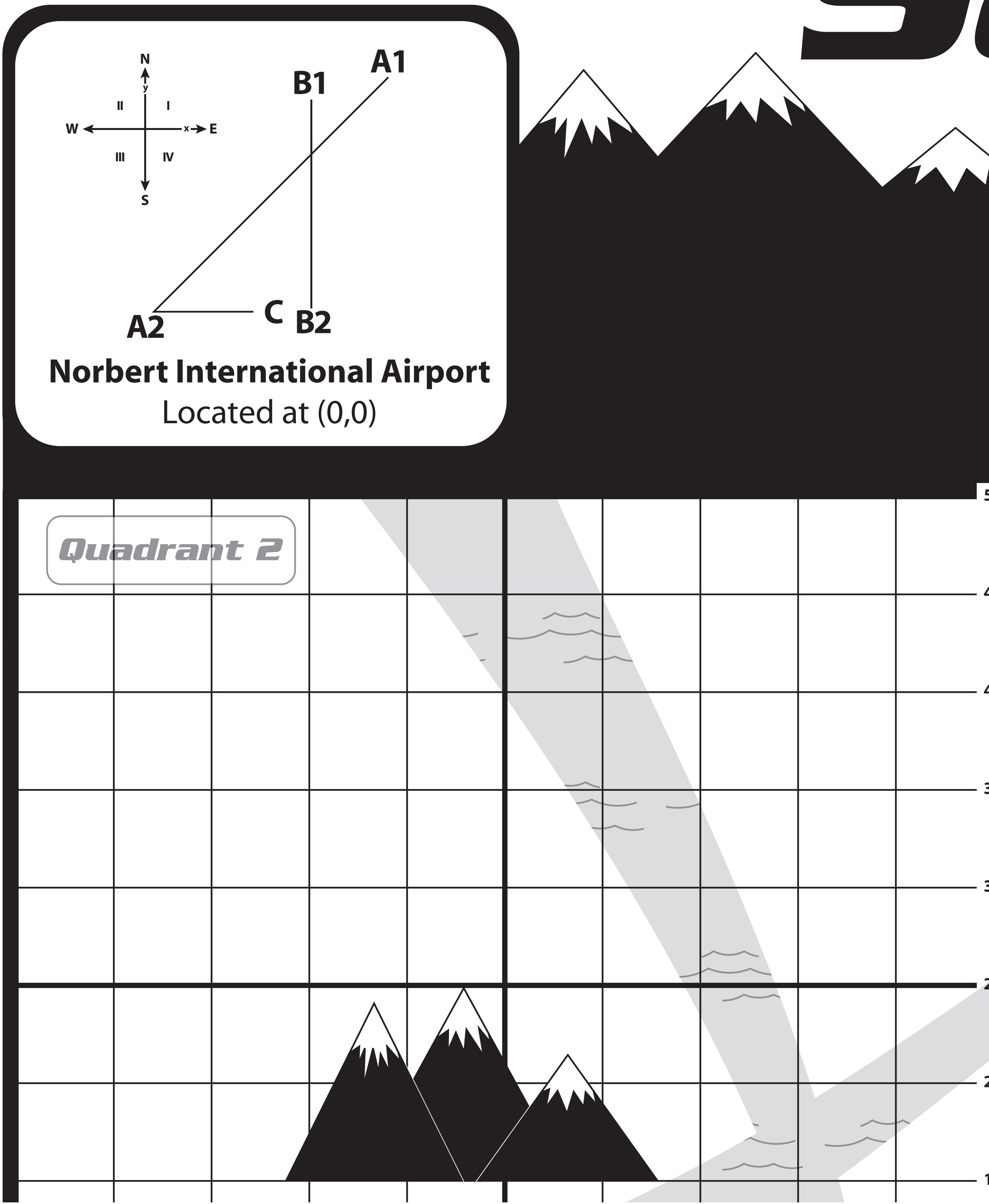






NASA SCI Files™

In the S

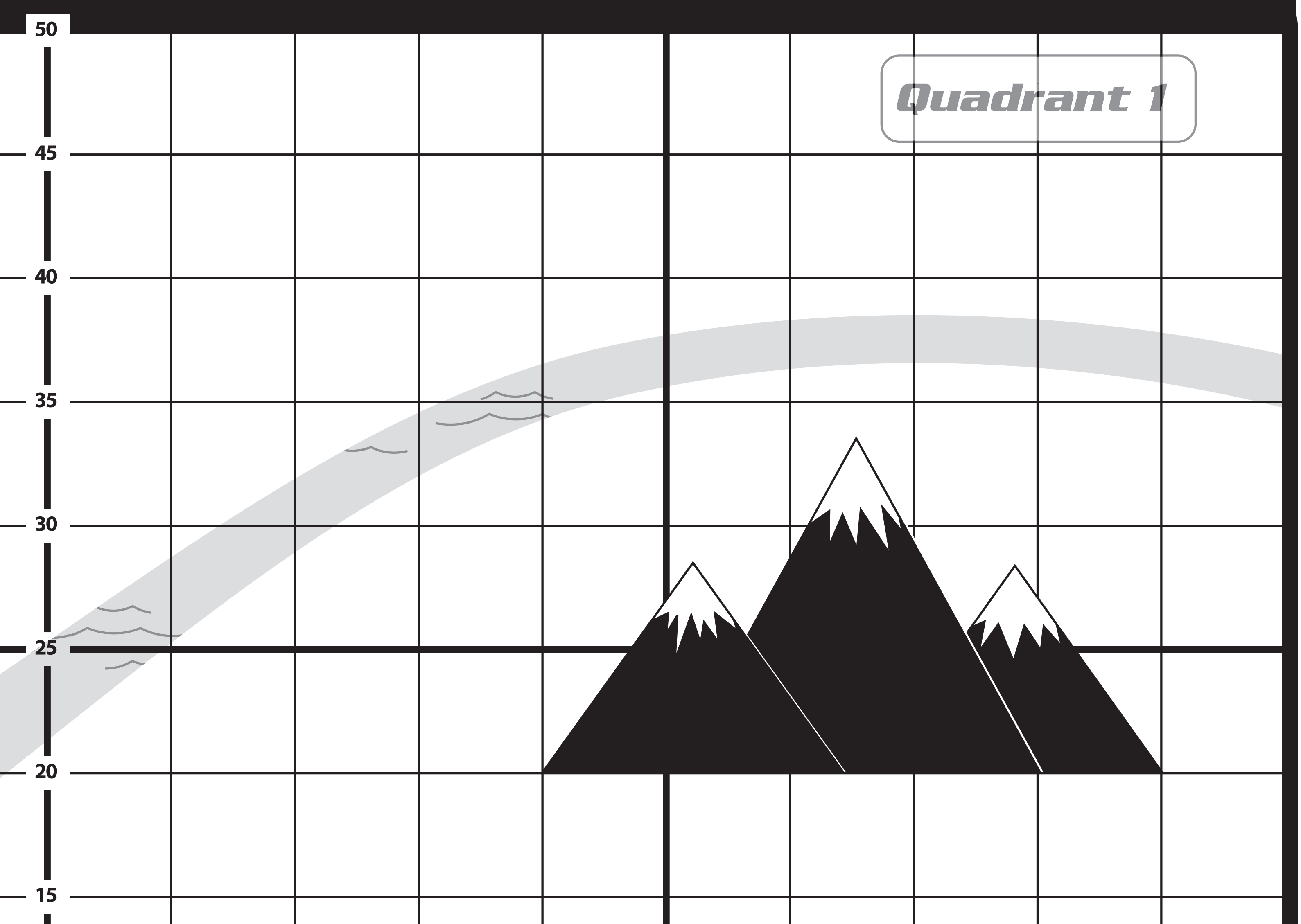


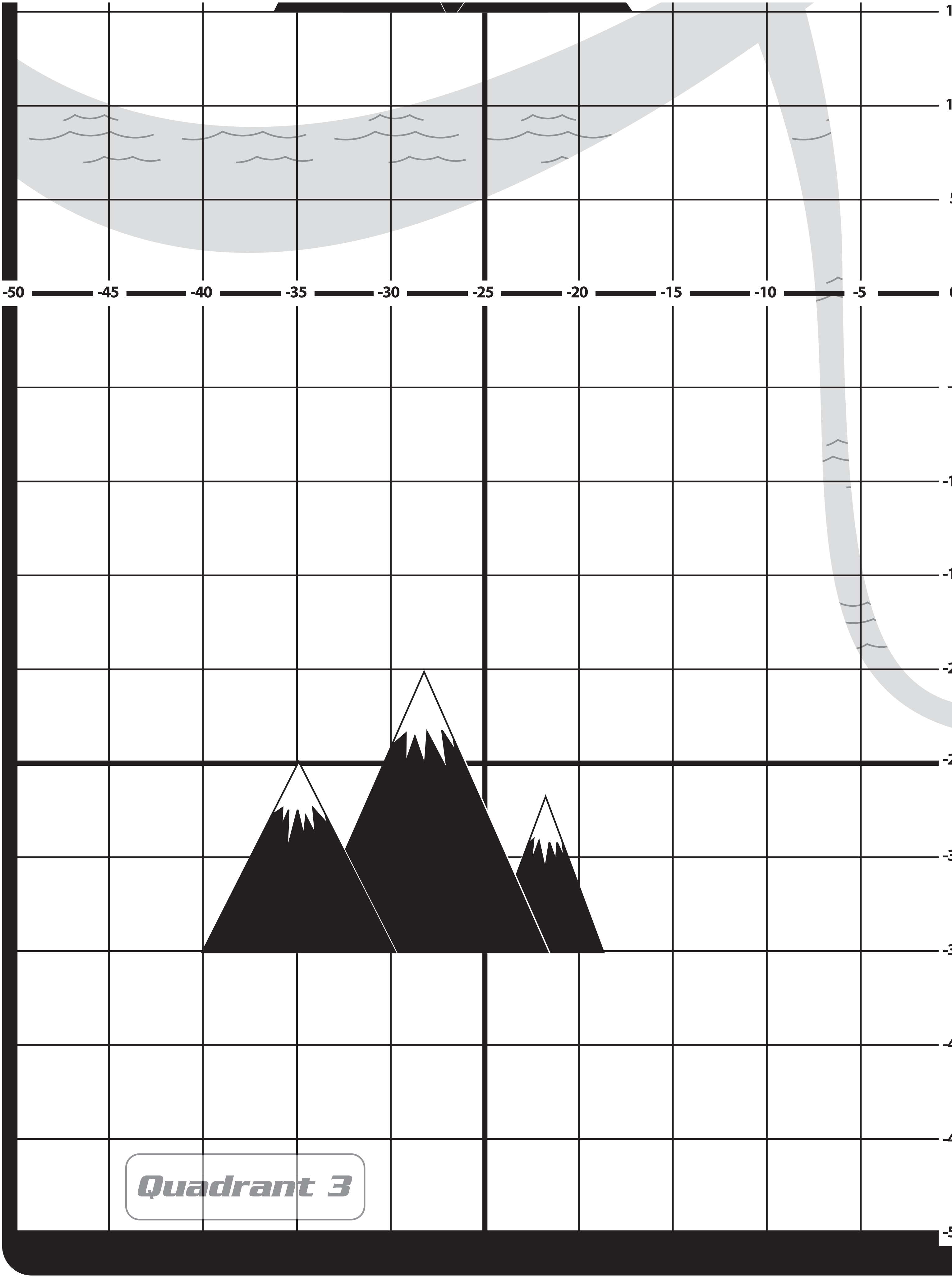
Safety Zone

0 cm 2 cm

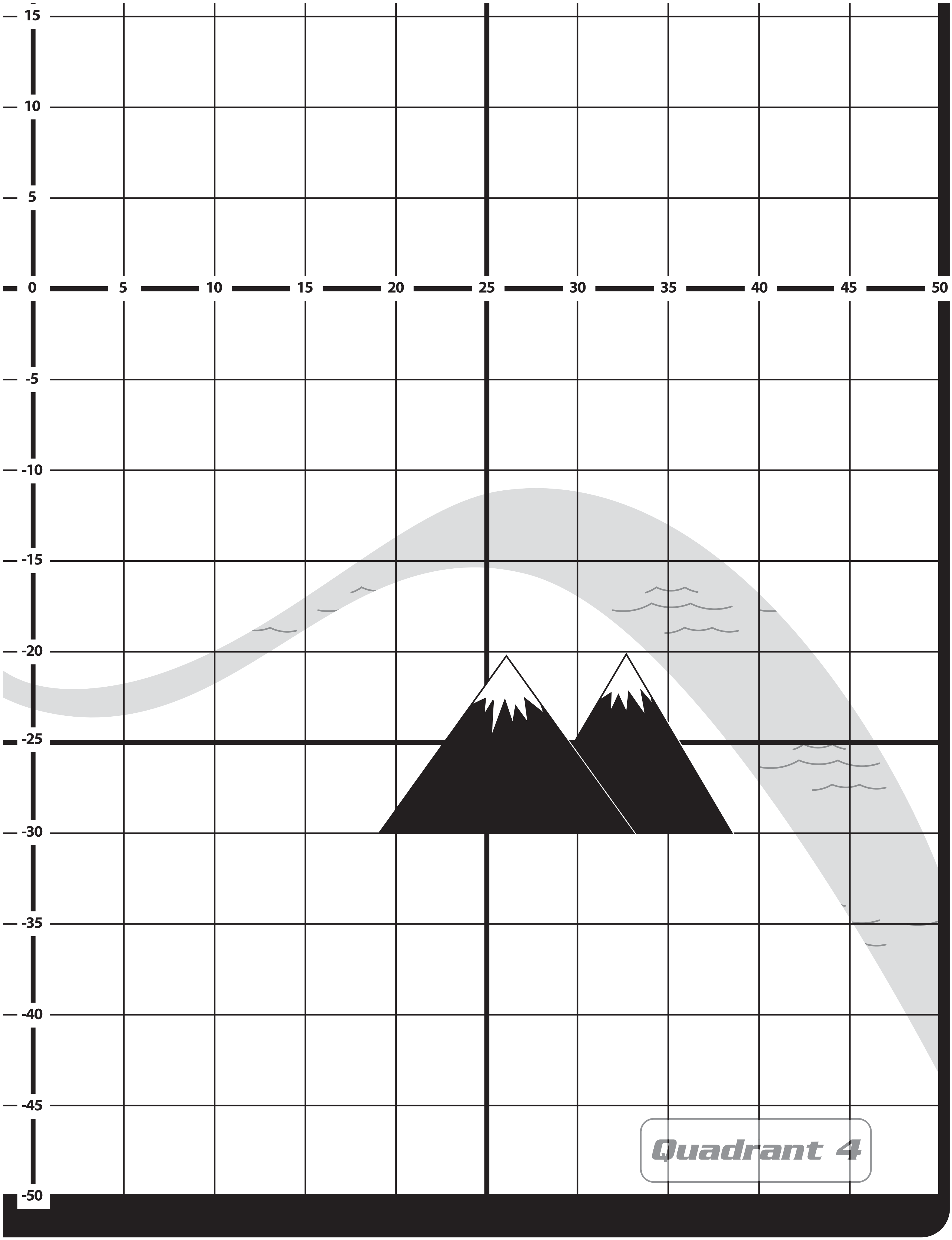
2 cm = 5 km

Scale





-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
Quadrant 3


15
10
5
0
5
10
15
20
25
30
35
40
45
50
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Quadrant 4

Up Close and Personal in the Air

Materials

Internet *(optional)*
aeronautics resources
construction paper
colored pencils

Problem

To design a personal air vehicle for future travel

Procedure

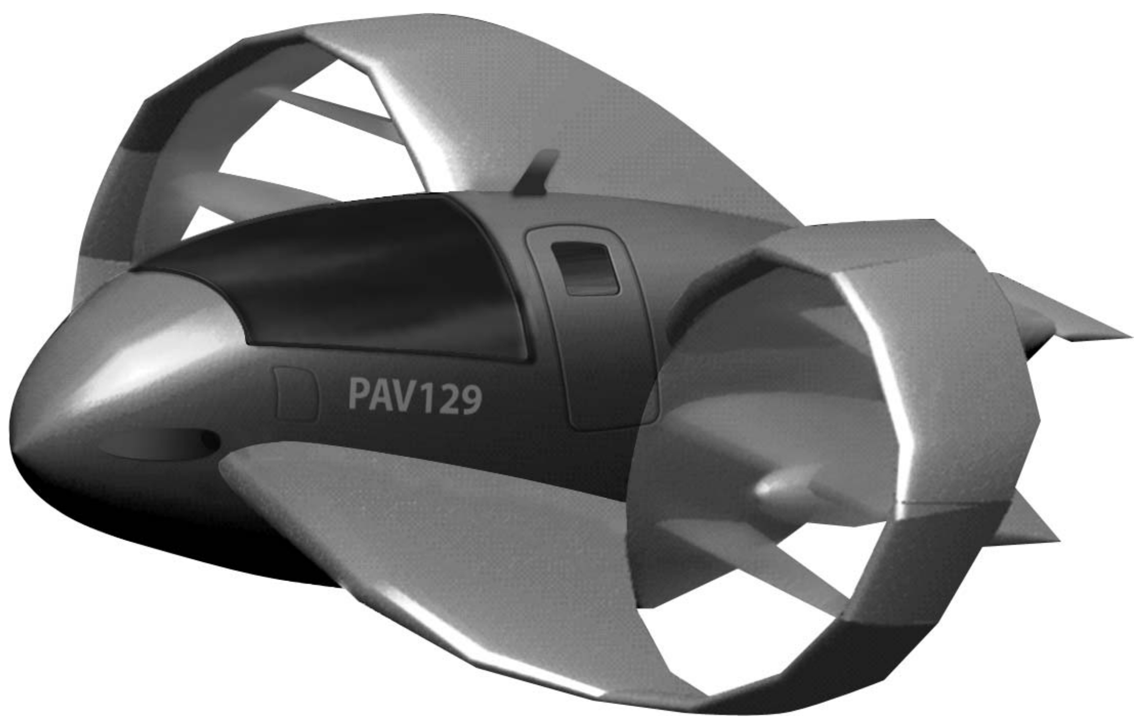
1. Conduct research on past, present, and future aircraft. Using your research and what you learned in The Case of the Radical Ride, discuss options for future personal air vehicles (PAVs).
2. Brainstorm a list of ideas and use them to create a web or brainstorm map.
3. In your group, decide which concept is the best PAV to present to the class.
4. Draw and color an illustration of your future PAV.
5. Create a report, poster, PowerPoint or other presentation to explain how your PAV will work, why you think it is the best option, and how it will benefit society if it is manufactured.
6. Present your presentation to the class.
7. As a class, vote on the PAV that would have the most effect on society.

Conclusion

1. When you become an adult, will you buy a PAV? Why or why not?
2. Explain what factor people will consider the most when choosing a PAV?
3. How will society change with the advent of the PAV and small airport communities?

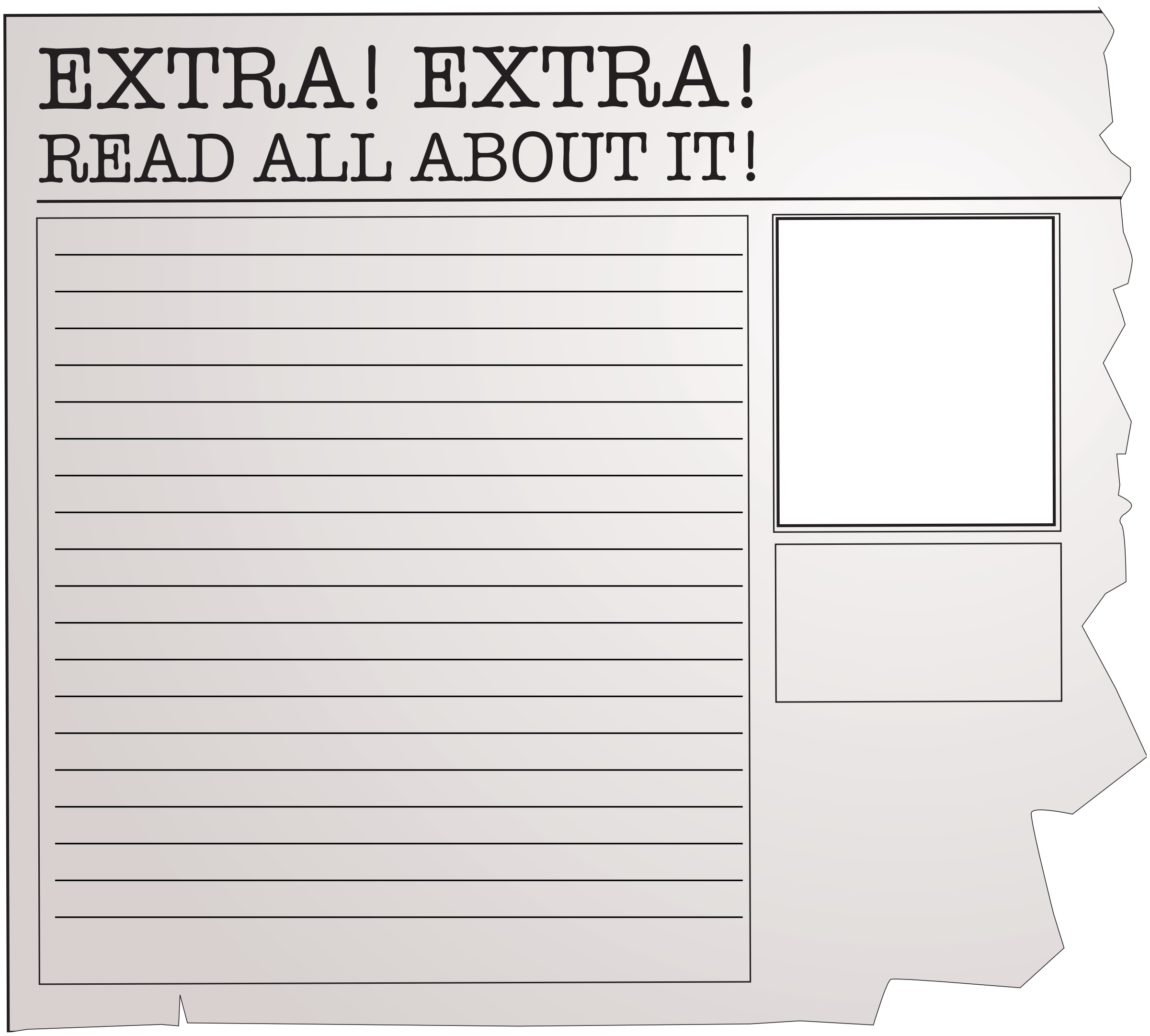
Extension

Create a model of your personal air vehicle.



EXTRA! EXTRA! READ ALL ABOUT IT!

The year is 2025 and you have just invented a new form of transportation. Using a newspaper writing style, write a story about your design and tell how it will affect future societies. Be sure to include a short biography about you, the engineer! Remember, when writing newspaper articles, answer the five Ws and an H: Who, What, Where, When, Why, and How!



Reaching Into the Future

Find the following words

solution
space tourist
PAV
SATS
aerospace
design
engineer
rocket
maglev
transatlantic
aeronautics
test
tunnel
Mars rover
iterative
crew vehicle
intermodal delay
data
shuttle
space station
airport community
problem
gridlock
redesign

S	O	L	U	T	I	O	N	A	R	Y	N	E	A	P	T	A	M	O	O	N	S
P	N	M	O	S	A	T	S	I	N	B	A	B	E	U	U	G	U	Y	I	H	I
A	A	C	A	M	O	R	P	M	E	T	S	Y	N	H	T	R	A	E	U	D	G
C	O	V	D	E	P	E	R	I	A	K	M	N	I	C	L	I	P	T	O	I	N
E	N	M	A	N	I	O	M	B	N	G	E	M	S	T	O	N	T	H	T	N	E
T	H	E	E	G	T	I	U	A	I	L	A	U	X	R	Y	L	I	S	H	T	O
O	K	A	I	I	O	R	K	N	K	I	N	V	Y	A	E	I	O	I	Y	E	U
U	J	I	L	N	E	S	N	M	D	C	C	E	T	N	L	L	E	R	D	R	G
R	L	P	L	E	T	E	T	E	C	T	O	L	I	S	S	A	G	O	R	M	R
I	A	I	E	E	E	R	G	E	H	Z	N	G	N	A	T	E	V	A	I	O	I
S	S	M	W	R	T	I	O	E	I	T	V	A	U	T	R	R	A	R	E	D	D
T	Z	Q	U	I	C	L	I	C	T	O	E	M	M	L	I	O	E	P	U	A	L
P	N	L	D	S	A	I	N	D	K	R	R	C	M	A	A	S	A	E	A	L	O
R	G	E	A	R	S	Z	A	I	E	E	G	O	O	N	T	P	E	L	A	D	C
O	I	V	E	R	T	S	S	N	G	P	T	D	C	T	I	A	N	C	T	E	K
B	S	P	A	C	E	S	T	A	T	I	O	N	T	I	O	C	L	I	A	L	H
L	I	R	T	J	E	S	C	I	E	W	T	E	R	C	N	E	I	H	D	A	E
E	E	N	E	I	G	D	E	S	I	G	N	K	O	I	S	A	C	E	T	Y	R
M	E	R	C	P	G	S	I	C	I	Z	U	A	P	T	E	S	T	V	I	C	I
A	K	A	T	I	I	T	G	U	D	T	B	I	R	B	I	L	L	W	I	I	N
M	A	R	S	R	O	V	E	R	S	R	I	R	I	O	Y	T	I	E	A	R	G
G	A	E	M	O	H	S	O	B	I	T	E	R	A	T	I	V	E	R	Q	U	E
A	E	R	O	N	A	U	T	I	C	S	N	I	K	K	I	N	Y	C	R	P	V
M	F	A	E	B	Z	X	R	S	W	R	E	D	E	S	I	G	N	S	O	R	E

Shooting for the Stars

Use the words below to create your own crossword puzzle.

Vocabulary

engineer	problem
solution	brainstorm
design	iterative
test	data
analyze	aeronautics
aerospace	transportation

Add your own:

____

____

____

____

Across

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

Down

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

Answer Key

In the Safety Zone

1. Answers will vary but might include that various conflicts such as the approaching storm and the runway shutdown caused planes to be diverted from their original plan.
2. Answers will vary and might include the same conflicts as in question 1.
3. Answers will vary but might include that without communication and someone controlling the planes, there would be chaos in the skies. Planes would run into each other and not know when to land, and so on.
4. Answers will vary.
5. Answers will vary but might include that there will be a need for either more controllers and/or better communication equipment.

Up Close and Personal in the Air

1–3. Answers will vary.

Reaching Into the Future

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S O L U T I O N A R Y N E A P T A M O O N S
P N M O S A T S I N B A B E U U G U Y I H I
A A C A M O R P M E T S Y N H T R A E U D G
C O V D E P E R I A K M N I C L I P T O I N
E N M A N I O M B N G E M S T O N T H T N E
T H E E G T I U A I L A U X R Y L I S H T O
O K A I I O R K N K I N V Y A E I O I Y E U
U J I L N E S N M D C C E T N L L E R D R G
R L P L E T E T E C T O L I S S A G O R M R
I A I E E E R G E H Z N G N A T E V A I O I
S S M W R T I O E I T V A U T R R A R E D D
T Z Q U I C L I C T O E M M L I O E P U A L
P N L D S A I N D K R R C M A A S A E A L O
R G E A R S Z A I E E G O O N T P E L A D C
O I V E R T S S N G P T D C T I A N C T E K
B S P A C E S T A T I O N T I O C L I A L H
L I R T J E S C I E W T E R C N E I H D A E
E E N E I G D E S I G N K O I S A C E T Y R
M E R C P G S I C I Z U A P T E S T V I C I
A K A T I I T G U D T B I R B I L L W I I N
M A R S R O V E R S R I R I O Y T I E A R G
G A E M O H S O B I T E R A T I V E R Q U E
A E R O N A U T I C S N I K K I N Y C R P V
M F A E B Z X R S W R E D E S I G N S O R E
```

On the Web

Home Sweet Hangar

1–3. Answers will vary.