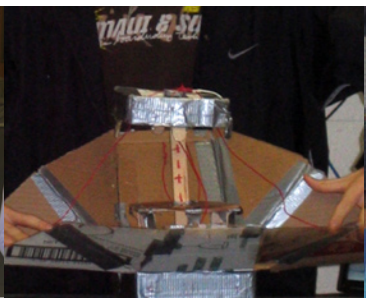
National Aeronautics and Space Administration

Space Transportation: Reshooting the Moon

Human Exploration Project II
Transportation

A Standards-Based Middle School Unit Guide






Engineering byDesign™

Advancing Technological Literacy

A Standards-Based Program Series

This unit coordinates with the ITEA EbD™ Course: ***Technological Systems.***

MS-8

Educational Product	
Educators	Grade 8

EP–2009–03–41–MSFC

International Technology Education Association

Center to Advance the Teaching of Technology and Science

Teacher Notes

This unit is intended to serve as part of a middle school experience for students who are interested in exploring Technology Education and/or Pre-Engineering. In terms of Science, Technology, Engineering, and Mathematics (STEM) education, this unit primarily focuses upon the "T" and "E" of STEM, with strong linkages to the "S" and "M." The intended audience includes students in Grades 7 or 8. While there are no prerequisites, prior experience in technological literacy through Technology Education is helpful.

Preface

Space Transportation: Reshooting the Moon
A Standards-Based Middle School Unit

Acknowledgments

Many individuals committed to developing high school technological literacy made this publication possible. Their strong commitment to developing standards-based technology resources is reflected in this guide. Special thanks are expressed to the following:

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The ITEA-CATTS Human Exploration Project (HEP)
People, Education and Technology

In May 2005, ITEA was funded by the National Aeronautics and Space Administration (NASA) to develop curricular units for Grades K–12 on Space Exploration. The units focus on aspects of the themes that NASA Engineers and Scientists—as well as future generations of explorers—must consider, such as Energy and Power, Transportation, and Lunar Plant Growth Chambers (the STS-118 Design Challenges). Moreover, the units are embedded within a larger model program for technology education known as Engineering byDesign™.

The Human Exploration Project (HEP) units have several common characteristics. All units:

- Are based upon the Technological Literacy standards (ITEA, 2000/2002/2007).
- Coordinate with Science (AAAS, 1993) and Mathematics standards (NCTM, 2000).
- Utilize a standards-based development approach (ITEA, 2005).
- Stand alone and coordinate with ITEA-CATTS Engineering byDesign™ curricular offerings.
- Reflect a unique partnership between NASA scientists and engineers and education professionals.

These unit guides are designed to be practical and user-friendly. ITEA welcomes feedback from users in the field as we continually refine these curricular products, ensuring that the content remains as dynamic as the technological world in which we live. Please email <ebd@iteaconnect.org> or call 703–860–2100.

Space Transportation: Reshooting the Moon

Table of Contents

Space Transportation: Reshooting the Moon

Lesson 2: Moving Our "Stuff" on Earth and in Space

Lesson 3: Ship Shape: Designing a Spacecraft Subsystem

Space Transportation: Reshooting the Moon

Space Transportation: Reshooting the Moon A Standards-Based Middle School Unit

Unit Overview

Big Idea

Transportation systems move people and goods. Transportation vehicles consist of subsystems that must function together for a system to work effectively.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Standards and Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop an understanding of the core concepts of technology. (ITEA/*STL* 2)
  - Requirements are the parameters placed on the development of a product or system. (2R)
- Students will develop an understanding of the effects of technology on the environment. (ITEA/*STL* 5)
  - The management of waste produced by technological systems is an important societal issue. (5D)
  - Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems. (5E)
  - Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. (5F)
- Students will develop an understanding of the role of society in the development and use of technology. (ITEA/*STL* 6)
  - Social and cultural priorities and values are reflected in technological devices. (6F)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/*STL* 10)
  - Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. (10F)
- Students will develop abilities to apply the design process. (ITEA/*STL* 11)
  - Make a product or system and document the solution. (11L)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/*STL* 12)
  - Use information provided in manuals, protocols, or by experienced people to see and understand how things work. (12H)
  - Use tools, materials, and machines safely to diagnose, adjust, and repair systems. (12I)
  - Use computers and calculators in various applications. (12J)
  - Operate and maintain systems in order to achieve a given purpose. (12K)
- Students will develop the abilities to assess the impact of products and systems. (ITEA/*STL* 13)
  - Identify trends and monitor potential consequences of technological development. (13H)

- Students will develop an understanding of and be able to select and use energy and power technologies. (ITEA/*STL* 16)
  - Energy can be used to do work, using many processes. (16F)
  - Power systems are used to drive and provide propulsion to other technological products and systems. (16H)
- Students will develop an understanding of and be able to select and use information and communication technologies. (ITEA/*STL* 17)
  - Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. (17H)
  - Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination. (17I)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/*STL* 18)
  - A transportation system has many parts that work together to help people travel. (18A)
  - The use of transportation allows people and goods to be moved from place to place. (18D)
  - A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working. (18E)
  - Transporting people and goods involves a combination of individuals and vehicles. (18F)
  - Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. (18G)
  - Governmental regulations often influence the design and operation of transportation systems. (18H)
  - Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. (18J)

Mathematics: Principles and Standards for School Mathematics *(NCTM, 2000)**

- Communication Standard (NCTM, All Grades)
  - Use the language of mathematics to express mathematical ideas precisely.
- Connections Standard (NCTM, All Grades)
  - Recognize and apply mathematics in contexts outside of mathematics.

Science: Benchmarks for Science Literacy *(AAAS, 1993)***

- Issues in Technology (AAAS, 3 C, Grades 3–5)
  - Any invention is likely to lead to other inventions. Once an invention exists, people are likely to think up ways of using it that were never imagined at first.
  - Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. Other factors, such as cost, safety, appearance, environmental impact, and what will happen if the solution fails, also must be considered.

** Standards are listed with the permission of the National Council of Teachers of Mathematics (NCTM). NCTM does not endorse the content or validity of these alignments.*

*** Material reprinted from* Benchmarks for Science Literacy *(AAAS, 1993) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.*

- The Universe (AAAS, 4 A, Grades 9–12)
  - Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed.
- Energy Transformations (AAAS 4 E, Grades 6–8)
  - Most of what goes on in the universe—from exploding stars and biological growth to the operation of machines and the motion of people—involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation.
- Forces of Nature (AAAS 4 G, Grades 6-8)
  - The Sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.

Purpose of Unit

To familiarize students with the characteristics of transportation systems and how they apply to the exploration of space.

Unit Objectives

Lesson 1: Moving People

Students will learn to:

- Explain that transportation systems move people and goods.
- Describe how a system may lose efficiency or fail if one of its subsystems is missing or malfunctioning.
- Explain that transportation systems are made up of subsystems that work together.
- Describe how much of the energy used in our environment is not used efficiently.
- Explain that energy can be used to do work, using many processes.

Lesson 2: Moving Our "Stuff" on Earth and in Space

Students will learn to:

- Collect and use data to identify trends and monitor potential consequences of technological development.
- Identify how governmental regulations often influence the design and operation of transportation systems.
- Describe the processes that are necessary for the entire transportation system to operate efficiently.
- Design a space transportation system that will complete a lunar mission and identify the processes it would require.

Lesson 3: Identifying Criteria and Specifying Constraints

Students will learn to:

- Identify the subsystems that must function together for a transportation system to work effectively.
- Describe the role of requirements in the development of a product or system.
- Identify the parts of a communication system.
- Describe how requirements are the parameters placed on the development of a product or system.
- Develop a subsystem for a Moon-bound manned spacecraft.

Lesson 1: Moving People

Lesson Snapshot

Overview

Big Idea: Transportation systems are made up of subsystems that work together.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson familiarizes students with transportation systems and how they relate to supporting human space travel.

Lesson Duration: Four to six hours.

Activity Highlights

Engagement: Students identify major achievements in human space exploration.

Exploration: Students identify the subsystems that must function together for a manned space transportations system to work effectively.

Explanation: The teacher explains the history of human travel to space and the obstacles that must be overcome.

Extension: Students research manned missions to space and create a timeline of major achievements.

Evaluation: Student knowledge, skills, and attitudes are assessed using selected response items and rubrics for brief constructed responses.

Lesson 1: Overview

Lesson Duration

- Four to six hours.

Standards/Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop an understanding of the effects of technology on the environment. (ITEA/*STL* 5)
  - The management of waste produced by technological systems is an important societal issue. (5D)
  - Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems. (5E)
  - Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. (5F)
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- Students will develop an understanding of and be able to select and use energy and power technologies. (ITEA/*STL* 16)
  - Energy can be used to do work, using many processes. (16F)
  - Power systems are used to drive and provide propulsion to other technological products and systems. (16H)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/*STL* 18)
  - A transportation system has many parts that work together to help people travel. (18A)
  - The use of transportation allows people and goods to be moved from place to place. (18D)
  - A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working. (18E)

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  - Most of what goes on in the universe—from exploding stars and biological growth to the operation of machines and the motion of people—involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation.
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  - The sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.

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Learning Objectives

Students will learn to:

1. Explain that transportation systems move people and goods.
2. Describe how a system may lose efficiency or fail if one of its subsystems is missing or malfunctioning.
3. Explain that transportation systems are made up of subsystems that work together.
4. Describe how much of the energy used in our environment is not used efficiently.
5. Explain that energy can be used to do work, using many processes.

Student Assessment Tools and/or Methods

1. True/False

False	1.	Much of the energy used in our environment is used efficiently.
False	2.	Transportation systems are only used to move people and animals.
True	3.	Troubleshooting is used to identify the cause of malfunction in a technology system.
True	4.	Energy can be used to do work.
True	5.	Technologies can be used to break down waste from the use of products of systems.

2. Brief Constructed Response

Use the information from ***Lesson Resource 1.1*** to explain how a great deal of the energy used in our environment is not used effectively. Write a one-paragraph answer. Include a strong topic sentence and good supporting details.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the graphics and/or the question.	Response demonstrates an understanding of the graphics.	Response demonstrates understanding of the complexities of the graphics.
Focus	Response lacks transitional information to show the relationship of the support to the question.	Response addresses the demands of the question.	Response exceeds the demands of the question.
Use of Related Information	Response uses minimal information from the graphics to clarify or extend meaning.	Response uses some expressed or implied information from the graphics to clarify or extend meaning.	Response effectively expressed or implied information from the graphics to clarify or extend meaning.

3. Fact Sheet Rubric (See ***Lesson Resource 1.2***)

Category	Below Target	At Target	Above Target
Mission and Date	Information is missing or difficult to locate. Lettering is not sized properly.	Information is properly located.	Information is properly located and sized on the paper.
Mission Facts	Facts of mission details are often inaccurate. Information is missing.	Mission details are accurate. Concise explanation of what was learned and how future missions were influenced.	Mission details are accurate. Extended explanation of what was learned and how future missions were influenced.
Images and Captions	Images are missing or not clear. Images are not located correctly.	Images are clear and located in the proper position with captions.	Images are exceptionally clear and sized to enhance the overall effect of the fact sheet.
Style and Organization	Images and text are poorly spaced. Large empty areas exist. Items are incorrectly placed. Poor contrast.	Images and text are well spaced. Minimal wasted space. Items are correctly placed. Good contrast between text and background.	Images and text are well sized and spaced. No wasted space. Items are correctly placed. Exceptional contrast.
Documentation	Sources are not properly documented, too few, or inappropriate. Sources are placed on front of sheet.	Two properly documented sources are located on the back of fact sheet.	More than two properly documented and placed sources.
Identification of Subsystems	Two or fewer appropriate subsystems are listed for each category. Incorrect subsystems are listed.	At least three appropriate subsystems are listed for each category.	More than three appropriate subsystems are listed for each category.

4. Oral Presentation Rubric

Category	Below Target	At Target	Above Target
Knowledge	Student is uncomfortable with the information and is able to answer only rudimentary questions.	Student is at ease with the information and has answers to all questions but fails to elaborate.	Student demonstrates knowledge (more than required) by answering class questions with explanations and elaboration.
Eye Content	Student occasionally uses eye contact but still reads most of report.	Student maintains eye contact most of the time but frequently returns to notes.	Student maintains eye contact with audience, seldom returning to notes.
Elocution	Student's voice is low. Student incorrectly pronounces terms. Audience members have difficulty hearing presentation.	Student's voice is clear. Student pronounces most words correctly. Most audience members can hear presentation.	Student uses a clear voice and correct, precise pronunciation of terms so that all audience members can hear presentation.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

Print Materials

Furniss, T. (2001). *The history of space vehicles.* San Diego, CA: Thunder Bay Press.

Heppenheimer, T.A. (1999). *Countdown: A history of spaceflight.* New York: John Wiley & Sons, Inc.

Audiovisual Materials

DeBoer, L. (Director). (2002). *The red stuff: The true story of the Russian race for space.* [DVD]. White Star Studio.

Hanks, T. (Executive Producer). (1998). *From the earth to the moon collection.* [DVD/VHS]. (Available from <http://www.libraryvideo.com/>, N0970)

Internet Sites

A & E Television Networks. (1996-2008). Interactive Space Timeline: Explore the Space Age. Retrieved April 19, 2008, from <http://www.history.com/minisite.do?content_type=Minisite_Generic&content_type_id=51655&display_order=5&mini_id=1438>.

Hamilton, C. J. (2007). History of Space Exploration. Retrieved April 19, 2008. <http://www.solarviews.com/eng/history.htm>.

Culp, R., (March 2007) Time Line of Space Exploration. Retrieved April 19, 2008. <http://my.execpc.com/~culp/space/timeline.html>.

Kennedy, J. F. (1962) Address at Rice University on the Nation's Space Effort. John F. Kennedy Presidential Library and Museum. Retrieved April 19, 2008. <http://www.jfklibrary.org/Historical+Resources/Archives/Reference+Desk/Speeches/JFK/003POF03SpaceEffort09121962.htm>.

NASA History Division. (April 2008). Steven Dick, Chief Historian. Key Documents in the History of Space Exploration. Retrieved April 19, 2008. <http://history.nasa.gov/spdocs.html>.

The Ultimate Space Place. (2004). Space History. Retrieved April 19, 2008. <http://www.thespace-place.com/index.html>.

Zak, A. (2008). Chronology: Moon Race. In News and History of Astronautics in the Former USSR. Retrieved April 19, 2008. <http://www.russianspaceweb.com/chronology_moon_race.html>.

Required Knowledge and Skills

Students should know that humans have created technology systems to prevent, eliminate, or lessen threats to life and the environment and to fulfill social needs.

Lesson 1: 5-E Lesson Plan

Engagement

1. The teacher reads or plays the audio/video of President Kennedy's speech from September 12, 1962: *We choose to go to the Moon*. One source is listed in the **Resource Materials**.
2. The teacher asks students to share with a neighbor the names of any astronauts, ships, or programs involved in the manned voyages to the Moon.
3. The teacher describes the Apollo program and how it met President Kennedy's charge from 1962. There were a series of manned and unmanned missions into Earth orbit and to the Moon before Apollo 11 landed on July 20, 1969.
4. The teacher asks students to individually think about and record obstacles involved in sending a human to the Moon.
5. Students share their ideas with their neighbors and extend their lists as they discuss what they wrote.

Exploration

1. The teacher uses the board or overhead to create a graphic organizer (web, etc.) based on student ideas. It should be created showing that there are two main categories of obstacles: transportation and life support.
2. Using the graphic organizer, the teacher leads a discussion about systems that have been developed to overcome the obstacles related to transportation and life support.
3. The teacher asks students to identify how different uses of energy allowed these systems to transport and support the life of astronauts.

Explanation

1. Students are asked to identify examples of energy being used to do work as it relates to transportation.
2. The teacher explains that:
   - Energy (in its many forms) can be used to do work using many processes.
   - Much of the energy in our environment is not used efficiently.
   - Energy waste from a transportation system can include heat, sound, and pollution.
   - The management of waste produced by a technology system is an important societal issue.
   - Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.
3. Students examine a graph showing the relative efficiency of automobiles through the years. (See ***Lesson Resource 1.1***)
4. Students complete the questions related to the graphical information and later use the data to complete a brief constructed response.
5. The teacher explains that decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.
6. The teacher explains that:
   - Transportations systems are used to move people and goods.
   - Transportation systems are made up of subsystems that work together.
   - A system may lose efficiency or fail if one of its subsystems is missing or malfunctioning, (e.g., Cars: low tire pressure, low oil, poor fuel pressure, low coolant, clogged air filter, etc.).
   - Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technology system.

Extension

1. Individually or in small groups, students use print and Internet resources to identify major events in the history of manned space exploration. To help students get started, the teacher may suggest Internet sites from the **Resource Materials**.
2. Each student creates a one-page fact sheet (***Lesson Resource 1.2***) about an important event in the history of manned space exploration. The teacher may suggest use of an interactive timeline site listed in the **Resource Materials**.
3. The teacher reviews the ***Oral Presentation Rubric*** to guide students in the completion of the assignment.
4. Students share their fact sheets with the class in a brief (three-minute) presentation.
5. Students place their fact sheets on a timeline that has been previously prepared and placed on the wall.

Evaluation

Student knowledge, skills, and attitudes are assessed using true/false, brief constructed response, and a fact sheet assignment. The rubrics should be presented in advance of the activities to familiarize students with the expectations and performance criteria. They should also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Lesson 1: Lesson Preparation

Teacher Planning

The laboratory-classroom should provide a flexible, resource-rich learning environment that includes areas for lectures and demonstrations, small-group meetings, and research activities. The teacher adapts the learning environment based on the requirements of the unit or lesson. For this lesson, areas for lectures, individual work, and computers with Internet access should be readied.

Tools/Materials/Equipment

- Computers with Internet access
- Reference books
- Calculators

Classroom Safety and Conduct

1. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
2. Students show respect and appreciation for the efforts of others.
3. Students follow all safety rules established for the laboratory-classroom.

Lesson 2: Moving Our "Stuff" on Earth and in Space

Lesson Snapshot

Overview

Big Idea: Increasingly sophisticated technology is used to learn about the universe. Space probes send back data and materials from remote parts of the solar system.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson familiarizes students with the processes of a transportation system and the design of a new system.

Lesson Duration: Two to three hours.

Activity Highlights

Engagement: Students identify transportation systems used in shipping and some of the processes used in each.

Exploration: Students identify the processes in the delivery of the U.S. mail.

Explanation: The teacher explains each of the processes that make a transportation system operate efficiently.

Extension: Students research and present data about the shipment of major commodities.

Evaluation: Student knowledge, skills, and attitudes are assessed using selected response items and rubrics for brief constructed responses.

Lesson 2: Overview

Lesson Duration

- Two to three hours.

Standards/Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop the abilities to use and maintain technological products and systems. (ITEA/*STL* 12)
  - Use computers and calculators in various applications. (12J)
- Students will develop the abilities to assess the impact of products and systems. (ITEA/*STL* 13)
  - Identify trends and monitor potential consequences of technological development. (13H)
- Students will develop an understanding of and ability to select and use transportation technologies. (ITEA/*STL* 18)
  - Transporting people and goods involves a combination of individuals and vehicles. (18F)
  - Governmental regulations often influence the design and operation of transportation systems. (18H)
  - Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. (18J)

Mathematics:* Principles and Standards for School Mathematics *(NCTM, 2000)*

- Communication Standard (NCTM, All Grades)
  - Use the language of mathematics to express mathematical ideas precisely.
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  - Any invention is likely to lead to other inventions. Once an invention exists, people are likely to think of ways of using it that were never imagined at first.
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  - Most of what goes on in the universe—from exploding stars and biological growth to the operation of machines and the motion of people—involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation.
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  - The Sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.

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Learning Objectives

Students will learn to:

1. Collect and use data to identify trends and monitor potential consequences of technological development.
2. Identify how governmental regulations often influence the design and operation of transportation systems.
3. Describe the processes that are necessary for the entire transportation system to operate efficiently.
4. Design a space transportation system that will complete a lunar mission and identify the processes it would require.

Student Assessment Tools and/or Methods

1. True/False

False 1. Governmental regulations do not influence the design and operation of transportation systems.

False 2. The Moon's gravitational pull holds Earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.

True 3. Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions, are necessary for the entire transportation system to operate efficiently.

True 4. Any invention is likely to lead to other inventions.

True 5. Most of what goes on in the universe involves some form of energy being transformed into another.

2. Brief Constructed Response

Write a one-paragraph answer. Include a strong topic sentence and good supporting details. What are conventions, and why are they necessary to the transport of goods?

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the graphics and/or the question.	Response demonstrates an understanding of the graphics.	Response demonstrates understanding of the complexities of the graphics.
Focus	Response lacks transitional information to show the relationship of the support to the question.	Response addresses the demands of the question.	Response exceeds the demands of the question.
Use of Related Information	Response uses minimal information from the graphics to clarify or extend meaning.	Response uses some expressed or implied information from the graphics to clarify or extend meaning.	Response effectively expressed or implied information from the graphics to clarify or extend meaning.

3. Brief Constructed Response

Write a one-paragraph answer. Include a strong topic sentence and good supporting details. Many processes are involved in the transport of goods. Identify three processes and tell how they contribute to the efficiency of a transportation system.

Category	Below Target	At Target	Above Target
Mission and Date	Information is missing or difficult to locate. Lettering is not sized properly.	Information is properly located.	Information is properly located and sized on the paper.
Mission Facts	Facts of mission details are often inaccurate. Information is missing.	Mission details are accurate. Concise explanation of what was learned and how future missions were influenced.	Mission details are accurate. Extended explanation of what was learned and how future missions were influenced.
Images and Captions	Images are missing or not clear. Images are not located correctly.	Images are clear and located in the proper position with captions.	Images are exceptionally clear and sized to enhance the overall effect of the fact sheet.
Style and Organization	Images and text are poorly spaced. Large empty areas exist. Items are incorrectly placed. Poor contrast.	Images and text are well spaced. Minimal wasted space. Items are correctly placed. Good contrast between text and background.	Images and text are well sized and spaced. No wasted space. Items are correctly placed. Exceptional contrast.
Documentation	Sources are not properly documented, too few, or inappropriate. Sources are placed on front of sheet.	Two properly documented sources are located on the back of fact sheet.	More than two properly documented and placed sources.
Identification of Subsystems	Two or fewer appropriate subsystems are listed for each category. Incorrect subsystems are listed.	At least three appropriate subsystems are listed for each category.	More than three appropriate subsystems are listed for each category.

4. Optional Class Participation Rubric (See ***Lesson Resource 2.1***)

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class. Attempts to answer teacher-generated questions.	Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation For Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily. Is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

5. Rubric: Transporting Materials to and From the Moon (See ***Lesson Resource 2.1)***

Category	Below Target	At Target	Above Target
Poster: Mission Title With Vehicle Names	Missing titles and names. Writing is small or hard to read from five feet away.	Mission title is clear and easily read from five feet away.	Mission title is clear, creative, and easily read from five feet away.
Mission Details	Mission stages are unclear or missing.	Each mission stage is clearly identified.	Each mission stage is accurately and clearly identified.
Poster Graphics	Graphics are incomplete, messy, or unclear. Poor spacing.	Graphics are neat and well spaced.	Graphics are exceptional and well spaced.
Transportation Processes	Fewer than five processes identified. Captions are missing or incorrect.	Five to six processes are identified. Caption describes what happens.	Eight or more processes are identified and clearly described.
Vehicle Sketches	Sketches are incomplete and messy. Labels are missing or unclear.	Sketches of each vehicle are complete, neat, and labeled.	Sketches are exceptionally neat and clear. Labels are appropriate.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

Print Materials

Bishop, R. (2005). *Intelligent vehicle technology and trends*. Norwood, MA: Artech House.
Lowe, D. (2005). *Intermodal freight transport*. Burlington, MA: Butterworth-Heinemann. Wright,
Wright, R.T. (2006). *Technology.* Tinley Park, IL: Goodheart-Wilcox.

Audiovisual Materials

DeBoer, L. (Director). (2002). *The red stuff: The true story of the Russian race for space.* [DVD]. White Star Studio.
Hanks, T. (Executive Producer). (1998). *From the earth to the moon collection*. [DVD/VHS]. (Available from <http://www.libraryvideo.com/, N0970>.)

Required Knowledge and Skills

Students should be familiar with transportation systems that move people and how they might be used in human space travel.

Lesson 2: 5-E Lesson Plan

Engagement

1. The teacher holds up a letter addressed to somebody in another part of the country and asks students to think about how the U.S. Postal Service can deliver it in just a few days.
2. Students offer information about what they know about the delivery process and are invited to ask questions about the parts they are not sure about.
3. Students identify other businesses that offer similar services.

Exploration

1. The teacher asks students to identify parts of the address label and tell how the types and order of information may have significance.
2. The teacher shows a flow chart of the steps in the delivery of mail and gives students a copy.
3. Students identify and record the processes needed at each step and indicate whether a person or machine is necessary to complete the task.

Explanation

1. Students share their information in small groups and elect a spokesperson to share their responses with the class.
2. The teacher explains that the transportation of people and goods involves a combination of individuals and vehicles.
3. The teacher describes and presents examples of the following processes and explains how they are important to the efficiency of a transportation system:
    - Receiving
    - Holding
    - Storing
    - Loading and unloading
    - Moving
    - Delivering
    - Evaluating
    - Marketing
    - Managing
    - Communicating
    - Using conventions
4. The teacher explains that government regulations often influence the design and operation of transportation systems.
5. Students review freight data within the United States and complete the following:
    - Calculation of growth rates
    - Description of trends
    - Identification of consequences if the trends continue (environmental, safety, energy use, etc.)
    - Identification of current and future regulations that will reduce damage to the environment and individual safety
6. The teacher presents the current NASA plan for sending manned missions to the Moon.

Extension

Individually or in small groups, students develop a transportation system for delivering supplies to and returning samples from the Moon. The steps are presented in the form of a chart that identifies the processes needed to complete the task. Labeled sketches of vehicles and related systems are included and described. (See ***Student Resource 2.1***)

Evaluation

Student knowledge, skills, and attitudes are assessed using true/false, brief constructed response, and transportation chart. The rubrics should be presented in advance of the activities to familiarize students with the expectations and performance criteria. They should also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Lesson 2: Lesson Preparation

Teacher Planning

The laboratory-classroom should provide a flexible, resource-rich learning environment that includes areas for lectures and demonstrations, small-group meetings, and research activities. The teacher adapts the learning environment based on the requirements of the unit or lesson.

Tools/Materials/Equipment

- Computers with Internet access
- Reference books
- Calculators

Classroom Safety and Conduct

1. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
2. Students show respect and appreciation for the efforts of others.
3. Students follow all safety rules established for the laboratory-classroom.

Lesson 3: Ship Shape: Designing a Spacecraft Subsystem

Lesson Snapshot

Overview

Big Idea: Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, which must function together for a system to work effectively.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson enables students to develop a subsystem for a moon-bound manned spacecraft.

Lesson Duration: Four to six hours.

Activity Highlights

Engagement: Students identify subsystems found in space vehicles.

Exploration: Students identify the subsystems that must function together for a transportation system to work effectively.

Explanation: The teacher explains that guidance and control rely on communication among people and machines and describes parts of communication systems.

Extension: Students work as a team to design and build a model of a space transport subsystem that must integrate with other subsystems.

Evaluation: Student knowledge, skills, and attitudes are assessed using selected response items and rubrics for brief constructed responses.

Lesson 3: Overview

Lesson Duration

- Four to six hours.

Standards/Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop an understanding of the core concepts of technology. (ITEA/*STL* 2)
  - Requirements are the parameters placed on the development of a product or system. (2R)
- Students will develop abilities to apply the design process. (ITEA/*STL* 11)
  - Make a product or system and document the solution. (11L)
- Students will develop the abilities to use and maintain technological products and systems. (ITEA/*STL* 12)
  - Use information provided in manuals, protocols, or by experienced people to see and understand how things work. (12H)
- Students will develop an understanding of and be able to select and use information and communication technologies. (ITEA/*STL* 17)
  - Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. (17H)
  - Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination. (17I)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA/*STL* 18)
  - A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working. (18E)
  - Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. (18G)

Mathematics:* Principles and Standards for School Mathematics *(NCTM, 2000)*

- Communication Standard (NCTM, All Grades)
  - Use the language of mathematics to express mathematical ideas precisely.
- Connections Standard (NCTM, All Grades)
  - Recognize and apply mathematics in contexts outside of mathematics.

Science:* Benchmarks for Science Literacy *(AAAS, 1993)**

- Issues in Technology (AAAS, 3 C, Grades 3–5)
  - Any invention is likely to lead to other inventions. Once an invention exists, people are likely to think of ways of using it that were never imagined at first.
  - Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. Other factors, such as cost, safety, appearance, environmental impact, and what will happen if the solution fails also must be considered.

- The Universe (AAAS, 4 A, Grades 9–12)
  - Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed.

** Standards are listed with the permission of the National Council of Teachers of Mathematics (NCTM). NCTM does not endorse the content or validity of these alignments.*

*** Material reprinted from* Benchmarks for Science Literacy *(AAAS, 1993) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.*

Learning Objectives

Students will learn to:

1. Identify the subsystems that must function together for a transportation system to work effectively.
2. Describe the role of requirements in the development of a product or system.
3. Identify the parts of a communication system.
4. Describe how requirements are the parameters placed on the development of a product or system.
5. Develop a subsystem for a Moon-bound manned spacecraft.

Student Assessment Tools and/or Methods

1. True/False

False 1. A transportation system may gain efficiency if one of its subsystems is missing or malfunctioning.

False 2. Scientific laws, engineering principles, properties of materials, and construction techniques are not relevant when designing engineering solutions to problems.

True 3. Requirements are the parameters placed on the development of a product or system.

True 4. Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.

True 5. Factors, such as cost, safety appearance, and environmental impact, must be considered in the design of transportation systems.

2. Brief Constructed Response (See ***Lesson Resource 3.1***)

Identify and describe the subsystems found in space transportation vehicles. Write a one-paragraph answer. Include a strong topic sentence and good supporting details.

Category	Below Target	At Target	Above Target
Understanding	Response demonstrates an implied, partial, or superficial understanding of the graphics and/or the question.	Response demonstrates an understanding of the graphics.	Response demonstrates understanding of the complexities of the graphics.

Focus	Response lacks transitional information to show the relationship of the support to the question.	Response addresses the demands of the question.	Response exceeds the demands of the question.
Use of Related Information	Response uses minimal information from the graphics to clarify or extend meaning.	Response uses some expressed or implied information from the graphics to clarify or extend meaning.	Response effectively expressed or implied information from the graphics to clarify or extend meaning.

3. Space Craft Rubric (See ***Lesson Resource 3.2***)

Category	Below Target	At Target	Above Target
Defining the Problem	Rephrases the problem with limited clarity.	Rephrases the problem clearly.	Rephrases the problem clearly and precisely.
Brainstorming a Solution	Each member does not contribute plausible ideas.	Each member contributes a plausible idea.	Each member contributes multiple plausible ideas.
Generating Ideas	Contributes no ideas. Produces incomplete sketches.	Contributes one plausible idea. Produces marginally accurate pictorial and orthographic sketches of design concepts.	Contributes multiple plausible ideas. Produces accurate pictorial and orthographic sketches of design concepts.
Identifying Criteria	Does not restate the criteria clearly and fails to identify constraints.	Restates the criteria clearly and identifies several constraints.	Restates the criteria clearly and precisely and identifies many constraints.
Exploring Possibilites	Inadequately analyzes the pluses and minuses of a variety of possible solutions.	Satisfactorily analyzes the pluses and minuses of a variety of possible solutions.	Thoroughly analyzes the pluses and minuses of a variety of possible solutions.
Selecting an Approach	Selection of solution is not based on consideration of criteria and constraints.	Selects a promising solution based on criteria and constraints.	Selects a promising solution based on a thorough analysis of criteria and constraints.
Making a Model or Prototype	Prototype meets the task criteria to a limited extent.	Prototype meets the task criteria.	Prototype meets the task criteria in insightful ways.
Testing and Evaluating the Design	Testing and evaluation processes are inadequate.	Testing and evaluation processes are adequate for refining the problem solution.	Testing processes are innovative.
Refining the Design	Refinement based on testing and evaluation is not evident.	Refinements made based on testing and evaluation results.	Significant improvement in the design is made based on prototype testing and evaluation.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

Print Materials

Fisher, D.K. (2003). The biggest rocket ever. *Technology and Children* 7(3), pp. 21.

Spangenburg, R. & Moser, K. (2001). *The history of NASA.* New York, New York: Frankllin Watts.

Audiovisual Materials

NASA. (2004). *A Renewed Spirit of Discovery*. Retrieved April 19, 2008. <http://www.nasa.gov/mission_pages/exploration/main/vision_video.html>.

NASA. (n.d.). *Earth, Moon, Mars, and beyond, narrated by Neil Armstrong* (5 Minutes). Retrieved April 19, 2008. <http://www.nasa.gov/mission_pages/exploration/main/vision_video.html>.

Howard, R. (Director), Lovell, J., & Kluger, J. (Writers). (1995). *Apollo 13* [Motion picture]. United States: Universal Pictures.

Sander, Mike (2006) *The Nation's vision for exploration - An update*. Retrieved April 19, 2008. <http://acquisition.jpl.nasa.gov/boo/2006Hightechpresentations/The%20Nations%20Vision%20for %20Exploration.pdf>.

Internet Sites

Hatfield, Skip (2006). *Project Orion overview and prime contractor announcement*. Retrieved April 19, 2008. <http://www.nasa.gov/pdf/156297main_orion_tv_slides.pdf>.

Wilson, Jim (2007). *Mercury: Americans in orbit interactive feature*. Retrieved April 19, 2008. <http://www.nasa.gov/mission_pages/mercury/index.html>.

Required Knowledge and Skills

Students should know that moving "stuff" on Earth and in space involves processes, such as receiving, holding, storing, loading, moving, unloading, and communicating.

Lesson 3: 5-E Lesson Plan

Engagement

1. The teacher shows a clip from the movie, *Apollo 13,* that depicts the living conditions for astronauts as they travel to and from the moon.
2. The teacher answers questions and guides the discussion.
3. The teacher asks students to identify the subsystems that must be on board to make the journey safe for the astronauts.

Exploration

1. Students share their ideas and create a group list of subsystems required on a journey to the moon.
2. The teacher shares three more clips from *Apollo 13* that show the following subsystems: propulsion, guidance, and air purification (scrubber).
3. Students are invited to speculate on the importance of each of these systems.
4. The teacher introduces the categories below. Students label the subsystems with the appropriate category.
    - Guidance and Control
    - Life Support
    - Communication
    - Energy Storage/Production
    - Structural
    - Others?

Explanation

1. Students share their classifications with the class in a group discussion.
2. The teacher presents the statement: A transportation system may lose efficiency or fail if one of its subsystems is missing or malfunctioning. The teacher asks students to comment on how it applies to the previous exercise.
3. The teacher explains that transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, which must function together for a system to work effectively.
4. The teacher explains that information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.
5. The teacher explains that communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.
6. The teacher explains that requirements are the parameters placed on the development of a product or system.
7. Students help identify some of the requirements placed on the development of a Moon-bound manned spacecraft.
8. The teacher shares the concept of trade-offs in design and how NASA uses a video conference room (CEDAR) to allow designers to share and discuss their ideas.

Extension

Students are assigned to project teams that are assigned the job of developing a subsystem for a Moon-bound manned spacecraft. Students use the engineering design process to develop their system while working with other design teams to negotiate trade-offs. Scale models of each system are produced and evaluated as well as written descriptions.

Evaluation

Student knowledge, skills, and attitudes are assessed using true/false, brief constructed response and system prototype. The rubrics should be presented in advance of the activities to familiarize students with the expectations and performance criteria. They should also be reviewed during the activities to guide students in the completion of assignments. The teacher may wish to develop a collection of annotated exemplars of student work based on the rubrics. The exemplars will serve as benchmarks for future assessments and may be used to familiarize students with the criteria for assessment.

Lesson 3: Lesson Preparation

Teacher Planning

The laboratory-classroom should provide a flexible, resource-rich learning environment that includes areas for lectures and demonstrations, small-group meetings, and research activities. The teacher adapts the learning environment based on the requirements of the unit or lesson.

Tools/Materials/Equipment

- Computers with Internet access
- Reference books
- Calculators

Classroom Safety and Conduct

1. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
2. Students show respect and appreciation for the efforts of others.
3. Students follow all safety rules established for the laboratory-classroom.

References

A & E Television Networks. (1996-2008). *Interactive Space Timeline: Explore the Space Age*. Retrieved April 19, 2008, from <http://www.history.com/minisite.do?content_type=Minisite_Generic&content_type_id=51655&display_order=5&mini_id=1438>.

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Bishop, R. (2005). *Intelligent vehicle technology and trends*. Norwood, MA: Artech House.

Culp, R. (March 2007) Time line of space exploration. Retrieved April 19, 2008. <http://my.execpc.com/~culp/space/timeline.html>.

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Furniss, T. (2001). *The history of space vehicles.* San Diego, CA: Thunder Bay Press.

Hamilton, C. J. (2007). History of space exploration. Retrieved April 19, 2008. <http://www.solarviews.com/eng/history.htm>.

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NASA History Division. (April 2008). Steven Dick, Chief Historian. Key Documents in the History of Space Exploration. Retrieved April 19, 2008. <http://history.nasa.gov/spdocs.html>.

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Spangenburg, R. & Moser, K. (2001). *The history of NASA*. New York, New York: Frankllin Watts.

The Ultimate Space Place. (2004). Space history. Retrieved April 19, 2008. <http://www.thespaceplace.com/index.html>.

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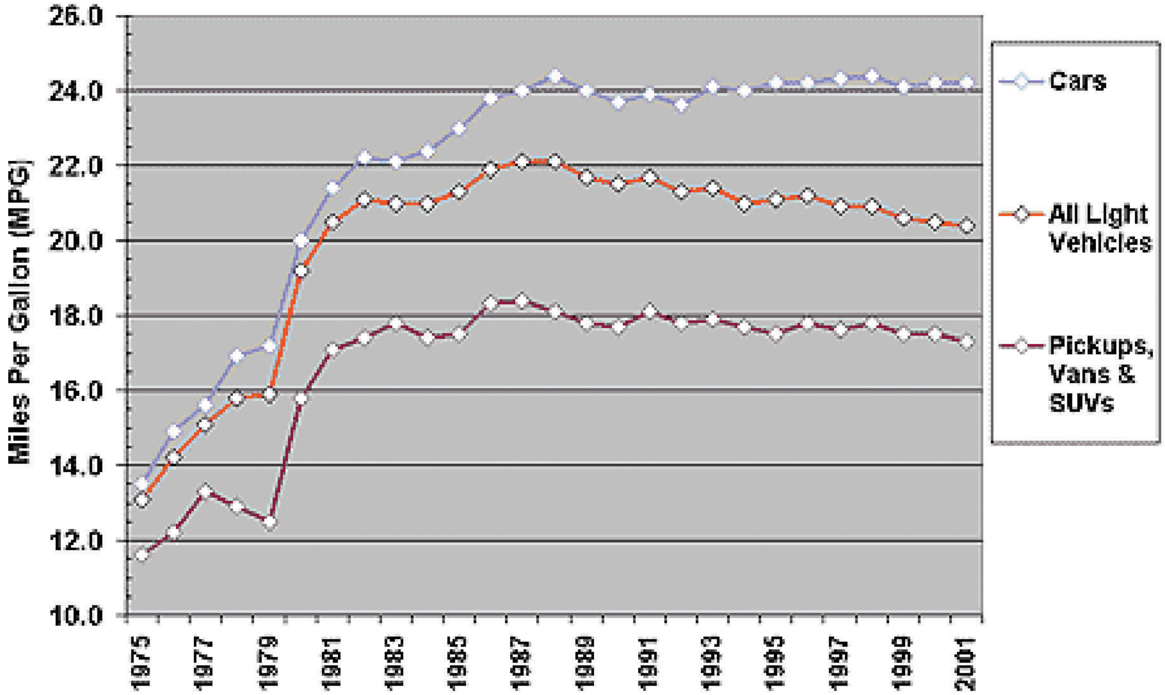
Appendices
Resource Documents

Automobile Fuel Efficiency



Minnesota Pollution Control Agency. (n.d.). Retrieved January 15, 2009 from <http://www.pca.state.mn.us/artwork/indicators/1101-figure1.gif>. Used with permission.

1. What does fuel efficiency mean with regard to this graph?
2. Describe in general terms how fuel efficiency has changed from 1975 to 2001.
3. What year did automakers increase fuel efficiency the most?
4. What changes do you think automakers made in order to improve fuel efficiency?

Fact Sheet
Major Events in Human Space Exploration

Procedure:

1. Choose a major event in the history of human space exploration. Possible topics include:
   - Vostok 1, Yuri Gagarin first human in orbit
   - Vostok 5, Valentina Tereshkova, first woman in space
   - Mercury Friendship 7, John Glenn, first American in orbit
   - Alexei A. Leonov on Voskhod 2 , first space walk
   - Apollo 8, first manned spacecraft to orbit the Moon
   - Apollo 11, first manned soft landing on the Moon, first moonwalk

2. I will be researching ______________________________________.

3. Using the Internet and other resources, research your topic and complete the following questions. Two references are needed in this activity.

Questions related to your topic: Answer the following questions related to your topic.

1. What was the name of the astronaut (or cosmonaut) involved in the mission?
2. When did the mission occur?
3. What was major accomplishment of the mission?
4. What was learned from the mission?
5. How did this mission help prepare for future missions?
6. What subsystems were necessary to make the mission a success?
   - Transportation
   - Life Support

After your research is completed: Prepare a one-page Fact Sheet (a sheet that could be given to others to teach them about your topic). It is recommended that you use Microsoft PowerPoint® to create this page. Your one-page sheet must be typed and in the following format (see sample in Figure 1):

A. Date of mission
B. Name of mission
C. Name of explorer(s)
D. Image of explorer(s)
E. Image of vehicle
F. Description of subsystems
   1. Transportation
   2. Life Support
G. Flag of country involved.

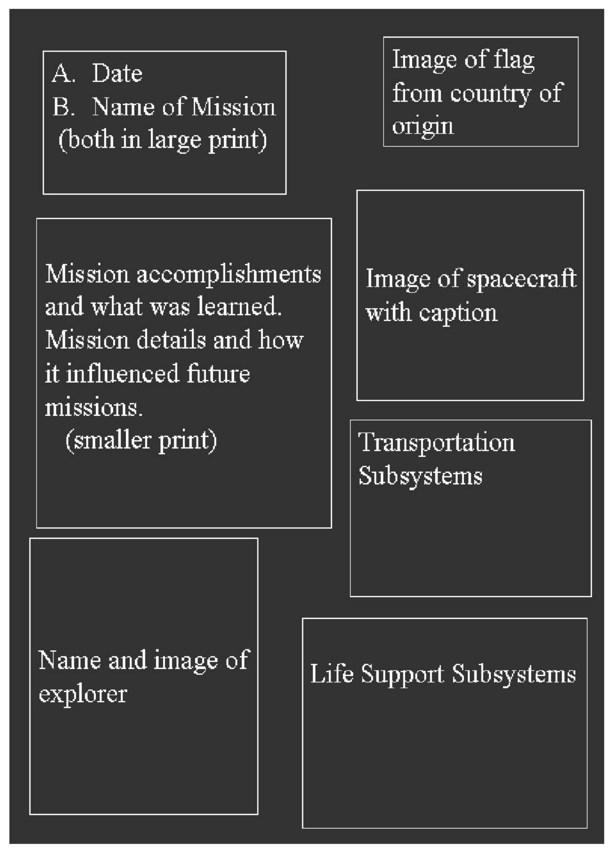


Figure 1: Sample Fact Sheet Layout

Design

Transporting Materials to and from the Moon

Procedure:

1. Review the NASA proposal for transporting astronauts to the Moon and back.
2. In your design team of 2–4 students, plan a transportation system that will deliver supplies to the Moon and return waste materials and lunar samples to Earth. Your systems must be based on modern and "leading edge" technology.
3. Sketch out a chart that indicates stages of the mission and the type of vehicles that will be used.
4. Identify where the following processes would occur and how they would be accomplished in your plan:
    - Receiving
    - Holding
    - Storing
    - Loading and unloading
    - Moving
    - Delivering
    - Evaluating
    - Marketing
    - Managing
    - Communicating
    - Using Conventions
5. Create a small poster depiction of your chart. This should include a title and mission name. Vehicles should also be given names and labeled.
6. Develop your sketch and lay it out neatly on your poster. Label each stage of the mission.
7. In smaller writing, label the processes on the poster and write a short caption telling what is happening. Some processes may occur more than once.
8. On separate sheets of paper, create sketches of your launch vehicle.

Category	Below Target	At Target	Above Target
Preparation	Rarely prepared. Minimal effort to participate.	Prepared for class. Attempts to answer teacher-generated questions.	Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.
Curiosity	Rarely demonstrates curiosity.	Usually demonstrates curiosity.	Consistently demonstrates curiosity.
Motivation For Learning	Rarely demonstrates motivation for learning.	Usually demonstrates motivation for learning.	Consistently demonstrates motivation for learning.
Use of Time	Gives up easily. Is not engaged. Has difficulty remaining on task.	Makes good use of class time to work on assignments and projects.	Makes excellent use of class time to work on assignments and projects.

Rubric: Transporting Materials To and From the Moon

Category	Below Target	At Target	Above Target
Poster: Mission Title With Vehicle Names	Missing titles and names. Writing is small or hard to read from five feet away.	Mission title is clear and easily read from five feet away.	Mission title is clear, creative, and easily read from five feet away.
Mission Details	Mission stages are unclear or missing.	Each mission stage is clearly identified.	Each mission stage is accurately and clearly identified.
Poster Graphics	Graphics are incomplete, messy, or unclear. Poor spacing.	Graphics are neat and well spaced.	Graphics are exceptional and well spaced.
Transortation Processes	Fewer than five processes identified. Captions are missing or incorrect.	Five to six processes are identified. Caption describes what happens.	Eight or more processes are identified and clearly described.
Vehicle Sketches	Sketches are incomplete, messy. Labels are missing or unclear.	Sketches of each vehicle are complete, neat, and labeled.	Sketches are exceptionally neat and clear. Labels are appropriate.

Spacecraft Design - Designing and Integrating Subsystems

Procedure

1. Meet with your design team and review the criteria and constraints of your assigned subsystem.
2. Use the back of this page to document your system's development using the engineering design process.
    - Each subsystem will be evaluated for weight, volume, and energy use (or production).
    - Measurements will be based on research and reasonable estimates.
3. Each team is to designate one member who will meet with the other teams to discuss designs, solve problems, and negotiate for space, weight, and power.
4. After selecting an approach, the teacher will call a meeting in which subsystems will be presented and vital information will be shared and tallied.
5. The design teams will make necessary adjustments and construct prototypes of their systems.
6. All models must be made at the same scale (one inch = one foot).

Project Criteria: All subsystems must fit together and meet the following requirements:

- Total energy use and production must come out even.
- A crew of two to four astronauts must have adequate living/working space and life support.

Project Constraints: The following limits apply to the design and construction of your system:

- Crew Exploration Vehicle (CEV) must have a volume between ___and ___ cubic feet.
- Total ship weight must not exceed _________ pounds.
- Five days (hours) to design and build prototype.

Engineering Design Process

Define the problem: ____

Brainstorm : ____

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Generate Ideas : Attach sketches or use the back of this page.

Identify Criteria: ____

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Analyze each idea that you sketched. Record pros and con next to each idea.

Identify the solution you will use and explain why you chose it: ___________________

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Explain how you tested and evaluated your solution: ____________________________

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Describe your refinements and their results:

Refinement	Result
1. ________________	________________________________
2. ________________	________________________________
3. ________________	________________________________

Spacecraft Subsystems

Crew Exploration Vehicle (CEV) Structure

Criteria and constraints: Structure of crew module will be cone shaped with a fifteen to eighteen foot (15'–18') diameter and eight to ten foot (8'–10') height. The walls of the vehicle should be smooth and should have one crew hatch and two portholes. The base should have a mechanism for attaching and releasing the Service Module and a method for connecting control cables. The weight of the shell material is estimated to be 60 pounds per square foot.

CEV Service Module

Criteria and constraints: The structure of the service module must match the diameter of the CEV and have a volume of at least 350 cubic feet for fuel. One third of the fuel is liquid oxygen weighing about 67 pounds per cubic foot. Two thirds of the fuel will be hydrogen, weighing 4.2 pounds per cubic foot. Battery space must also be provided for the Energy Production Team as well as space for deployable solar arrays.

Energy Production

Criteria and constraints: Solar arrays and batteries will provide the electricity requirements for the CEV. The solar arrays must be designed to fit among the structure of the Service Module and deploy once in space. Photovoltaic cells (solar panels) will produce 6 watts per square foot. The mass density for space-qualified batteries is 0.02 pounds per watt.

Communication

Criteria and constraints: Each crew member must have a headset communication system for use while in launch suits. Space to ground communication requires a retractable parabolic antenna. Transmitter and receiver will require 300 watts during intermittent operation.

Life Support

Criteria and constraints: Oxygen and water tanks must be used to supply the needs of each astronaut. Tank material is 5 pounds per square foot. Water purification (50 watts) may be used to reduce the total needed. Filters systems may be used to remove carbon dioxide from the air.

Guidance and Control

Criteria and constraints: Main engines used for orbit and de-orbit burns require 800 pounds of fuel per burn (3 needed for lunar mission). An additional 200 pounds are needed for attitude adjustment. Each gallon of fuel weighs 8 pounds and has a volume of 0.134 cubic feet. Tank material is 5 pounds per square foot. Computers and navigation systems will require 400 watts.

Crew Living/Work Space

Criteria and constraints: Each astronaut should have between 80 and 120 cubic feet of space. Crew members must be able to work and sleep in a fully extended position. Each crew member must have a launch seat that can change from a launch to stowed configuration. Each astronaut must have 5.5 pounds of food per day, 2 pounds of water per day for drinking, food preparation and hygiene and 11 pounds of oxygen per day. Accommodations for waste management, crew equipment storage (clothes, personal items, etc.), and emergency medical supplies require 662 pounds.

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