## Course Description

<table>
<thead>
<tr>
<th><strong>Standards Addressed</strong></th>
<th>See Course Outlines for a complete explanation of how educational standards are addressed in the course. Each unit also lists the specific standards associated with it.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intended Audience</strong></td>
<td>Grade 8</td>
</tr>
<tr>
<td><strong>Purpose of Course</strong></td>
<td><em>Technological Systems</em> is designed to introduce students to systems and processes to develop an understanding of the impact of technology on humans, the environment, and the global community. By investigating systems through their function, design, and development, students will understand what systems are, why they are developed and how ‘systems thinking’ can be used to describe them. Students engage in activities and experiences where they evaluate the impacts of technology through the lenses of culture, society, economics and the environment.</td>
</tr>
<tr>
<td><strong>Course Overview</strong></td>
<td><em>Technological Systems</em> is intended to teach students how systems work together to solve problems and capture opportunities. A system can be as small as two components working together (technical system/device level) or can contain millions of interacting devices (user system/network level). We often break down the Macro systems into less complicated Microsystems in order to understand the entire system better. However, technology is becoming more integrated and systems are becoming more and more dependent upon each other than ever before. Electronic systems are interacting with natural (i.e., bio) systems as humans use more and more monitoring devices for medical reasons. Electrical systems are interacting with mechanical and fluid power systems as manufacturing establishments become more and more automated. This course gives students a general background on the different types of systems but concentrates more on the connections between these systems.</td>
</tr>
<tr>
<td><strong>Course Length</strong></td>
<td>18 weeks recommended</td>
</tr>
<tr>
<td><strong>Connections to Engineering byDesign™ Program Sequence</strong></td>
<td><em>Technological Systems</em> builds on K–5 experiences as well as those in <em>Exploring Technology</em> and <em>Invention and Innovation</em> to develop student understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students are involved in activities and experiences, where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students also develop skills in researching for information, communicating design information, and reporting results. As the suggested capstone middle school course, <em>Technological Systems</em> provides the foundation for future studies in a technology education sequence. Students learn how technology, innovation, design, and engineering interrelate and are interdependent.</td>
</tr>
</tbody>
</table>
# Unit Highlights

<table>
<thead>
<tr>
<th>UNITS OF STUDY</th>
<th>LESSONS</th>
<th>REQUIRED HOURS</th>
<th>ENRICHMENT (OPTIONAL) HOURS</th>
<th>TOTAL HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNIT 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technological Systems: How They work</td>
<td>Lesson 1 – Development of Technological Systems</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Big Idea – Technological Systems are designed and developed following specific Criteria.</td>
<td>Lesson 2 – Design of Technological Systems</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>UNIT 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technological Systems: Issues and Impacts</td>
<td>Lesson 1 – Social and Cultural Impacts</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Big Idea – Technological Systems can impact the world in a variety of ways, and can be both positive and negative.</td>
<td>Lesson 2 – Environment and Economics</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>UNIT 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technological System Interaction</td>
<td>Lesson 1 – System Functions, Processes, and Interactions</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Big Idea – Technological Systems are designed to meet a specific need and can address this need through a variety of functions, processes, and interactions with other systems.</td>
<td>Lesson 2 – System Design and Development</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td><strong>UNIT 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintaining Technological Systems</td>
<td>Lesson 1 – Understanding Technical Information</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Big Idea – Technical information comes in many forms and is used to test, evaluate, and problem-solve within systems.</td>
<td>Lesson 2 – Problem-solving Within Systems</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td><strong>UNIT 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintaining Technological Systems</td>
<td>Lesson 3 – System Testing and Evaluation</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>
### UNIT 5  
**Technological Systems in the Designed World**

Big Idea – A variety of different technological tools, processes, and materials can be integrated to form systems.

<table>
<thead>
<tr>
<th>Lesson 1 – Power and Energy Systems</th>
<th>5</th>
<th>2</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson 2 – Communication Systems</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Lesson 3 – Constructing Specialized Manufacturing Environments</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
</tbody>
</table>

### UNIT 6  
**The Refocus of NASA**

Big Idea – Space transportation systems, although highly sophisticated and technologically advanced, employ the basic subsystems found in conventional transportation systems.

<table>
<thead>
<tr>
<th>Lesson 1 – Celebrating the Space Shuttle</th>
<th>4</th>
<th>2</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson 2 – The Future of the Space Program</td>
<td>9</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>

| Totals | 70 | 24 | 94 |
Unit #1: Technological Systems: How They Work

Overview

This course will investigate technological systems through their function, design, development, interaction and maintenance. Systems included in this exploration include communications, construction, manufacturing, bio-medical and power energy.

Big Idea

Technological Systems are designed and developed following specific criteria.

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

Purpose of the Unit

Unit 1 prepares students to understand and evaluate the design and development of technological systems.
### Standards/Benchmarks

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

<table>
<thead>
<tr>
<th>STL 1F</th>
<th>New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2M</td>
<td>Technological systems include input, processes, output, and, at times, feedback.</td>
</tr>
<tr>
<td>2N</td>
<td>Systems thinking involves considering how every part relates to others.</td>
</tr>
<tr>
<td>2O</td>
<td>An open-loop system has no feedback path and requires human intervention, while a closed loop system uses feedback.</td>
</tr>
<tr>
<td>2R</td>
<td>Requirements are the parameters placed on the development of a product or system.</td>
</tr>
<tr>
<td>7E</td>
<td>The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.</td>
</tr>
<tr>
<td>10G</td>
<td>Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product to improve it.</td>
</tr>
</tbody>
</table>

**Mathematics:** Common Core Standards for Mathematics *(CCSM, 2011)*

#### Expressions & Equations Standard *(CCSM, Grade 7)*

| 7.EE   | Use properties of operations to generate equivalent expressions.                                                                     |
| 7.EE   | Solve real-life and mathematical problems using numerical and algebraic expressions and equations.                                |

#### Geometry Standard *(CCSM, Grade 7)*

| 7.G    | Draw, construct, and describe geometrical features and describe the relationships between them.                                   |
| 7.G    | Solve real-life and mathematical problems involving angle measure, area, surface area and volume.                              |

#### Ratios & Proportional Relationships Standard *(CCSM, Grade 7)*

| 7.RP.1 | Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. |
| 7.RP.3 | Use proportional relationships to solve multistep ratio and percent problems.                                                      |
### English Language Arts: Common Core Standards for English Language Arts (CCSELA, 2011)

#### Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)

- **RST.6-8.1.** Cite specific textual evidence to support analysis of science and technical texts.

- **RST.6-8.3.** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

#### Integration of Knowledge and Ideas (Literacy in Science and Technical Subjects, Grades 6-12)

- **RST.6-8.7.** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

### Science: Benchmarks for Science Literacy (AAAS, 1993/2009)

#### The Nature of Technology

<table>
<thead>
<tr>
<th>3A/M3</th>
<th>Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. They also usually have to take human values and limitations into account.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3B/M3a</td>
<td>Almost all control systems have inputs, outputs, and feedback.</td>
</tr>
<tr>
<td>11A/M2</td>
<td>Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole. Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.</td>
</tr>
<tr>
<td>3B/M1</td>
<td>Design usually requires taking into account not only physical and biological constraints, but also economic, political, social, ethical, and aesthetic ones.</td>
</tr>
<tr>
<td>3C/M2</td>
<td>Technology cannot always provide successful solutions to problems or fulfill all human needs.</td>
</tr>
</tbody>
</table>

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1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Unit Objectives

Lesson 1: Development of Technological Systems
Students learn to:
• Define a system as “open” or “closed
• Identify requirements placed on a system
• Interpret the components of the systems model: input, processes, output, and feedback
• Understand and explain the relationship between components in a technological system

Student Assessment
• Engineering Design Journal
• Constructed Response items
• Performance Rubrics
• End of lesson quiz
• End of unit quiz

Lesson 2: Design of Technological Systems
Students learn to:
• Compare and contrast the process of invention versus the process of innovation
• Explain how the development and construction of technological systems have changed over time, due to increased control capabilities.
• Design a product, system or environment that could not be produced without technology.

Student Assessment
• Engineering Design Journal
• Presentation
• Constructed Response items
• Performance Rubrics
• End of unit quiz
Unit 1: Technological Systems: How They Work

Lesson 1: Development of Technological Systems

Lesson Snapshot

Overview

Big Idea: Technological Systems are developed to meet specific criteria and must be able to function to complete the systems loop.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn that technological systems are built from multiple components to meet specific criteria. Systems are “open” or “closed” and include: input, processes, output, and feedback. The relationship between components in a system determine the function of the system.

Lesson Duration: 4 hours, plus 1 enrichment hour.

Activity Highlights

Engagement
Students are introduced to the concept of systems through the investigation and discussion of what components make up a system and describing systems in their daily lives.

Exploration
Using descriptions of existing systems, students work in pairs to identify and explain system components, types, relationships and the requirements on that system.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject.

Extension
Working in engineering design teams, students develop a diagram or demonstration of a system to accomplish a specific goal or process. Teams document and explain the role and type of each component in their system, describing it appropriately as an open or closed system, and present it to the class.

Enrichment
Using the designed systems, engineering design teams will build a model of the completed system, and relate it to systems developed by other design teams.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, an End of lesson quiz and an End of unit quiz.
## Unit 1: Technological Systems: How They Work

### Lesson 1: Development of Technological Systems

#### Lesson Overview

**Lesson Duration**
4 hours, plus 1 enrichment hours.

**Standards/Benchmarks**

<table>
<thead>
<tr>
<th><strong>Technology:</strong> Standards for Technological Literacy (STL) (ITEA/ITEEA, 2000/2002/2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL 2M</td>
</tr>
<tr>
<td>2N</td>
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</tr>
<tr>
<td>2R</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mathematics:</strong> Common Core Standards for Mathematics (CCSM, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry Standard (CCSM, Grade 7)</td>
</tr>
<tr>
<td>7.G - 1</td>
</tr>
<tr>
<td>7.G - 2</td>
</tr>
<tr>
<td>Ratios &amp; Proportional Relationships Standard (CCSM, Grade 7)</td>
</tr>
<tr>
<td>7.RP.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>English Language Arts:</strong> Common Core Standards for English Language Arts (CCSELA, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Ideas and Details</strong> (Literacy in Science and Technical Subjects, Grades 6-12)</td>
</tr>
<tr>
<td>RST.6-8.1</td>
</tr>
<tr>
<td>RST.6-8.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Science:</strong> Benchmarks for Science Literacy (AAAS, 1993/2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3B/M3a</td>
</tr>
<tr>
<td>11A/M2</td>
</tr>
</tbody>
</table>

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every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.

**3B/M1** Design usually requires taking into account not only physical and biological constraints, but also economic, political, social, ethical, and aesthetic ones.
Learning Objectives
Students learn to:

1. Define a system as “open” or “closed
2. Identify requirements placed on a system
3. Interpret the components of the systems model: input, processes, output, and feedback
4. Understand and explain the relationship between components in a technological system
5. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
6. Work safely and accurately with a variety of tools, machines, and materials.
7. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials
3. Discovery Channel, How Stuff Works 3 DVD set,

Print Materials

Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. System Models, System Engineering
   b. Basic Flowcharts
   c. Technology System Components

3. LMS Engineering Innovation, Model Based System Engineering - an Introduction, Retrieved on 04/26/12 from http://www.lmsintl.com/Model-Based-System-Engineering (Permission to link requested)
8. Discovery Channel, How Stuff Works, Retrieved on 04/29/12 from http://www.howstuffworks.com/ (Permission to link requested)

Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software.
Unit 1: Technological Systems: How They Work

Lesson 1: Development of Technological Systems

5-E Lesson Plan

Teacher’s Note: Separate students into small groups, considering the needs of diverse learners. If students do not have design journals, blank paper must be available. The Extension activity may require diverse materials, depending on the purposes of the systems selected for modeling. The Engineering Design Journal may be reviewed throughout the lesson or as a summative assessment.

Engagement
The teacher lists five different common items or tasks on the board, such as making a phone call, mailing a letter or preparing to walk a dog. Students are introduced to the concept of systems through the investigation and discussion of what components make up a system and describing systems in their daily lives.

- Using their Engineering Design Journals, students write down the steps that they consider important in completing the selected task from the list.
- Other potential steps that are part of the process such as charging or plugging in the phone are discussed as requirements or constraints on the system.
- Once the steps have been listed, the class will discuss the steps needed to complete these tasks, and the teacher will introduce systems terminology, including: input, output, process, feedback and open and closed systems.
- In their engineering design journals, students are asked to create a chart or diagram of the system that was previously described.

Exploration
The teacher provides students with a visual description of a specific system, and students work in pairs to identify components and the purpose of the system.

- Using their engineering design journals, students document possible system purposes and identify component types with specific examples.
- Working with their partner, students identify the relationships between components and the restraints on the function of the system.
- In their engineering design journals, students describe the steps that make up the process from the visual description.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- As a class, students will discuss requirements placed on systems as constraints in their design. Discussion will include potential sources of requirements, such as social, economic, political, ethical and aesthetic concerns.
• Students are divided into Engineering Design Teams to discuss and brainstorm possible tasks or processes to accomplish with a system that they will design. Tasks should be simple, with no more than 5 components and 5 processes, and may include human interaction.

• Once each team has a list of possible tasks, the class will discuss ideas together to make the final selection for each team.

• Potential processes, materials and the selected task to be completed by each team's system should be documented in the Engineering Design Journal.

• In preparing to construct a model of their system, students will solve real-life math problems with an emphasis on geometric shapes, ratios and fractional measurement.

Extension
Working in engineering design teams, students develop a diagram or demonstration of a system to accomplish a specific goal or process.

• Using the system goal selected by the team in the Explanation activity, students develop a system to complete that task, using appropriate measurement, angles, area, surface area and volume of system components.

• Documentation of the design process including system sketches, processes and a diagram or demonstration are included in the Engineering Design Journal.

• Documentation of system components, the role that they play within the system and the system type are included in the presentation and Engineering Design Journal.

• Teams will present the system with a diagram or demonstration of the system to the class.

Enrichment
Using the designed systems, engineering design teams will build a model of the completed system, and relate it to systems developed by other design teams.

Evaluation
Students' knowledge, skills, and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, End of lesson quiz, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Assessment instruments are both below and included as separate resources, suitable for distribution to students.
**Assessment Resource 1.1.1: Engineering Design Journal Rubric**

Name _______________________

The purpose of the Engineering Design journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

**Assessment:**

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>3</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
</tr>
<tr>
<td>Activity 1- identified steps in process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity 1- chart or diagram</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity 2- System purposes &amp; components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity 2- System relationships &amp; process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity 3- System process, components and tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity 4- Sketches of diagram/demonstration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improvement in drawing skills over time</td>
<td></td>
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</tr>
<tr>
<td>Includes notes and comments</td>
<td></td>
<td></td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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<tr>
<td>Bonus: Additional materials</td>
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<tr>
<td>Total</td>
<td></td>
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</tr>
</tbody>
</table>

Comments:

Grade:

**Student Assessment**
- Performance Rubrics
• End of unit quiz

**Assessment Resource 1.1.2: Constructed Response Quiz**

Students are asked to reflect on, and write a one-paragraph response to one of the following statements.

1. Describe the systems model in your own words.

2. Identify the type of system shown in the diagram below, and describe the characteristic(s) that make it that type of system.

![Diagram of system model](image)

3. Describe the system that you use to brush your teeth.

4. Draw a diagram of the process of sending an e-mail or text, including system components.

5. Locate the four parts of the systems model in the following system:
   
   a. Extract money from pocket or purse
   b. Deposit money in appropriate slot
   c. Select button to press
   d. Press button
   e. Listen for operation of machine
   f. Retrieve can from bin
   g. Retrieve change if necessary

6. What is the goal of the system described above?

7. What kind of system is the system described in #5? Why?

8. Describe in your own words, three systems processes you can see in your life now that you are familiar with the concept of systems.

9. If there were no constraints, like time and money, what kind of system would you want to build? What would be the purpose of that system?

10. Identify 5 constraints on a system, other than time and money.
### Assessment Instrument - Brief Constructed Response (BCR) Writing Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>
# Assessment Resource 1.1.3: Rubric for Presentations

Grade: 

**Presenter(s)**

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explained goal of the system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explained system components and their roles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explained system type</td>
<td></td>
<td></td>
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### Assessment Instrument – Class Participation Rubric

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</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td>Curiosity</td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td>Use of Time</td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
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Comments:

Grade:
Unit 1: Technological Systems: How They Work

Lesson 1: Development of Technological Systems

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times for viewing or reading resource materials. Teachers should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Depending on the types of systems selected for the presentations, you may need to provide materials for demonstration.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

If students are using the computer to make charts, there are many different software options, including free flow chart software listed in the internet resources section. Students may also construct these charts using word processing or graphic software.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and graphic design companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges or field trips, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Engineering Design Journals or blank paper for sketching
4. 12” Ruler for each student
5. Drafting pencils for each student
6. Optional: flowchart templates

Enrichment Activity Materials
1. Safety glasses, one pair per student
2. Bamboo skewers, pack of 50
3. Twine, 100 yard roll
4. Gift Wrap Tape
5. GT-RX Wheels
6. Corrugated Cardboard, salvaged, approximately 1 *” X 10” piece per student
7. Assorted sandpaper

Laboratory-Classroom Safety and Conduct
1. Students use tools and equipment safely, and only as allowed.
2. Students demonstrate respect and courtesy for the ideas expressed by others.
3. Students use computers only for lesson appropriate tasks.

Teacher Resources
- Teacher Resource 1.1.1: Brief Constructed Response Writing Rubric
- Teacher Resource 1.1.2: Class Participation Rubric
- Teacher Resource 1.1.3: Constructed Response Quiz Answer Key
- Teacher Resource 1.1.4: Geometry and Measurement in Systems Answer Key

Student Resources
- Student Resource 1.1.1: Unit PowerPoint
- Student Resource 1.1.2: Lesson Glossary
- Student Resource 1.1.3: Engineering Design Journal Guidelines
- Student Resource 1.1.4: Making a Chart or Diagram of a System
- Student Resource 1.1.5: Geometry and Measurement in Systems
- Student Resource 1.1.5: Lesson Design Brief

Assessment Resources
- Assessment Resource 1.1.1: Engineering Design Journal Rubric
- Assessment Resource 1.1.2: Constructed Response Quiz
- Assessment Resource 1.1.3: Rubric for Presentations
Lesson 1: Development of Technological Systems

Teacher Resource 1.1.1: Brief Constructed Response Writing Rubric

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</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
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<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
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<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
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Comments:

Grade:
## Unit 1: Technological Systems: How They Work

### Lesson 1: Development of Technological Systems

**Teacher Resource 1.1.2: Class Participation Rubric**

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Comments:

Grade:
Unit 1: Technological Systems: How They Work

Lesson 1: Development of Technological Systems

Teacher Resource 1.1.3: Constructed Response Quiz Answer Key

Name: ___________________________________________________________

Students are asked to reflect on, and write a one-paragraph response to one of the following statements.

1. Describe the systems model in your own words.

Student responses should include the purpose of a system and descriptions of input, process, output and feedback.

2. Identify the type of system shown in the diagram below, and describe the characteristic(s) that make it that type of system.

   ![Diagram of a closed loop system]

   This is a closed loop system, because it has feedback.

3. Describe the system that you use to brush your teeth.

   Student responses should include inputs like toothbrush, toothpaste, processes such as turning on the water or brushing, outputs described similarly to clean teeth and may include feedback, such as looking in a mirror to visually confirm results.

4. Draw a diagram of the process of sending an e-mail or text, including system components.

   Student responses should include the appropriate symbols for input, process, output, feedback to describe their process.
4. Locate the four parts of the systems model in the following system:

   h. Extract money from pocket or purse  
   i. Deposit money in appropriate slot  **Input**  
   j. Select button to press  
   k. Press button  **Process**  
   l. Listen for operation of machine  
   m. Retrieve can from bin  **Output**  
   n. Retrieve change if necessary  **Feedback**

5. What is the goal of the system described above?

   The system described above is intended to purchase a can of soda from a vending machine.

6. What kind of system is the system described in #5? Why?

   This system could be described as an open or closed loop system. In describing it as an open loop system, students should cite the human intervention needed to retrieve the soda. In describing it as a closed loop system, students should describe feedback within the system.

8. Describe in your own words, three systems processes you can see in your life now that you are familiar with the concept of systems.

   Students should be able to identify a variety of systems processes from mechanical, electronic or operational systems that they witness in their lives.

9. If there were no constraints, like time and money, what kind of system would you want to build? What would be the purpose of that system?

   Students should describe any system of their choice, clearly stating the purpose or goal of the system and listing the inputs, processes, outputs and feedback for that system.

10. Identify 5 constraints on a system, other than time and money.

   There are many potential answers to this item, including environmental, social, cultural, political and aesthetic concerns.
Lesson 1: Development of Technological Systems

Teacher Resource 1.1.4: Geometry and Measurement in Systems

Answer Key

Name: ________________________________

Ratios: Complete the following problems, reducing all answers to the smallest possible ratio. Round decimals to create whole numbers. Ratios will help you to see the scale between your model and real-life systems.

1. 4:16 ______ 1:4 ______
2. 14:21 ______ 2:3 ______
3. 30:18 ______ 5:3 ______
4. 144:12 ______ 12:1 ______
5. 12:9 ______ 4:3 ______
6. 6.3:9.9 ______ 2:3 ______
7. 9.9:6.3 ______ 3:2 ______
8. 7/9: 1/18 ______ 14:1 ______
9. 8/4:6/12 ______ 4:1 ______
10. 9/10:1/100 ______ 90:1 ______

Measurement: Convert these linear measurements to the specified unit.

1. 1 inch = ___2.54________cm
2. 12 inches = ___30.48______cm
3. ¼ inch = ___6.35________mm
4. 3 miles = _____15840____ ft
5. 26000 ft = ___4.92_______ mi
6. 983mm = ___38.70______ in
7. 18 miles = _28.97________ km
8. 8 yards = ___7.31_______ m
9. 13 km = ___42650.8_______ ft
10. 41 cm = ___1.35_______ ft

Area: Compute the area of the following shapes, using the units indicated.

1. A rectangle with sides of length 9 inches and 6 inches.
   54 square inches

2. A rectangle with sides of length 0.75 ft and 0.5 ft.
   0.375 square feet
3. A circle with a 1 foot radius.
   3.14 square feet

4. A circle with a 12 inch radius.
   452.16 square feet

5. A right triangle with legs of length 6 cm and 8 cm.
   24 square cm
Lesson 1: Development of Technological Systems

Student Resource 1.1.2: Lesson Glossary

**Closed System**  A closed system is one which has feedback. The feedback may come a variety of forms including ratings, materials for reuse or information.

**Component**  Individual parts of the system are called components.

**Engineering Design Journal**  A book, notebook or binder that contains documentation of the process of attempting to solve a problem through technology is an engineering design journal. These journals generally contain notes, sketches and comments to help the designer improve the solution to the problem.

**Engineering Design Team**  A group of people working together to develop a solution to a problem.

**Feedback**  Information given about the output of the system is feedback.

**Input**  An input is something that goes into a system, a resource such as time, money, communication, etc.

**Open System**  An open system is one that does not have feedback. The inputs are processed, to make the desired outputs and no information is given to make a change in the system.

**Output**  An output is what comes out of the process, the finished product, or completed process.

**Process**  A process is something that happens to or with the inputs.

**System**  A system is a group of parts that work together as a unit.

**Systems Model**  The systems model is a general model of components that work together, with each one serving a specific function.

**Task**  A job or chore to complete, or a goal to be reached are called the task.

**Technology**  is an object, environment or process that was created by man.
Lesson 1: Development of Technological Systems

Student Resource 1.1.3: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 1: Technological Systems: How They Work

Lesson 1: Development of Technological Systems

Student Resource 1.1.4: Making a Chart or Diagram of a System

The purpose of creating a visual representation of a system is to show the operation of a system, all of the components involved and how they are related to each other.

A visual representation like this can help to plan a system prior to building, to select materials based on what a component needs to do in a system and to help troubleshoot problems when a system is not functioning properly.

Charts or diagrams can be created using word processing, spreadsheet or other office software, as well as in specialized visual software applications. These charts and diagrams may also be drawn.

Here are examples of the basic shapes used to designate specific pieces of flow or process charts:

- **Start**: This is the beginning of the process, prior to adding any inputs.
- **Input**: This is the symbol for inputs. In more complicated systems, inputs may be added multiple times throughout the system process.
- **Process**: This is the symbol for process.
- **Output**: This symbol represents the terminator of the process, or the output.
- **Feedback**: This symbol represents data in the system, or feedback.

These process shapes are connected by arrows or lines like these:
**Unit 1: Technological Systems: How They Work**

**Lesson 1: Development of Technological Systems**

**Student Resource 1.1.5: Geometry and Measurement in Systems**

Name: ____________________________

**Ratios:** Complete the following problems, reducing all answers to the smallest possible ratio. Round decimals to create whole numbers. Ratios will help you to see the scale between your model and real-life systems.

2. 4:16__________________________
3. 30:18__________________________
4. 14:21__________________________
5. 12:9__________________________
6. 144:12__________________________
7. 9.9:6:3__________________________
8. 7/9: 1/18__________________________
9. 8/4:6/12__________________________

**Measurement:** Convert these linear measurements to the specified unit.

1. 1 inch = _______________ cm
2. 12 inches = _______________ cm
3. 1/4 inch = _______________ mm
4. 3 miles = _______________ ft
5. 26000 ft = _______________ mi
6. 983 mm = _______________ in
7. 18 miles = _______________ km
8. 8 yards = _______________ m
9. 13 km = _______________ ft
10. 41 cm = _______________ ft

**Area:** Compute the area of the following shapes, using the units indicated. Sketch the shape to help you complete the problem.

1. A rectangle with sides of length 9 inches and 6 inches.
2. A rectangle with sides of length 0.75 ft and 0.5 ft.

3. A circle with a 1 foot radius.

4. A circle with a 12 inch radius.

5. A right triangle with legs of length 6 cm and 8 cm.
The Problem: Working with your Engineering Design Team, you are asked to develop a system to accomplish a specific task, as selected by your team, and build a prototype of that system.

Design Constraints:

Tasks should be simple, with no more than 5 components and 5 processes, and may include human interaction. Use your time and materials wisely.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

Social, economic, political, ethical and aesthetic concerns will impact the success of your design. How will your Engineering Design Team work to address these issues?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, rulers, drafting pencils, bamboo skewers, twine, gift wrap tape, Plastic wheels, cardboard and assorted sandpaper. Other materials may be used - consult your teacher.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation.

The Presentation: When presenting your system, (1) describe your development process, (2) the plans that your Engineering Design Team has for the innovation, (3) successes and failures in your designs and (4) how each team member was involved throughout the process. Include documentation geometric shapes, ratios and fractional measurement used to develop your prototype.
Lesson 1: Development of Technological Systems

Assessment Resource 1.1.1: Engineering Design Journal Rubric

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

8. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

9. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

10. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

Assessment:

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<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
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<td>Activity 1- identified steps in process</td>
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<td>Activity 1- chart or diagram</td>
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<td>Activity 2- System relationships &amp; process</td>
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<td>Activity 3- system process, components and tasks</td>
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<td>Activity 4- Sketches of diagram/demonstration</td>
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<td>Includes notes and comments</td>
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<td>Ability to understand and interpret images, notes and sketches</td>
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<td>Bonus: Additional materials</td>
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Comments:
Lesson 1: Development of Technological Systems

Assessment Resource 1.1.2: Constructed Response Quiz

Name: ___________________________________________________________

Students are asked to reflect on, and write a one-paragraph response to one of the following statements.

1. Describe the systems model in your own words.

2. Identify the type of system shown in the diagram below, and describe the characteristic(s) that make it that type of system.

3. Describe the system that you use to brush your teeth.

4. Draw a diagram of the process of sending an e-mail or text, including system components.
5. Locate the four parts of the systems model in the following system:

   o. Extract money from pocket or purse
   p. Deposit money in appropriate slot
   q. Select button to press
   r. Press button
   s. Listen for operation of machine
   t. Retrieve can from bin
   u. Retrieve change if necessary

6. What is the goal of the system described above?

7. What kind of system is the system described in #5? Why?

8. Describe in your own words, three systems processes you can see in your life now that you are familiar with the concept of systems.

9. If there were no constraints, like time and money, what kind of system would you want to build? What would be the purpose of that system?

10. Identify 5 constraints on a system, other than time and money.
## Lesson 1: Development of Technological Systems

### Assessment Resource 1.1.3: Rubric for Presentations

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<td>Complete All areas addressed</td>
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<td>Explained goal of the system</td>
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<td>Explained system components and their roles</td>
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Grade:
Lesson 2: Design of Technological Systems

Lesson Snapshot

Overview

**Big Idea:** Technological systems are designed to meet a specific need while addressing design constraints.

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

*Teacher’s Suggestion:* For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

**Purpose of Lesson:** This lesson enables students to learn that systems have design constraints, from funding to time to available materials and must be designed within those constraints. Systems are designed to meet a specific need or purpose.

**Lesson Duration:** 4 hours, plus 2 enrichment hours.

**Activity Highlights**

**Engagement**
Students are introduced to the historical changes in manufacturing and construction of systems through the development of new technologies for movies.

**Exploration**
Students will investigate everyday objects to locate control systems and component purposes within the system.

**Explanation**
Using examples of existing technology, through class discussion, students will develop an understanding of the differences between invention and innovation.

**Extension**
Students work together in Engineering Design Teams to develop a system intended to make 3 distinctly different sounds with constraints on time and available materials, which could not be completed without technology.

**Enrichment**
Utilizing local resources, students will visit a manufacturing or construction facility to observe the systems processes and their constraints.

**Evaluation**
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Presentations, Constructed Response items, Performance Rubrics, and an End of unit quiz.
Lesson 2: Design of Technological Systems

Lesson Overview

Lesson Duration
4 hours, plus 2 enrichment hours.

Standards/Benchmarks

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<td>7E</td>
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<td>10G</td>
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<thead>
<tr>
<th>Mathematics: Common Core Standards for Mathematics (CCSM, 2011)</th>
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<tr>
<td>Expressions &amp; Equations Standard (CCSM, Grade 7)</td>
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<tr>
<td>7.EE - 1 Use properties of operations to generate equivalent expressions.</td>
</tr>
<tr>
<td>7.EE - 2 Solve real-life and mathematical problems using numerical and algebraic expressions and equations.</td>
</tr>
<tr>
<td>Ratios &amp; Proportional Relationships Standard (CCSM, Grade 7)</td>
</tr>
<tr>
<td>7.RP.3 Use proportional relationships to solve multistep ratio and percent problems.</td>
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<thead>
<tr>
<th>English Language Arts: Common Core Standards for English Language Arts (CCSELA, 2011)</th>
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<tr>
<td>Integration of Knowledge and Ideas (Literacy in Science and Technical Subjects, Grades 6-12)</td>
</tr>
<tr>
<td>RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).</td>
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</table>
**Science**: Benchmarks for Science Literacy *(AAAS, 1993/2009)*

<table>
<thead>
<tr>
<th>The Nature of Technology</th>
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<tbody>
<tr>
<td><strong>3A/M3</strong> Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. They also usually have to take human values and limitations into account.</td>
</tr>
<tr>
<td><strong>3C/M2</strong> Technology cannot always provide successful solutions to problems or fulfill all human needs.</td>
</tr>
</tbody>
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1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Learning Objectives
Students learn to:
1. Compare and contrast the process of invention versus the process of innovation.
2. Explain how the development and construction of technological systems have changed over time, due to increased control capabilities.
3. Design a product, system or environment that could not be produced without technology.
4. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
5. Work safely and accurately with a variety of tools, machines, and materials.
6. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials

Print Materials

Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. History of movie technology
   b. Manufacturing of Musical Instruments
   c. Production Control Systems
   d. Inventions vs. innovation
2. Innovation Zen, Invention vs. Innovation, Retrieved on 04/29/12 from http://innovationzen.com/blog/2006/07/26/invention-vs-innovation/ (Permission to link requested)

Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. They should be able to accurately read a ruler or tape measure.
Lesson 2: Design of Technological Systems

5-E Lesson Plan

Teacher’s Note: Simple objects can be used to demonstrate improved systems and production such as comparing a fountain pen to a ballpoint pen. Objects used for this portion of the lesson should be easily disassembled without damage, unless the objects are already non-functional. The suggested video clips are from current movies that show current or historical technology in action. Other videos may be substituted at the discretion of the teacher.

Engagement

The teacher will locate additional video clips with examples of materials and tools used currently and in the past to discuss changes in manufacturing and construction of systems

- Students will begin the discussion by watching the video clips and identifying specific technology systems as they are shown in movies with current or historical systems.
- Working in groups, students will identify ways in which the tools or materials have improved, such as through increased accuracy or control systems.
- Each group reports the results of their discussions to the class.
- In their Engineering Design Journals, students will reflect on changes or improvements to systems that they have seen during their lifetime, with specific examples

Exploration

Using everyday objects, students will work in groups to understand them as systems, locating control mechanisms that contribute to the operation of the system.

- Objects will be carefully disassembled, using appropriate tools and safety procedures.
- During disassembly, students will sketch and catalog each component in their Engineering Design Journals, with notes on control systems or mechanisms and the purpose of each component.
- After completing the catalog of components and the sketches, students will write step by step directions to reassemble the object in their Engineering Design Journals.

Explanation

Using examples of existing technology, through class discussion, students will develop an understanding of the differences between invention and innovation.

- Invention is described as the process of turning ideas and imagination into devices and systems.
- Innovation is described as the process of modifying an existing product to improve it.
- In their Engineering Design Journals, students will list 5 products that could be improved through innovation, and 5 problems that could be addressed through invention, but do not currently have a reasonable solution.
Extension
Students work together in Engineering Design Teams to develop an innovation to a system with constraints on time and available materials, which could not be completed without technology.

- Using their Engineering Design Journals, students will brainstorm ideas for systems which need improvement, and could be accessed for this project.
- Human values and limitations of each solution will be discussed in reaching a decision on the final system for innovation.
- Constraints for developing an innovation to the selected system will be time and available materials.
- Teams will document their planned innovation through sketches, measurements and the systems rubric in their Engineering Design Journals prior to constructing the innovation.
- Completed innovations will be presented to the class, with documentation of improvements in quality listed in numeric and ratio or percentage values.
- A bill of materials for hardware, materials and tools used in the innovation process will be included.

Enrichment

Utilizing local resources, students will visit a manufacturing or construction facility to observe the systems processes and their constraints within that environment.

Evaluation

Students’ knowledge, skills, and attitudes are assessed using Engineering Design Journals, Presentations, Constructed Response items, Performance Rubrics and an End of unit quiz.

**The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
### Teacher Resource 1.2.1: Brief Constructed Response Writing Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
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**Comments:**

**Grade:**
Teacher Resource 1.2.2: Class Participation Rubric

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<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
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<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
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Comments:

Grade:
Unit 1: Technological Systems: How They Work

Lesson 2: Design of Technological Systems

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read.

Prepare the room for multimedia presentations, including showing DVDs. If selecting other video clips for viewing, in addition or in place of those suggested here, locate those and screen them for appropriate content. In selecting objects for the Exploration portion of the lesson, choose objects that are easily disassembled with minimal tools. Objects should be able to be reassembled, or already non-functional if they are to be used again.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

The building materials for innovation will depend on the object selected for innovation. Alternatively, students may be asked to locate their own materials for that project.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and graphic design companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Everyday objects that can be disassembled, such as click-style ballpoint pens, or other object as selected, 1 per student
4. Engineering Design Journal or blank paper
5. Tools for disassembly: X-Acto knives, 1 per student, with replacement blades
6. Precision screwdrivers, 10 sets
7. Coping saws, 5 with replacement blades
8. Safety glasses, 1 pair per student
9. Protective Hi-dexterity gloves, 5 pairs
10. 18” X 24” self-healing cutting mats, 10
**Enrichment Activity Materials**
1. Computer w/Internet access
2. Presentation projector
3. Engineering Design Journal or blank paper
4. X-Acto knives, 1 per student, with replacement blades
5. Coping saws, 5 with replacement blades
6. Safety glasses, 1 pair per student
7. Protective Hi-dexterity gloves, 5 pairs
8. 18” X 24” self-healing cutting mats, 10
9. Gift wrap tape, 1-2 rolls per group
10. Masking tape, 1”, 1 roll per group
11. School Glue, 4 oz, 2 bottles per group
12. Posterboard, 18” X 24” 1 per student
13. Scissors, 1 pair per student
14. 12” rulers, 1 per student
15. Corrugated cardboard, approx. 8” X 10”, 15 per class
16. Used file folders, 1 per student
17. Packing materials as available, such as bubble wrap and Styrofoam
18. Balsa Wood Economy Bag, 3 per class
19. Hot melt glue guns, 10 per class
20. Hot melt glue sticks, 50 pack, 1 per class

**Laboratory-Classroom Safety and Conduct**
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

**Teacher Resources**
- Teacher Resource 1.2.1: Brief Constructed Response Writing Rubric
- Teacher Resource 1.2.2: Class Participation Rubric
- Teacher Resource 1.2.3: End of Unit Quiz Answer Key
- Teacher Resource 1.2.4: Researching Inventions and Innovations Answer Key
- Teacher Resource 1.2.5: Ratios and Percentages in Production Systems Answer Key

**Student Resources**
- Student Resource 1.2.1: Lesson Glossary
- Student Resource 1.2.2: Engineering Design Journal Guidelines
- Student Resource 1.2.3: Researching Inventions and Innovations
- Student Resource 1.2.4: Ratios and Percentages in Production Systems
- Student Resource 1.2.5: Lesson Design Brief

**Assessment Resources**
- Assessment Resource 1.2.1: Engineering Design Journal Rubric
- Assessment Resource 1.2.2: Brief Constructed Response Writing Prompts
- Assessment Resource 1.2.3: Extension Project Rubric
- Assessment Resource 1.2.4: Rubric for Presentation
  - Assessment Resource 1.2.5: End of Unit Quiz
### Lesson 2: Design of Technological Systems

#### Teacher Resource 1.2.1: Brief Constructed Response Writing Rubric

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**Comments:**

**Grade:**
Lesson 2: Design of Technological Systems
Teacher Resource 1.2.2: Class Participation Rubric

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Grade:
Unit 1: Technological Systems: How They Work

Lesson 2: Design of Technological Systems
Teacher Resource 1.2.3: End of Unit Quiz Answer Key

1. Which of the following components causes a system to be classified as “closed”?

2. Which of the following items should be included in an Engineering Design Journal? (Circle all that apply)

3. When designing a system, a constraint is
   a. Something that is put into the system
   b. Something that limits the system
   c. Something that helps the system to perform better
   d. Something that comes out of the system

4. What types of constraints can be placed on the design of a system? (Circle all that apply)

5. Over time, systems have improved due to changes in (Circle all that apply)
   a. Work conditions   b. Workers   c. measurement   d. control systems
   e. computers

6. You are the production manager for a company. Your boss has asked you to increase your current output of 125 units by 30%, while reducing your current waste material from 30 by 5%. List the formulas that you would need to accomplish this task.

   \[ 125 + (125 \times 30\%) \text{ or } (1 + 30\%) \times 125 \]

   \[ 30 - (30 \times 5\%) \]

7. List the ratios of components in the following statements with appropriate labels.

   a. There were six times as many batteries as there were lights. 6:1, 6 batteries to 1 light
   
   b. The system used seven sheets of lumber to make fourteen tables. 1:2, 1 sheet makes 2 tables
   
   c. Four quarters were required to start the game, which allowed two people to play for three rounds. 4:2:3 Four quarters for two people over 3 rounds
d. Three passwords were entered to access the account. \(3:1, 3\) passwords to one account

e. 50% more of the product was produced through the system than in previous productions. \(1.5:1, 1\) and a half times as many were produced

8. Label the components of the system diagram shown here:

```
Inputs --> Processes --> Outputs
```

```
Feedback
```

Match the following terms to the correct definition:

A. Closed System  B. Engineering Design Team  C. Output  D. Technology  E. Components
F. Open System  G. Systems Model  H. Task  I. Feedback  J. Process
K. Engineering Design Journal  L. System  M. Input  N. Constraints

9. Individual parts of the system are called ______E______________.

10. A group of people working together to develop a solution to a problem is called ______B______________.

11. A(n) ______F______________ is one that does not have feedback.

12. A(n) ______K__________________contains documentation of the process of attempting to solve a problem through technology.

13. The ______G____________ is a general model of components that work together, with each one serving a specific function.

14. A job or chore to complete, or a goal to be reached are called the ______H____________.

15. ______D______________ is an object, environment or process that was created by man.

16. A(n) ______A__________________ is one which has feedback. The feedback may come a variety of forms including ratings, materials for reuse or information.
17. Factors that limit the ability of the system are called __________ N__________________.

18. A(n) ______ M__________ is something that goes into a system, a resource such as time, money, communication, etc.

19. A(n)______ C__________ is the result of the process, or the finished product.

20. A(n) _____ L______________ is a group of parts that work together as a unit.

21. Information given about the output of the system is __________I__________.

22. A(n) ______ J__________ is something that happens to or with the inputs.

Short Answer: write a paragraph responding to each of the writing prompts listed. Use the back of the sheet if needed.

23. Compare and contrast the terms invention and innovation

   Student responses will vary, but should include that inventions are the result of new ideas, and innovations are modifications or improvements to existing products, environments, processes or systems.

24. Pretend that you have an idea for a video game. What constraints would be on the development of your system to get that video game out to the public?

   Student responses will vary, but could include budget, time constraints, social acceptability of game design, cultural restraints in selected design, etc.

25. Explain how visual representations of systems can be helpful.

   Student responses will vary, but should include that visual representations can be helpful in designing a system, selecting materials and components and in troubleshooting a system when it malfunctions. Responses may also include that they can be helpful in presenting designs to interested groups, such as investors.
In this lesson, you are researching existing inventions and developing innovations, to help you to learn about inventions that currently hold patents.

Begin at the main site for the United States Patent and Trademark Office: http://www.uspto.gov/ (Permission to link requested)

1. What is the difference between a patent and a trademark?
   A trademark is a word, phrase or symbol used to distinguish the products of one company from another. A patent is a limited duration property right issued in exchange for public disclosure of the invention.

2. When searching for the terms “cellular” and “telephone”, how many total patents are located? 914

3. What is the full title of the first patent issued in this search?
   Cellular mobile radio service telephone system

4. In the background section of this patent, it describes how the original cellular phone technology works. Summarize this in your own words.

5. Using the advanced search feature, search for the inventor name Steve Wozniak. What is the common name of the device listed in his first patent?
   Universal remote control

6. Why would it matter if you held the patent on an object?
   Student answers will vary, but should include production and license rights.

7. Locate the patent filing fee schedule. What is the basic filing fee for a utility patent?
   $380 or $190 for a small entity

8. Describe the three kinds of patents and their purpose.
   a. design patents - ornamental characteristics, such as a specific style of computer case
   b. Plant patent – new variety of asexually produced plant
   c. Utility patent – useful process, machine, article of manufacture, composition of matter
**Unit 1: Technological Systems: How They Work**

**Lesson 2: Design of Technological Systems**

Teacher Resource 1.2.5: Ratios and Percentages in Production Systems Answer Key

Name: ____________________________________________

**Order of Operations:** Complete the problems below, following the correct order of operations. In these equations, the first number refers to the production rate, the second is the change in that rate, the third number is the amount of waste product produced and the fourth is the change in waste products produced.

1. \(7(14+23)/9 = \) _____28.777______ 2. \((7*14) + (23/9) = \) _____100.55______

3. \(15*-3(12-7) = \) ___-225___________ 4. \((15/3)(12+7) = \) _______95___________

5. \(93/(3.2(28/3)) = \) ___3.11___________ 6. \(93*3.2(28-3) = \) _______7440__________

**Solving problems within systems:** In developing a new system, there are many adjustments to be made, many of which involve the size and spacing of components. Complete these problems to understand how the components affect the system. **Note:** Shapes not drawn to scale.

7. If one side of the rectangle is 6 cm, and the area is 48 cm, what is the length of the other side? 8 cm

8. How would the overall area of the rectangle above change if the length of each side was divided by 2? The area would be reduced by 75%. 3 cm * 4 cm = 12 cm

9. If the diameter of the given circle is 4.6, what is the area of the circle?

\[3.14*(2.3*2.3) = 3.14 * 5.29 = 16.61\]

10. If this circle is a wheel inside your system, and you need it to be .5 inches bigger in diameter, what would be the new area of the circle? 2.3 + .25 = 2.55

\[3.14*(2.55*2.55) = 3.14*6.5 = 20.41\]

**Component Ratios:** As you adjust your system, there are many changes that can be made easily using ratios. Complete the following problems to determine appropriate component sizes.
11. List the ratios between the sides of these components. Round decimal values to the nearest whole number.

   12.7  
   9  

   13:9

12. List the ratio between sides.

   9  
   27  

   1:3

For problems 13-15, find the area of each shape and list the ratio of the areas for the shapes given in each problem.

13. 

   \[ 3.14 \times (3\times3) = 3.14 \times 9 = 28.26 \]

   \[ 3.14 \times (6.1\times6.1) = 3.14 \times 37.21 = 116.84 \]

   \[ 28:117 \]

14. 

   \[ 7.2 \times 7.2 = 51.84 \]

   \[ 4.3 \times 4.3 = 18 \]

   \[ 52:18 = 26:9 \]

15. 

   \[ 3.14 \times (2.5\times2.5) = 3.14 \times 6.25 = 19.6 \]

   \[ 6 \times 5 = 30 \]

   \[ 9.2 \times 9.2 = 84.6 \]

   \[ 20:30:85 = 4:6:17 \]
Unit 1: Technological Systems: How They Work

Lesson 2: Design of Technological Systems

Student Resource 1.2.1: Lesson Glossary

Controls  These components are part of a system that determine how it functions and how the components interact.

Control Systems  are integrated into another system in the function of that system. They may also be used in the building of a system.

Constraint  These are factors that govern or limit the system. They may be physical and biological constraints, but also economic, political, social, ethical, and aesthetic ones.

Flow Chart  A flow chart is a specific kind of visual representation of a system. Specific symbols are used to represent specific kinds of components such as inputs.

Integration  In the systems model, integration refers to components or systems working together.

Invention  is a process of turning ideas and imagination into devices and systems.

Innovation  is the process of modifying an existing product to improve it.

Subsystem  This is a system contained inside another system or group of systems. An example of this would be the sink in your kitchen working within the system of overall plumbing in your house.

Visual Representation  In this case, a visual representation of a system refers to a chart or diagram of the system.
The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.

8. In this lesson, you will be working together in Engineering Design Teams. Be sure that everyone has all of the information from group works sessions in his or her individual journal. It is easier to work toward the same goal when everyone has all of the information.
Lesson 2: Design of Technological Systems

Student Resource 1.2.3: Researching Inventions and Innovations

In this lesson, you are researching existing inventions and developing innovations, to help you to learn about inventions that currently hold patents.

Begin at the main site for the United States Patent and Trademark Office: http://www.uspto.gov/ (Permission to link requested)

6. What is the difference between a patent and a trademark?

7. When searching for the terms “cellular” and “telephone”, how many total patents are located?

8. What is the full title of the first patent issued in this search?

9. In the background section of this patent, it describes how the original cellular phone technology works. Summarize this in your own words.

10. Using the advanced search feature, search for the inventor name Steve Wozniak. What is the common name of the device listed in his first patent?

6. Why would it matter if you held the patent on an object?

7. Locate the patent filing fee schedule. What is the basic filing fee for a utility patent?

8. Describe the three kinds of patents and their purpose.
Unit 1: Technological Systems: How They Work

Lesson 2: Design of Technological Systems

Student Resource 1.2.4: Ratios and Percentages in Production Systems

Name: ______________________________________

Order of Operations: Complete the problems below, following the correct order of operations. In these equations, the first number refers to the production rate, the second is the change in that rate, the their number is the amount of waste product produced and the fourth is the change in waste products produced.

1. \(7(14+23)/9 = \) ____________
2. \((7*14)+ (23/9) = \) ______________
3. \(15*-3(12-7) = \) ________________
4. \((15/3)(12+7) = \) ________________
5. \(93/(3.2(28/3)) = \) ________________
6. \(93*3.2(28-3) = \) ________________

Solving problems within systems: In developing a new system, there are many adjustments to be made, many of which involve the size and spacing of components. Complete these problems to understand how the components affect the system. Note: Shapes not drawn to scale.

7. If one side of the rectangle is 6 cm, and the area is 48 cm, what is the length of the other side?

8. How would the overall area of the rectangle above change if the length of each side was divided by 2?

9. If the diameter of the given circle is 4.6, what is the area of the circle?

10. If this circle is a wheel inside your system, and you need it to be .5 inches bigger in diameter, what would be the new area of the circle?

Component Ratios: As you adjust your system, there are many changes that can be made easily using ratios. Complete the following problems to determine appropriate component sizes.
11. List the ratios between the sides of these components. Round decimal values to the nearest whole number.

12. List the ratio between sides.

For problems 13-15, find the area of each shape and list the ratio of the areas for the shapes given in each problem.
Unit 1: Technological Systems: How They Work
Lesson 2: Design of Technological Systems
Student Resource 1.2.5: Lesson Design Brief

The Problem: Many of the mechanisms and systems that we use every day would not exist without technology. Working in Engineering Design Teams, the goal is to develop an innovation to a system with constraints on time and available materials, which could not be completed without technology.

Design Constraints: Remember, this is an innovation, not an invention:

- Invention is described as the process of turning ideas and imagination into devices and systems.
- Innovation is described as the process of modifying an existing product to improve it.

Your Engineering Design Team will have limited time and materials to complete this process, as described by your teacher. Use your time and materials wisely.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

If your Engineering Design Team wants to work on a system that cannot physically be brought into your classroom, can you locate enough information to address this problem?

Human values and limitations will impact the success of your design. How will your Engineering Design Team work to address these issues?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, poster board, hot melt glue guns and sticks, X-Acto knives, coping saws, scissors, rulers, corrugated cardboard, file folders, packing materials, and Balsa Wood. Other materials may be used - consult your teacher.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation.

The Presentation: When presenting your system, (1) describe your development process, (2) the plans that your Engineering Design Team has for the innovation, (3) successes and failures in your designs and (4) how each team member was involved throughout the process. Include a bill of materials for hardware, materials and tools used in the innovation process, and improvements in quality listed in numeric and ratio or percentage values.
Lesson 2: Design of Technological Systems

Assessment Resource 1.2.1: Engineering Design Journal Rubric

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

Assessment:

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Comments:

Grade:
Unit 1: Technological Systems: How They Work

Lesson 2: Design of Technological Systems

Assessment Resource 1.2.2: Brief Constructed Response Writing Prompts

Name______________________________

1. In your own words, describe the differences between invention and innovation.

2. What is the purpose of having a patent?

3. If you were to invent something, what would it be and what kind of problem would it solve?

4. In the system that you disassembled and sketched, what was the most interesting component to you? Describe the component and its function.

5. Describe what you have learned about writing instructions, with examples.

6. How have control systems impacted modern technological systems? Provide examples.
# Lesson 2: Design of Technological Systems

## Assessment Resource 1.2.3: Extension Project Rubric

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**Comments:**

Grade:
Lesson 2: Design of Technological Systems

Assessment Resource 1.2.4: Rubric for Presentation

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Grade:
Unit 1: Technological Systems: How They Work

Lesson 2: Design of Technological Systems

Assessment Resource 1.2.5: End of Unit Quiz

1. Which of the following components causes a system to be classified as “closed”?

2. Which of the following items should be included in an Engineering Design Journal? (Circle all that apply)

3. When designing a system, a constraint is
   e. Something that is put into the system
   f. Something that limits the system
   g. Something that helps the system to perform better
   h. Something that comes out of the system

4. What types of constraints can be placed on the design of a system? (Circle all that apply)
   b. Environmental b. Emotional c. Political d. Physical e. Social

5. Over time, systems have improved due to changes in (Circle all that apply)
   b. Work conditions b. Workers c. measurement d. control systems e. computers

6. You are the production manager for a company. Your boss has asked you to increase your current output by 30%, while reducing your current waste material from 25% to 20%. List the formulas that you would need to accomplish this task.

7. List the ratios of components in the following statements with appropriate labels.
   f. There were six times as many batteries as there were lights.
   g. The system used seven sheets of lumber to make fourteen tables.
   h. Four quarters were required to start the game, which allowed two people to play for three rounds.
   i. Three passwords were entered to access the account.
   j. 50% more of the product was produced through the system than in previous productions.
8. Label the components of the system diagram shown here:

Match the following terms to the correct definition:

B. Closed System  B. Engineering Design Team  C. Output  D. Technology  E. Component
F. Open System  G. Systems Model  H. Task  I. Feedback  J. Process
K. Engineering Design Journal  L. System M. Input  N. Constraints

9. Individual parts of the system are called ____________________.

10. A group of people working together to develop a solution to a problem is called ____________________.

11. An ____________________ is one that does not have feedback.

12. A(n) ____________________ contains documentation of the process of attempting to solve a problem through technology.

13. The ____________________ is a general model of components that work together, with each one serving a specific function.

14. A job or chore to complete, or a goal to be reached are called the ____________________.

15. ____________________ is an object, environment or process that was created by man.

16. A ____________________ is one which has feedback. The feedback may come in a variety of forms including ratings, materials for reuse or information.
17. Factors that limit the ability of the system are called _______________________.

18. A(n) _______________ is something that goes into a system, a resource such as time, money, communication, etc.

19. An ________________ is the result of the process, or the finished product.

20. A _________________ is a group of parts that work together as a unit.

21. Information given about the output of the system is _________________.

22. A _________________ is something that happens to or with the inputs.

Short Answer: write a paragraph responding to each of the writing prompts listed. Use the back of the sheet if needed.

23. Compare and contrast the terms invention and innovation

24. Pretend that you have an idea for a video game. What constraints would be on the development of your system to get that video game out to the public?

25. Explain how visual representations of systems can be helpful.
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

Lesson Snapshot

Overview

Big Idea: Human needs and interests in technological devices reflect social and cultural priorities.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn that a variety of human factors have an impact on the development of technological devices. Social and cultural needs are tied to marketing of products and can determine the success or failure of a product.

Lesson Duration: 4 hours, plus 1 enrichment hour.

Activity Highlights

Engagement

Using a variety of advertisements and logos, students will discuss what makes them want to buy a particular product.

Exploration

Working in Engineering Design Teams, students will create both positive and negative ads for the same product.

Explanation

Using the positive and negative ads, the teacher will facilitate a discussion about definitions and explanations as to why an ad may appear to be positive or negative.

Extension

Using the advertisements for the products that they have created, students will survey friends, families and classmates on their preferences between products.

Enrichment

Students will create packaging for a product that they believe would be popular with students in their school.

Evaluation

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Research Projects, an End of Lesson quiz, Reflective writing prompts, and an End of unit quiz.
Lesson 1: Social and Cultural Impacts

Lesson Overview

Lesson Duration
4 hours, plus 1 enrichment hour.

Standards/Benchmarks

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<td>STL 1I Corporations can often create demand for a product by bringing it onto the market and advertising it.</td>
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<tr>
<td>6F Social and cultural priorities and values are reflected in technological devices.</td>
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<td>RST.6-8.9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.</td>
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<tr>
<td>The Nature of Science</td>
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<tr>
<td>1C/M3 No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world.</td>
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<tr>
<td>1C/M1 Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times</td>
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Learning Objectives
Students learn to:
1. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
2. Work safely and accurately with a variety of tools, machines, and materials.
3. Actively participate in group discussions, ideation exercises, and debates.
4. Compare and contrast social and cultural technology needs.
5. Describe instances where technological devices reflect social and cultural priorities.
6. Understand the impact of marketing on consumer demand

¹ Material reprinted from Benchmarks for Science Literacy (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Resource Materials
Audiovisual Materials
1. Frontera House, *How To Build Effective Print Ads*, Retrieved on 05/01/12 from http://www.youtube.com/watch?v=Ie_f2Dv9j0U Used by permission.

Print Materials

Internet Search Terms and Suggested Sites
a. How to construct a print advertisement
b. Advertising
c. Visual advertisements

3. PBS Kids, *Don’t Buy It: Get Media Smart!*, Retrieved on 04/30/12 from http://pbskids.org/dontbuyit/advertisingtricks/ (permission to link requested)

Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software.
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

5-E Lesson Plan

Teacher’s Note: When selecting advertisements for use in class, be sure to screen for appropriate content, and if possible choose materials that students may have seen prior to this lesson. This may help further the discussion of the impact that each advertisement had.

Engagement

The teacher provides a variety of advertisements and logos from print and digital sources for the students to examine.

- Students are asked to study the advertisements and describe what the product is, and why this advertisement would or would not influence their decision to buy.
- In small groups, students discuss factors that influence their choices, such as color, price, availability, etc.
- In their Engineering Design Journals, students will list things that they especially like or dislike, and locate examples of 2-3 ads that they like and 2-3 ads that they dislike and include them with comments explaining their choices.

Exploration

Working in Engineering Design Teams, students will create both positive and negative ads for the same product.

- The teacher will select a specific technological product or category of products (real or fictional) and ask teams to create a positive and negative ad for the same product.
- The teacher will emphasize that contributions to STEM fields can come from anyone, at any time, such as through student projects like this.
- Students will develop ideas for the ads in their Engineering Design Journals, with preliminary sketches and notes for the finished ad.
- The completed ads may be created using a computer and the software of choice of the team, or through other artistic materials.
- Completed ads will be presented to the class.

Explanation

The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- Using the positive and negative ads, the teacher will facilitate a discussion about definitions and explanations as to why an ad may appear to be positive or negative.
- Personal choice, preferences of materials, colors, etc. all influence the selection of products to buy.
- Using leading questions, the teacher will guide students to discuss the social and cultural expectations, pros and cons and stereotypes of technology.
• The teacher will help students to understand and apply correct terminology.

**Extension**
Using the advertisements for the products that they have created, students will survey friends, families and classmates on their preferences between products.

• Working as a class, the teacher and students will develop a brief survey instrument and method to accurately record responses from a variety of people on their reactions to the positive and negative ads that the class created.
• The survey should be short, 10 items or less, and be simple to administer. If needed, ads could be broken up into multiple surveys per class to keep the item count low.
• Students should survey a pre-determined number of people to ensure that a sufficient sample is assessed.
• Once the survey process is complete, results can be compiled and displayed for the class, with a discussion of the outcome.

**Enrichment**
Students will create packaging for a product that they believe would be popular with students in their school, based on the results of the survey.

**Evaluation**
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Research Projects, an End of Lesson quiz, Reflective writing prompts, and an End of unit quiz.

The **rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.

<table>
<thead>
<tr>
<th>Assessment Instrument – Brief Constructed Response Writing Rubric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>Understanding</td>
</tr>
<tr>
<td>Focus</td>
</tr>
</tbody>
</table>
show the relationship of the support to the question.

| Use of Related Information | Uses minimal information from the text to clarify or extend meaning. | Uses some expressed or implied information from the text to clarify or extend meaning. | Effectively uses expressed or implied information from the text to clarify or extend meaning. |

Comments:

Grade:

**Assessment Instrument – Class Participation Rubric**

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
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<th>Above Target</th>
</tr>
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<tbody>
<tr>
<td>Preparation</td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td>Curiosity</td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td>Use of Time</td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
### Assessment Resource 2.1.3: Positive/Negative Ad Rubric

**Engineering Design Team Members**

<table>
<thead>
<tr>
<th>Assessment Criteria</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
<td></td>
</tr>
<tr>
<td>Finished size at least 8.5” X 11” for each ad.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains both graphics and text</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conveys some actual (not necessarily factual) information</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Was the presentation professional? (as if family were in the audience)</td>
<td></td>
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</tr>
<tr>
<td>The completed ads were well crafted – not torn, smeared, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Described the intended audience for the ads</td>
<td></td>
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</tr>
<tr>
<td>Explained selection of materials, colors, etc.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Defined each ad as positive or negative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slides or other visuals – relevant and clear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addressed all relevant information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personalized presentation through individualized information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation – active in the presentation, not just reading</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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</tr>
</tbody>
</table>

**Comments:**

Grade:

### Assessment Resource 2.1.4: Research Project Rubric

**Engineering Design Team Members**

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<tr>
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<tr>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
<td></td>
</tr>
<tr>
<td>Survey instrument was appropriate for</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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planned administration

<table>
<thead>
<tr>
<th>Survey instrument was easy to read, legible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student completed the assigned number of surveys</td>
</tr>
<tr>
<td>Purpose of the survey was explained on the survey form</td>
</tr>
<tr>
<td>A participant list was collected for all survey participants</td>
</tr>
<tr>
<td>Items were as short as possible, addressed only one idea, used clear wording</td>
</tr>
<tr>
<td>The scale was appropriate to the items</td>
</tr>
<tr>
<td>Survey had 10 or fewer items</td>
</tr>
<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
</tr>
<tr>
<td>Addressed all relevant information</td>
</tr>
<tr>
<td>Personalized presentation through individualized information</td>
</tr>
<tr>
<td>Participation – active in the presentation, not just reading</td>
</tr>
</tbody>
</table>

Total Comments:

Grade:
Lesson 1: Social and Cultural Impacts

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content. Gather recyclable materials to represent a variety of categories.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

If students are using the computer to make ads, there are many graphic products available, including many free options available online. Ads may also be produced with art supplies. These will need to be collected if they are not already in your classroom and include cutting mats if X-Acto knives are used.

In separating students into Engineering Design Teams for this lesson, it may be helpful to allow students to self-select their groups, because personal opinions and preferences will influence the completed assignments.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and advertising or graphic design companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Engineering design Journals or blank paper
4. Access to printed advertisements, old magazines, catalogs, etc.
5. Construction paper, multi-colored pack
6. Glue sticks, 1 per student
7. Water based markers, 36 count, 5 sets
8. Permanent markers, 1 per student
9. Scissors, 1 pair per student
10. Clipboards to aid students in conducting surveys, 1 per group

Enrichment Activity Materials
1. Gift wrap tape 1-2 rolls per group
2. Masking tape, 1”, 1 roll per group
3. School glue, 4 oz, 1-2 per group
4. Posterboard, 1 per student
5. Hot melt glue guns, 10 per class
6. Hot melt glue sticks, 50 pack

**Laboratory-Classroom Safety and Conduct**

a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

**Teacher Resources**

- Teacher Resource 2.1.1.: Brief Constructed Response Writing Rubric
- Teacher Resource 2.1.2.: Class Participation Rubric
- Teacher Resource 2.1.3.: Reflective Writing Prompts Rubric
- Teacher Resource 2.1.4.: Lesson Quiz Answer Key

**Student Resources**

- Student Resource 2.1.1: Unit PowerPoint
- Student Resource 2.1.2: Lesson Glossary
- Student Resource 2.1.3: Engineering Design Journal Guidelines
- Student Resource 2.1.4: Positive/Negative Ad Guidelines
- Student Resource 2.1.5: Research Project Guidelines
- Student Resource 2.1.6: Lesson Design Brief

**Assessment Resources**

- Assessment Resource 2.1.1.: Engineering Design Journal Rubric
- Assessment Resource 2.1.2.: Lesson Quiz
- Assessment Resource 2.1.3.: Positive/Negative Ad Rubric
- Assessment Resource 2.1.4.: Research Project Rubric
- Assessment Resource 2.1.5.: Reflective Writing Prompts
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

Teacher Resource 2.1.1: Brief Constructed Response Writing Rubric

<table>
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<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
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</table>

Comments:

Grade:
## Unit 2: Technological Systems: Issues and Impacts

### Lesson 1: Social and Cultural Impacts

#### Teacher Resource 2.1.2: Class Participation Rubric

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<td><strong>Use of Time</strong></td>
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<td>Makes excellent use of class time to work on assignments and projects.</td>
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</table>

**Comments:**

**Grade:**
### Teacher Resource 2.1.3: Reflective Writing Prompts Rubric

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</tr>
<tr>
<td><strong>Focus</strong></td>
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</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
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<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td><strong>Ability to apply information gained in class to prior knowledge</strong></td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

Teacher Resource 2.1.4: Lesson Quiz Answer Key

Name:__________________________________________________________________________________

Multiple Choice:

1. Which of the following is a social impact? Circle all that apply.
   a. My friends like it.  b. I have enough money to buy it.  c. I like the color.  d. I can buy it
   where I live.

2. Which of the following is a cultural impact? Circle all that apply.
   a. My friends all have one.  b. It is something that I need.  c. I like the color because it
   matches my school colors.  d. I can buy it where I live.

3. Advertising is:
   a. a question, phrase or statement that is asked, on paper, on the computer or in person to
   the person completing the survey.
   b. the behavior, attitude or beliefs of a particular group that one identifies with.
   c. visual, auditory, multimedia or print announcements or notices that are intended to make
   a consumer aware of, or interested in purchasing a particular product.
   d. a term used to describe the process of trying to generate a variety of ideas to meet a
   particular need or solve a problem.

4. Which of the following are guidelines for developing a survey? Circle all that
   apply.
   a. Keep items as short as possible.  b. Use technical terms and special language.  c. send out
   as many surveys as possible.  d. Use a variety of different response formats.

Matching: Match the correct response from the word bank with the statement below.

a. Advertisement  d. Brainstorming  g. Response Rate  j. Scale  l. Outcome
b. Population  e. Survey  h. Survey Item  k. Culture  m. Social
c. Thumbnail Sketch  f. Survey Sample  i. Survey Instrument

1. A group of questions or items are designed to be asked in the same way every time to
get the most reliable results is called a __________e__________.
2. A(n)_______a__________ is a visual, auditory, multimedia or print announcement or notice that is intended to make a consumer aware of, or interested in purchasing a particular product.

3. The behavior, attitude or beliefs of a particular group that one identifies with is called ______k__________.

4. In surveys, the entire group that could possibly represent the kind of people that the researcher would like to study is called the_______b__________.

5. Humans as they interact with each other based on their community and people around them are reacting to their surroundings in a ______m_________ way.

6. A(n) ______________i________________ is a questionnaire or interview sheet that has been developed to be used to collect data from a specific group of people.

7. The ______________j_________ is the way that the participants can respond and how those responses are recorded or categorized. Such as yes, moderately agree, etc.

8. A(n) ______________h__________ is a question, phrase or statement that is asked, on paper, on the computer or in person to the person completing the survey.

9. The compiled results of the completed survey are called the __________i______________.

10. __________d___________ is a term used to describe the process of trying to generate a variety of ideas to meet a particular need or solve a problem.

11. Many surveys are administered to a smaller group of the population that the survey would like to measure that is selected randomly to achieve a certain number. This group is called the ______________f__________________.

12. If a survey was mailed to 10 people, and only 8 of those people sent it back complete, the __________g___________ would be 8.

13. ______________c______________ are often completed in multiples during brainstorming.

**Short Answer: Using complete sentences, respond to the following items:**

1. Describe how an ad can be both positive and negative.

Student responses will vary but should include personal preference, social and cultural influences.

2. List three guidelines for developing a survey.

Keep items as short as possible, avoid technical terms, use a similar response scale for all items, or break it up into sections, they should be simple to complete, only asking about one concept in each item

3. Explain how advertisements can influence a consumer to buy a product.
Student responses will vary but could include appearance of better lifestyle, social and cultural influences, constant appearance, appealing to a specific audience through color, placement, etc.
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

Student Resource 2.1.2: Lesson Glossary

Advertisement A visual, auditory, multimedia or print announcement or notice that is intended to make a consumer aware of, or interested in purchasing a particular product.

Brainstorming A term used to describe the process of trying to generate a variety of ideas to meet a particular need or solve a problem.

Culture The behavior, attitude or beliefs of a particular group that one identifies with.

Outcome The compiled results of the completed survey.

Population In surveys, the entire group that could possibly represent the kind of people that the researcher would like to study is called the population.

Response Rate The number of people who complete the entire survey as is was administered. For example if a survey was mailed to 10 people, and only 8 of those people sent it back complete, the response rate would be 8.

Scale The scale is the way that the participants can respond and how those responses are recorded or categorized. Such as yes, moderately agree, etc.

Social Humans as they interact with each other based on their community and people around them are reacting socially to their surroundings.

Survey A survey is a specific type of interview that can be given through a variety of sources. Surveys can be paper-based, coming through the mail, given out in a public place, etc. They can be given online through e-mail, social media or a survey website, or they may be given as face-to-face interviews. The questions or items are designed to be asked in the same way every time to get the most reliable results.

Survey Instrument A survey instrument is a questionnaire or interview sheet that has been developed to be used to collect data from a specific group of people.

Survey Item A survey item is a question, phrase or statement that is asked, on paper, on the computer or in person to the person completing the survey.

Survey Sample In general, the people that a survey would like responses from are a much larger group than could be reasonably surveyed. Many surveys are administered to a smaller group of the population that the survey would like to measure that is selected randomly to achieve a certain number.

Thumbnail Sketch A small pictorial representation of an idea for a completed project. They are often completed in multiples during brainstorming.
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

Student Resource 2.1.3: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

Student Resource 2.1.4: Positive/Negative Ad Guidelines

We are surrounded by advertisements in all aspects of our lives, from the trademark on your classmate’s running shoe to the billboard on the side of a bus. Every ad is trying to get your attention, and is especially trying to reach a specific group.

Think about the kinds of things that you really like, or really do not like. How do these likes and dislikes influence your choices?

Web and print media are just like this. Design layout and physical materials in the final form define print media. There is no room for a Flash animation, sound bites or background music. Your design can make or break your message.

For example, consider a résumé that is in poor handwriting, with smeared ink on a page torn from a spiral notebook. This sends a very different message than a clear copy, printed in a legible font on heavy, textured cream-colored paper.

There are also cases where the smeared ink could be the kind of thing that you are looking for to reach your intended audience.

Always consider your intended audience and the location where you would want to display your ad. Something that has a lot of text would not work as well on a bus or a very high billboard as it would in a magazine.

As you begin to design your ads:
- The finished size should be at least 8.5”X 11” for each ad.
- They should contain both graphics and text
- They should convey some actual (not necessarily factual) information
- You should be able to describe your intended audience, why you chose the design, materials, color, etc. that you did and what you are trying to represent (positive or negative) in each ad.
Lesson 1: Social and Cultural Impacts

Student Resource 2.1.5: Research Project Guidelines

Purpose: The purpose of the research project is to complete a survey to better understand how your friends and families will react to the positive and negative ads that were created by your Engineering Design Team.

With your teacher, as a class, you will decide if you are trying to reach a specific population, such as 8th graders in your school, people who live in your community or just people that you know. The class will also need to decide the number of surveys that each student will need to complete.

Consent: Professional researchers need to obtain permission from each person who is participating in a research study to use their responses prior to beginning the study. Since you will not be trying to publish your results in a journal or magazine, you do not have to formally obtain this permission, but it is a good idea to explain the purpose of the survey to your participants prior to asking them any questions.

Format: As a class, you will need to decide if you are going to use an interview style survey, where you will read the items to participants and record their answers, or if they will fill out a paper form of some kind. You may also have the option of administering the survey through e-mail or other social media, depending on availability.

Generating Items: Here are a few guidelines on generating survey items:

- They should be as short as possible.
- Make sure that you are only asking about one thing in each item.
- They should use clear wording, avoiding special terminology.
- They should be simple to complete.

Scale: The scale is the way that the participants can respond and how those responses are recorded or categorized. Will you use a two-point scale, such as yes or no, a three point scale, such as yes, no and don’t know? It is recommended that you select the same type of scale for all questions, or break different scale types into sections.

Other considerations: In addition to the explanation about the survey, you should tell your participants how the data is being used.

The length of the completed survey instrument should be 10 or fewer items in order to maximize the response rate.

Names of respondents can be listed to ensure that the same person is not completing the survey multiple times, but the names should not be listed on the completed survey forms to protect the identity of the person completing the survey.

Remember to thank your participants for their time.
Unit 2: Technological Systems: How They Work

Lesson 1: Social and Cultural Impacts
Student Resource 2.1.6: Lesson Design Brief

The Problem: Packaging often affects a consumer’s decision on whether or not to purchase a product. Working individually, students will create packaging for a product that they believe would be popular with students in their school, based on the results of the survey.

Design Constraints: You will have limited time and materials to complete this process, as described by your teacher. Use your time and materials wisely. Follow the trends described in the survey to complete your package design.

Things to Consider: What kind product will you choose? Will it be something that you would like or something that appeals to another type of consumer?

The results of your survey may have produced very different results than what you would have chosen. How will you overcome this to design for your audience?

Human values and limitations will impact the success of your design. How will you work to address these issues?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, poster board, hot melt glue guns and sticks, construction paper, glue sticks, water-based markers, permanent markers, X-Acto knives, coping saws, scissors, rulers, corrugated cardboard, file folders, and packing materials. Other materials may be used - consult your teacher.

The Completed Package: What can you do to make your package look realistic? Consider some of the information common to all packages: UPC code, size and weight information, descriptive information or comparisons to other products, or ingredient and nutrition information for food products.
Unit 2: Technological Systems: Issues and Impacts

Lesson 1: Social and Cultural Impacts

Assessment Resource 2.1.1: Engineering Design Journal Rubric

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

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<td>Activity 1- examples from ads</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Activity 2- Sketches and ideas for positive and negative ads</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Activity 2- System relationships &amp; process</td>
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<tr>
<td>Activity 3- Notes on positive and negative perceptions</td>
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<tr>
<td>Improvement in drawing skills over time</td>
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<tr>
<td>Includes notes and comments</td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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<tr>
<td>Bonus: Additional materials</td>
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<td>Total</td>
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</tbody>
</table>

Comments:

Grade:
**Unit 2: Technological Systems: Issues and Impacts**

**Lesson 1: Social and Cultural Impacts**

**Assessment Resource 2.1.2: Lesson Quiz**

Name:________________________________________________________

**Multiple Choice:**

1. **Which of the following is a social impact? Circle all that apply.**
   a. My friends like it.  b. I have enough money to buy it.  c. I like the color.  d. I can buy it where I live.

2. **Which of the following is a cultural impact? Circle all that apply.**
   a. My friends all have one.  b. It is something that I need.  c. I like the color because it matches my school colors.  d. I can buy it where I live.

3. **Advertising is:**
   a. a question, phrase or statement that is asked, on paper, on the computer or in person to the person completing the survey.
   b. the behavior, attitude or beliefs of a particular group that one identifies with.
   c. visual, auditory, multimedia or print announcements or notices that are intended to make a consumer aware of, or interested in purchasing a particular product.
   d. a term used to describe the process of trying to generate a variety of ideas to meet a particular need or solve a problem.

4. **Which of the following are guidelines for developing a survey? Circle all that apply.**
   a. Keep items as short as possible.  b. Use technical terms and special language.  c. send out as many surveys as possible.  d. Use a variety of different response formats.

**Matching: Match the correct response from the word bank with the statement below.**

<table>
<thead>
<tr>
<th></th>
<th>a. Advertisement</th>
<th>d. Brainstorming</th>
<th>g. Response Rate</th>
<th>j. Scale</th>
<th>l. Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Population</td>
<td>e. Survey</td>
<td>h. Survey Item</td>
<td>k. Culture</td>
<td>m. Social</td>
<td></td>
</tr>
<tr>
<td>c. Thumbnail Sketch</td>
<td>f. Survey Sample</td>
<td>i. Survey Instrument</td>
<td></td>
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</tr>
</tbody>
</table>

1. A group of questions or items are designed to be asked in the same way every time to get the most reliable results is called a ________________.

2. A(n) ________________ is a visual, auditory, multimedia or print announcement or notice that is intended to make a consumer aware of, or interested in purchasing a particular product.
3. The behavior, attitude or beliefs of a particular group that one identifies with is called ________________.

4. In surveys, the entire group that could possibly represent the kind of people that the researcher would like to study is called the___________________________.

5. Humans as they interact with each other based on their community and people around them are reacting to their surroundings in a _________________ way.

6. A(n) __________________________ is a questionnaire or interview sheet that has been developed to be used to collect data from a specific group of people.

7. The ____________________ is the way that the participants can respond and how those responses are recorded or categorized. Such as yes, moderately agree, etc.

8. A(n) _______________ is a question, phrase or statement that is asked, on paper, on the computer or in person to the person completing the survey.

9. The compiled results of the completed survey are called the ______________________.

10. ______________________ is a term used to describe the process of trying to generate a variety of ideas to meet a particular need or solve a problem.

11. Many surveys are administered to a smaller group of the population that the survey would like to measure that is selected randomly to achieve a certain number. This group is called the ________________________________.

12. If a survey was mailed to 10 people, and only 8 of those people sent it back complete, the ___________________________ would be 8.

13. __________________________ are often completed in multiples during brainstorming.

**Short Answer: Using complete sentences, respond to the following items:**

1. Describe how an ad can be both positive and negative.

2. List three guidelines for developing a survey.

3. Explain how advertisements can influence a consumer to buy a product.
**Unit 2: Technological Systems: Issues and Impacts**

**Lesson 1: Social and Cultural Impacts**

Assessment Resource 2.1.3: Positive/Negative Ad Rubric

### Engineering Design Team Members

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>3</th>
<th>2</th>
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</thead>
<tbody>
<tr>
<td><strong>Complete All areas addressed</strong></td>
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<tr>
<td><strong>Most areas well done</strong></td>
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<tr>
<td><strong>Some areas well done</strong></td>
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<tr>
<td><strong>Minimal effort</strong></td>
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<td><strong>Not attempted, missing</strong></td>
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<tr>
<td>Finished size at least 8.5” X 11” for each ad.</td>
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<tr>
<td>Contains both graphics and text</td>
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<tr>
<td>Conveys some actual (not necessarily factual) information</td>
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<td>Was the presentation professional? (as if family were in the audience)</td>
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<td>The completed ads were well crafted – not torn, smeared, etc.</td>
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<td>Described the intended audience for the ads</td>
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<td>Explained selection of materials, colors, etc.</td>
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<td>Defined each ad as positive or negative</td>
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<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
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<td>Slides or other visuals – relevant and clear</td>
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<tr>
<td>Addressed all relevant information</td>
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<tr>
<td>Personalized presentation through individualized information</td>
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<tr>
<td>Participation – active in the presentation, not just reading</td>
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**Total**

Comments:

Grade:
**Unit 2: Technological Systems: Issues and Impacts**

**Lesson 1: Social and Cultural Impacts**

**Assessment Resource 2.1.4: Research Project Rubric**

**Engineering Design Team Members**

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<td>Complete All areas addressed</td>
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<td>Minimal effort</td>
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<tr>
<td>Not attempted, missing</td>
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<tr>
<td>Survey instrument was appropriate for planned administration</td>
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<td>Survey instrument was easy to read, legible</td>
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<td>Student completed the assigned number of surveys</td>
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<td>Purpose of the survey was explained on the survey form</td>
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<td>A participant list was collected for all survey participants</td>
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<td>Items were as short as possible, addressed only one idea, used clear wording</td>
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<td>The scale was appropriate to the items</td>
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<td>Survey had 10 or fewer items</td>
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<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
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<tr>
<td>Addressed all relevant information</td>
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<tr>
<td>Personalized presentation through individualized information</td>
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<tr>
<td>Participation – active in the presentation, not just reading</td>
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<td>Total</td>
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<td>Comments:</td>
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</table>

Grade:
Lesson 1: Social and Cultural Impacts

Assessment Resource 2.1.5: Reflective Writing Prompts

Write a paragraph responding to each of the writing prompts listed. Use the back of the sheet if needed.

1. Describe the purpose of advertisements in your own words.

2. Explain how social and cultural influences can impact the choices of a consumer.

3. Describe how your Engineering Design Team developed the survey items that were used to understand reactions to your ads.

4. How has this lesson influenced your understanding of how marketing can drive consumer demand for products?

5. After completing the survey process, what changes would you make in your ads if you got to do them again?
Lesson 2: Environment and Economics

Lesson Snapshot

Overview
Big Idea: Technology can have both positive and negative impacts on the environment and the economy.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn that the development of technological products has an impact on the environment and the economy. The environment and the economy are often on opposing sides of the same issues. Positive and negative impacts can result from technology.

Lesson Duration: 4 hours, plus 2 enrichment hours.

Activity Highlights

Engagement
The teacher will bring a variety of recyclable and non-recyclable materials to class. Students will discuss the pros and cons of each type of material, documenting what they use and graphing materials as a class.

Exploration
Using a variety of waste materials or other items that are non-functional, students will develop an “upcycled” product to meet a specific need.

Explanation
Students will discuss the conflict between the environmental impacts of waste management and the economic concerns that are presented by different waste management options.

Extension
Students will investigate waste management processes in their school to design and build a system to minimize waste that reaches the landfill.

Enrichment
Students will take a field trip to a local recycling center.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Presentations, Performance Rubrics, and an End of unit quiz.
Lesson 2: Environment and Economics

Lesson Overview

Lesson Duration
4 hours, plus 2 enrichment hours.

Standards/Benchmarks

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>STL 4E</strong> Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.</td>
</tr>
<tr>
<td><strong>5D</strong> The management of waste produced by technological systems is an important societal issue.</td>
</tr>
<tr>
<td><strong>5E</strong> Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.</td>
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<tr>
<td><strong>5F</strong> Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.</td>
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<table>
<thead>
<tr>
<th>Mathematics: Common Core Standards for Mathematics (CCSM, 2011)</th>
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</thead>
<tbody>
<tr>
<td><strong>Functions Standard (CCSM, Grade 8)</strong></td>
</tr>
<tr>
<td><strong>8.F.5</strong> Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.</td>
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<tr>
<th><strong>Expressions &amp; Equations Standard (CCSM, Grade 8)</strong></th>
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<tbody>
<tr>
<td><strong>8.EE.4</strong> Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used.</td>
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</table>

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<thead>
<tr>
<th>English Language Arts: Common Core Standards for English Language Arts (CCSELA, 2011)</th>
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</thead>
<tbody>
<tr>
<td><strong>Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)</strong></td>
</tr>
<tr>
<td><strong>RST.6-8.1</strong> Cite specific textual evidence to support analysis of science and technical texts.</td>
</tr>
<tr>
<td><strong>RST.6-8.3</strong> Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.</td>
</tr>
</tbody>
</table>
Learning Objectives
Students learn to:
1. Understand the impact of waste on society and the environment.
2. Design technology to address issues of waste and natural disasters.
3. Understand that technology can have both positive and negative impacts.
4. Explain the balance between environment and economics when it comes to the application of technology.
5. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
6. Work safely and accurately with a variety of tools, machines, and materials.
7. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials

Print Materials

Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. Impact of waste on society
   b. Economic impacts of waste
   c. eWaste

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1 Material reprinted from Benchmarks for Science Literacy (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
2. Green Choices, Environmental Impacts, Retrieved on 04/30/12 from http://www.greenchoices.org/green-living/waste-recycling/environmental-impacts (permission to link requested)

**Required Knowledge and/or Skills**
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software.
Teacher’s Note: Many materials that depict a clash between environment and economics are graphic in nature – displaying the extremes of these impacts. View all materials carefully before watching or using with students.

Engagement
The teacher will bring a variety of recyclable and non-recyclable materials to class. Students will discuss the pros and cons of each type of material, documenting what they use and graphing materials as a class.

- Recycling is viewed in a variety of ways. Reasons for recycling may include reducing the cost of waste disposal, to reduce impact on the environment or to regain a deposit.
- Many materials can be both positive and negative, such as plastic. Many modern medical technologies would not be possible without plastic, but it is also a large contributor to overall waste production.
- In some areas, recycling is not socially accepted, even though facilities may be available.
- Students may not be aware of all of the materials that can be recycled in the local context.
- In their Engineering Design Journals, students will discuss their recycling habits, and barriers to recycling in any location, documenting their material use for 2 days.

Exploration
Using a variety of waste materials or other items that are non-functional, students will develop an “upcycled” product to meet a specific need, preventing the material from going to the landfill.

- Students will collect materials, recyclable, waste or other non-functioning items to use in the "upcycling" process.
- Students will sketch designs and develop a specific goal for the completed product in their Engineering Design Journals.
- Using the materials available, students will design and create a completed project to meet the goal or need specified in their Engineering Design Journals.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- Beginning with the individual data that was collected in the Engineering Design Journals on material use, students will discuss patterns and develop graphs of material use.
• Using internet research, students will collect data by country on types of materials that are sent to landfills, and express those numbers in scientific notation.
• During the discussion, the teacher will include considerations of how long materials take to break down, as well as how they can be used to repair damage caused by natural disasters.
• Some materials can have both positive and negative side effects, which can lead to conflicts between groups.

Extension
Students will investigate waste management processes in their school to design and build a system to minimize waste that reaches the landfill.

• Students will gather data about the amount of waste that is collected at their school for disposal from a variety of sources.
• Working in Engineering Design Teams, students will design processes that will lessen the amount of waste produced by their school.
• Specific areas such as the cafeteria may be targeted, or teams can be assigned a specific material.
• Using their Engineering Design Journals, teams will develop 3 potential solutions that could be reasonably deployed in the school.
• Designs will be presented to the class, with a written report describing the design process.

Enrichment
Students will present their potential waste management solutions to the school board, advisory committee or other interested parties.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Presentations, Performance Rubrics, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
### Assessment Instrument – Brief Constructed Response Writing Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
## Assessment Instrument – Teacher Resource 2.2.2: Class Participation Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
Assessment Resource 2.2.2: Creating a new product through Upcycling rubric

Product Designer(s)

<table>
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<tr>
<th>Item</th>
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<tbody>
<tr>
<td>Explained purpose or problem to be solved by product</td>
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<tr>
<td>Described materials used and why they were selected</td>
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<tr>
<td>Described process of finding and collecting materials</td>
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<td>Explained product as invention or innovation</td>
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<tr>
<td>Was the presentation professional? (as if family were in the audience)</td>
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<td>Engineering Design Notebook – Evidence of Project planning</td>
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<tr>
<td>Project was well-constructed, not messy</td>
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<td>Project could meet identified need</td>
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<td>Described process of making the product</td>
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<td>Vocal presentation - clear, relevant, answered questions</td>
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<td>Participation – active in the presentation, not just reading</td>
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Comments:

Grade:
Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content. Gather recyclable materials to represent a variety of categories.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

If students are using the computer to make charts, they can be made using spreadsheet or word processing software.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and graphic design companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Safety glasses, 1 pair per student
4. Assorted Recyclable materials, from recycling center
5. General adhesives such as tape, glue or fasteners
6. X-Acto knives, 1 per student with replacement blades
7. Coping saws, 5 per class, with replacement blades
8. 18” X 24 “ self-healing cutting mats, 10 per class
9. Gift wrap tape, 1-2 rolls per group
10. Masking tape, 1”, 1 roll per group
11. School glue, 40z, 1-2 per group
12. Paper fasteners (brads) 1 box per class
13. Hot melt glue guns, 10 per class
14. Hot melt glue sticks, 50 pack
15. 60” flexible measuring tapes, 1 per student
16. Polyester thread assortment
17. Hand sewing needle assortment
18. Sandpaper assortment
19. Scissors, 1 pair per student
20. 12” Rulers, 1 per student

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
- Teacher Resource 2.2.1: Brief Constructed Response Writing Rubric
- Teacher Resource 2.2.2: Class Participation Rubric
- Teacher Resource 2.2.3: Understanding Environmental and Economic Data Answer Key
- Teacher Resource 2.2.4: Reflective Writing Prompts Answer Key
- Teacher Resource 2.2.5: End of Unit Quiz Answer Key

Student Resources
- Student Resource 2.2.1: Lesson Glossary
- Student Resource 2.2.2: Engineering Design Journal Guidelines
- Student Resource 2.2.3: Creating a new product through Upcycling
- Student Resource 2.2.4: Understanding Environmental and Economic Data
- Student Resource 2.2.5: Lesson Design Brief

Assessment Resources
- Assessment Resource 2.2.1: Engineering Design Journal Rubric
- Assessment Resource 2.2.2: Creating a new product through Upcycling Rubric
- Assessment Resource 2.2.3: Rubric for Presentation
- Assessment Resource 2.2.4: Reflective Writing Prompts
- Assessment Resource 2.2.5: End of Unit Quiz
# Lesson 2: Environment and Economics

## Teacher Resource 2.2.1: Brief Constructed Response Writing

### Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
## Teacher Resource 2.2.2: Class Participation Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
Name: ____________________________________________

When data with very large values are expressed, it is sometimes difficult to comprehend or relate to that information. Many ways to address this problem have been created, such as visual displays like graphs and charts, and scientific notation.

**Scientific Notation:** The purpose of scientific notation is to simplify calculations using decimal values. Scientific notation allows for an estimate and faster calculations. Decimal values can be converted to simple whole numbers by dividing or multiplying by a power of 10.

Note: Dividing by 10 moves the decimal 1 place to the right, and multiplying by 10 moves the decimal 1 place to the left.

Complete these problems, expressing your answer in scientific notation:

1. 1000 *10^{12} = _____1.0 * 10^{15}_______  
   2. 10*10^{-6} = ______1.0 * 10^{-5}_______
   3. 74.3 *10^{-9} = _____7.43 * 10^{-10}_______  
   4. 16.2*10^{11} = _____1.62*10^{12}_______
   5. 19.3*10^{16} = _____1.93 * 10^{17}_______  
   6. 17.586*10^{-7} = ___1.7586 * 10^{-8}_____

Complete these problems, expressing your answer in decimal form:

1. 5*10^{9} = ___5000000000_______  
   2. 2.76*10^{6} = _____276000__________
   3. 17.3*10^{12} = _17300000000000______  
   4. 97.2*10^{-14} = _0.000000000000972_____ 
   5. 14*10^{-8}=_0.000000014___________  
   6. 394567 / 10^{4} = _39.4567___________
**Graphing:** Based on the following descriptions, sketch a graph of what the function might look like. Your graph should show if the function is increasing or decreasing, linear or non-linear.

1. A function with an output that is equal to two times the input.

2. All points of distance 2 from the origin.
3. A function with an output that is the square of the input plus 3

4. A function with the output equal to the square root of the input.

5. A function with an output equal to -3 divided by the input.
Unit 2: Technological Systems: Issues and Impacts

Lesson 2: Environment and Economics

Teacher Resource 2.2.4: Reflective Writing Prompts Answer Key

Write a paragraph responding to each of the writing prompts listed. Use the back of the sheet if needed.

1. Describe in your own words the process of upcycling.

   Student answers will vary but should include the idea taking non-functional or non-useful products or waste materials and making them into a new useful product.

2. Using examples, explain how technology can create unintended or unexpected results.

   Student responses will vary, but should include accurate information about a technological development that turned out differently than planned, such as the need to go through banking software for Y2K due to the shortened process of entering years as 2 digit numbers instead of 4.

3. Explain how environmental and economic concerns about technology can clash.

   Student response will vary, but environmental and economic concerns are at war with each other on a variety of areas, primarily in that the more environmentally sound process/material/product may not be economically feasible.

4. Describe some of the design constraints that you encountered in your upcycling project.

   Student answers will vary but should include constraints such as available materials, time, ability to connect or bond materials, etc.

5. Why is it important to consider waste management in our society?

   Student responses will vary but should address, health, safety, environment, social and cultural concerns.
Multiple Choice:

1. Which of the following is a social impact? Circle all that apply.
   a. My friends like it. b. I have enough money to buy it. c. I like the color. d. I can buy it where I live.

2. Which of the following is a cultural impact? Circle all that apply.
   a. My friends all have one. b. It is something that I need. c. I like the color because it matches my school colors. d. I can buy it where I live.

3. How many types of plastic are currently produced?
   a. 4 b. 7 c. 10 d. 9

4. Which of the following are guidelines for developing a survey? Circle all that apply.
   a. Keep items as short as possible. b. Use technical terms and special language. c. send out as many surveys as possible. d. Use a variety of different response formats.

5. Technology can create results that are___________. Circle all that apply.
   a. the planned outcome b. unintended c. unexpected d. undesirable

Matching: Match the correct response from the word bank with the statement below.


1. A group of questions or items are designed to be asked in the same way every time to get the most reliable results is called a _______m__________.

2. A(n)________i__________ is a visual, auditory, multimedia or print announcement or notice that is intended to make a consumer aware of, or interested in purchasing a particular product.

3. ___________r______________ are an effect from a force of nature or weather event such as fire, flood, tornado, etc. that has damaged the environment.

4. The process of using unwanted or refuse materials to create a new product, generally of better quality or extended use is called _______a_______

5. The behavior, attitude or beliefs of a particular group that one identifies with is called _______q__________.
6. In surveys, the entire group that could possibly represent the kind of people that the researcher would like to study is called the________f___________.

7. Humans as they interact with each other based on their community and people around them are reacting to their surroundings in a _______j_________ way.

8. __________g____________ is the collection, transport, processing and disposal of unwanted or refuse materials. This can also include recycling and monitoring of hazardous materials.

9. A(n) __________p____________ is a questionnaire or interview sheet that has been developed to be used to collect data from a specific group of people.

10. A community or group of people that live and work together, following a common set of rules and laws is called a(n) __________o______________.

11. A(n) __________h_________ is a question, phrase or statement that is asked, on paper, on the computer or in person to the person completing the survey.

12. The________e____________ is the surroundings, location or conditions where people, plants and animals live and work.

13. The compiled results of the completed survey are called the __________d______________.

14. __________b____________ is a term used to describe the process of trying to generate a variety of ideas to meet a particular need or solve a problem.

15. Many surveys are administered to a smaller group of the population that the survey would like to measure that is selected randomly to achieve a certain number. This group is called the __________l__________________.

16. The financial and material prosperity of a group of people, region or country is referred to as __________n______________.

17. If a survey was mailed to 10 people, and only 8 of those people sent it back complete, the __________c______________ would be 8.

18. __________k______________ are often completed in multiples during brainstorming.

Short Answer: Using complete sentences, choose three of the following and respond in your own words:

1. Describe how an ad can be both positive and negative.

Student responses will vary but should include personal preference, social and cultural influences.
2. List three guidelines for developing a survey.

Keep items as short as possible, avoid technical terms, use a similar response scale for all items, or break it up into sections, they should be simple to complete, only asking about one concept in each item.

3. Describe the purpose of advertisements in your own words.

Student answers will vary but should include making a consumer aware of and interested in purchasing a product or service.

4. Describe in your own words the process of upcycling. Student answers will vary but should include the idea taking non-functional or non-useful products or waste materials and making them into a new useful product.

5. Why is it important to consider waste management in our society?

Student responses will vary but should address, health, safety, environment, social and cultural concerns.

When data with very large values are expressed, it is sometimes difficult to comprehend or relate to that information. Many ways to address this problem have been created, such as visual displays like graphs and charts, and scientific notation.

**Scientific Notation:** The purpose of scientific notation is to simplify calculations using decimal values. Scientific notation allows for an estimate and faster calculations. Decimal values can be converted to simple whole numbers by dividing or multiplying by a power of 10.

Note: Dividing by 10 moves the decimal 1 place to the right, and multiplying by 10 moves the decimal 1 place to the left.

Complete these problems, expressing your answer in scientific notation:

1. \(7.43 \times 10^{-9} = \) _____ \(7.43 \times 10^{-10}\) ______
2. \(16.2 \times 10^{11} = \) _____ \(1.62 \times 10^{12}\) ______
3. \(19.3 \times 10^{16} = \) _____ \(1.93 \times 10^{17}\) ______
4. \(17.586 \times 10^{-7} = \) _____ \(1.7586 \times 10^{-8}\) ______

Complete these problems, expressing your answer in decimal form:

1. \(5 \times 10^9 = \) _____ \(5000000000\) ______
2. \(2.76 \times 10^6 = \) _____ \(2760000\) ______
3. \(1.4 \times 10^{-8} = \) _____ \(0.00000014\) ______
4. \(394567 / 10^4 = \) _____ \(39.4567\) ______
Graphing: Based on the following descriptions, sketch a graph of what the function might look like. Your graph should show if the function is increasing or decreasing, linear or non-linear.

1. A function with an output that is equal to two times the input.

![Graph showing a linear function with output equal to two times the input.]

2. All points of distance 2 from the origin.

![Graph showing a circle centered at the origin with radius 2.]
Economics The financial and material prosperity of a group of people, region or country. As it is applied in this lesson, it may refer to a smaller unit, such as an individual business.

Environment The surroundings, location or conditions where people, plants and animals live and work. In manufacturing settings, it can also refer to specific conditions such as a cleanroom environment.

Natural Disasters An effect from a force of nature or weather event such as fire, flood, tornado, etc. that has damaged the environment.

Plastic types There are seven different types of plastics used in product and container production.

- Number 1 plastics are PET or PETE, such as soda and water bottles.
- Number 2 plastics are HDPE, such as milk jugs and shampoo bottles.
- Number 3 plastics are V or PVC, such as window cleaner bottles and piping.
- Number 4 plastics are LDPE, such as squeezable bottles and shopping bags.
- Number 5 plastics are PP, such as yogurt containers and straws.
- Number 6 plastics are PS, such as egg cartons and CD cases.
- Number 7 plastics are Miscellaneous, such as sunglasses, DVDs and computer cases.


Society A community or group of people that live and work together, following a common set of rules and laws.

Upcycling The process of using unwanted or refuse materials to create a new product, generally of better quality or extended use.

Waste Management The collection, transport, processing and disposal of unwanted or refuse materials. This can also include recycling and monitoring of hazardous materials.
Unit 2: Technological Systems: Issues and Impacts

Lesson 2: Environment and Economics

Student Resource 2.2.2: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 2: Technological Systems: Issues and Impacts

Lesson 2: Environment and Economics

Student Resource 2.2.3: Creating a New Product through Upcycling

Generally, when a product is created, it has a life cycle. It is intended to be used for a specific purpose for a certain amount of time. After it has reached the end of its useful life, or is no longer wanted, it is discarded.

Raw materials such as wood and metal are collected through mining or harvesting, and subjected to a series of processes to develop a material that is ready for the manufacturing process.

From there, the material is further manipulated to take on the form and characteristics of the finished product. Additional surface treatments and packaging are added before the product can be shipped and sold.

Once something is used up, broken, worn out or otherwise no longer useful or wanted, it is at the end of its life cycle, which generally ends in a landfill.

But what if that wasn’t the end?

The purpose of upcycling is to take materials that are ready to be discarded, for any reason, and to make them into useful products again.

Upcycling can be both invention - the creation of new products, or innovation - the improvement or repair of an existing product.

In designing and creating your product, think about these constraints and issues:

- Think of a specific need that you or someone you know has. Can you design something to help with that need?
- What materials are available? There are many materials available for little or no cost if you are willing to find them. Do you want to use a material that may be difficult to recycle in your area such as LDPE plastic shopping bags? Is there something in your home that is broken or no longer useful that could be part of your product?
- How much time do you have to create your product?
- Is it something that you would want to make more than once?

For Inspiration: Visit the website [http://www.instructables.com/index](http://www.instructables.com/index) (permission to link requested)

Assessment: For this project, you will be designing your upcycled product in your Engineering Design Journal with notes and sketches, collecting materials to create your product, constructing a completed, functional product and presenting it to the class.
Student Resource 2.2.4: Understanding Environmental and Economic Data

Name:______________________________________

When data with very large values are expressed, it is sometimes difficult to comprehend or relate to that information. Many ways to address this problem have been created, such as visual displays like graphs and charts, and scientific notation.

**Scientific Notation:** The purpose of scientific notation is to simplify calculations using decimal values. Scientific notation allows for an estimate and faster calculations. Decimal values can be converted to simple whole numbers by dividing or multiplying by a power of 10.

Note: Dividing by 10 moves the decimal 1 place to the right, and multiplying by 10 moves the decimal 1 place to the left.

Complete these problems, expressing your answer in scientific notation:

1. \(1000 \times 10^{12} = \) ______________________
2. \(10^{-6} = \) ______________________
3. \(74.3 \times 10^{-9} = \) ______________________
4. \(16.2 \times 10^{11} = \) ______________________
5. \(19.3 \times 10^{16} = \) ______________________
6. \(17.586 \times 10^{-7} = \) ______________________

Complete these problems, expressing your answer in decimal form:

1. \(5 \times 10^9 = \) ______________________
2. \(2.76 \times 10^6 = \) ______________________
3. \(17.3 \times 10^{12} = \) ______________________
4. \(97.2 \times 10^{14} = \) ______________________
5. \(14 \times 10^8 = \) ______________________
6. \(394567 / 10^4 = \) ______________________

**Graphing:** Based on the following descriptions, sketch a graph of what the function might look like. Your graph should show if the function is increasing or decreasing, linear or non-linear.

Continued on next page.
1. A function with an output that is equal to two times the input.

2. All points of distance 2 from the origin.
3. A function with an output that is the square of the input plus 3

4. A function with the output equal to the square root of the input.
5. A function with an output equal to -3 divided by the input.
Part One: Exploration: Upcycling

The Problem: There are many materials sent to landfills that may be used for another application when they are broken or no longer wanted for the original purpose of the item. Using recycled materials, you will design and build a new object to meet a specific need.

Design Constraints: All materials used must be repurposed or recycled, other than adhesives, fasteners or other hardware.

You will have limited time and materials to complete this process, as described by your teacher. Use your time and materials wisely.

Things to Consider: Since you are using recycled materials, you may not have the specific material available that you would prefer to use, such as size or color. What can you do to address this using the materials that are available? Always use appropriate safety equipment.

Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, hot melt glue guns and sticks, X-Acto knives, coping saws, scissors, rulers, assorted recyclable materials, paper fasteners (brads), Flexible measuring tapes, polyester thread, hand sewing needles, and assorted sandpaper. Other materials may be used - consult your teacher.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation, if it is a functional object.

The Completed Product: Submit a description with your project of where your materials were obtained, how they were used, and how the object meets your specified need.

Part Two: Extension: Minimizing Waste in Your School

The Problem: In a school system, a great deal of waste is often generated. Working with your Engineering Design Team, you will work together to develop a system to minimize waste that reaches the landfill.

Design Constraints: Materials selected must be easy to use (for students, teachers, etc.) and easy to empty or maintain by custodians or others as appropriate.

Specific areas such as the cafeteria may be targeted, or teams can be assigned a specific material.

Using your Engineering Design Journal, each team will develop 3 potential solutions that could be reasonably deployed in the school.
**Things to Consider:** Where will your system or equipment be located? How does this affect how the design of your system?

How will you let students, teachers and parents know this system is in place?

Always use appropriate safety equipment.

**Materials:** Engineering Design Journals, data collected on waste in the school

**Presentation:** Designs will be presented to the class, with a written report describing the design process. Consider presenting your ideas to the school board, CTE Advisory Committee or student council.
Assessment Resource 2.2.1: Engineering Design Journal Rubric

Name______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1- Recycling habits &amp; material use</td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Activity 1- Barriers to recycling discussed</td>
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<tr>
<td>Activity 2- Upcycling project notes and sketches</td>
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<tr>
<td>Extension- Documentation of research in setting</td>
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<td>Extension - planning sketches</td>
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<tr>
<td>Extension- development of 3 potential solutions</td>
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<tr>
<td>Improvement in drawing skills over time</td>
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<td>Includes notes and comments</td>
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<td>Ability to understand and interpret images, notes and sketches</td>
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<td>Bonus: Additional materials</td>
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<td>Total</td>
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</table>

Comments:

Grade:
## Lesson 2: Environment and Economics

### Assessment Resource 2.2.2: Creating a new product through Upcycling rubric

#### Product Designer(s)

<table>
<thead>
<tr>
<th></th>
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<th>3</th>
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<tbody>
<tr>
<td>Complete All areas addressed</td>
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<tr>
<td>Most areas well done</td>
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<td>Some areas well done</td>
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<td>Minimal effort</td>
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<td>Not attempted, missing</td>
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<tr>
<td>Explained purpose or problem to be solved by product</td>
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<tr>
<td>Described materials used and why they were selected</td>
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<tr>
<td>Described process of finding and collecting materials</td>
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<tr>
<td>Explained product as invention or innovation</td>
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<td>Was the presentation professional? (as if family were in the audience)</td>
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<td>Engineering Design Notebook – Evidence of Project planning</td>
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<td>Project was well-constructed, not messy</td>
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<tr>
<td>Project could meet identified need</td>
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<td>Described process of making the product</td>
<td></td>
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</tr>
<tr>
<td>Vocal presentation – clear, relevant, answered questions</td>
<td></td>
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</tr>
<tr>
<td>Participation – active in the presentation, not just reading</td>
<td></td>
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<tr>
<td>Total</td>
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</tr>
</tbody>
</table>

**Comments:**

**Grade:**

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## Lesson 2: Environment and Economics

### Assessment Resource 2.2.3: Rubric for Presentations

<table>
<thead>
<tr>
<th>Presenter(s)</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explained goal of the system</td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Explained system components and their roles</td>
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<tr>
<td>Explained how the system would impact the current situation</td>
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<tr>
<td>Documentation of planned completed system</td>
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<tr>
<td>Was the presentation professional? (as if family were in the audience)</td>
<td></td>
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<tr>
<td>Use of visuals - pictures, graphs, sketches, objects</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Use of text information - handouts, notes, lists</td>
<td></td>
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<td></td>
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<tr>
<td>Use of audiovisual information - videos, websites, sounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Slides or other visuals – relevant and clear</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Addressed all relevant information</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Personalized presentation through individualized information</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Participation – active in the presentation, not just reading</td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

**Comments:**

Grade:
Unit 2: Technological Systems: Issues and Impacts

Lesson 2: Environment and Economics

Assessment Resource 2.2.4: Reflective Writing Prompts

Write a paragraph responding to each of the writing prompts listed. Use the back of the sheet if needed.

1. Describe in your own words the process of upcycling.

2. Using examples, explain how technology can create unintended or unexpected results.

3. Explain how environmental and economic concerns about technology can clash.

4. Describe some of the design constraints that you encountered in your upcycling project.

5. Why is it important to consider waste management in our society?
Unit 2: Technological Systems: Issues and Impacts

Lesson 2: Environment and Economics

Assessment Resource 2.2.5.: End of Unit Quiz

Name: ________________________________

Multiple Choice:

1. Which of the following is a social impact? Circle all that apply.
   a. My friends like it.  b. I have enough money to buy it.  c. I like the color.  d. I can buy it where I live.

2. Which of the following is a cultural impact? Circle all that apply.
   a. My friends all have one.  b. It is something that I need.  c. I like the color because it matches my school colors.  d. I can buy it where I live.

3. How many types of plastic are currently produced?
   a. 4  b. 7  c. 10  d. 9

4. Which of the following are guidelines for developing a survey? Circle all that apply.
   a. Keep items as short as possible.  b. Use technical terms and special language.  c. Send out as many surveys as possible.  d. Use a variety of different response formats.

5. Technology can create results that are__________. Circle all that apply.
   a. the planned outcome  b. unintended  c. unexpected  d. undesirable

Matching: Match the correct response from the word bank with the statement below.

a. Upcycling  b. Brainstorming  c. Response Rate  d. Outcome  e. Environment  
   f. Population  g. Waste Management  h. Survey Item  i. Advertisement  j. Social  
   k. Thumbnail Sketch  l. Survey Sample  m. Survey  n. Economics  o. Society  
   p. Survey Instrument  q. Culture  r. Natural Disasters

1. A group of questions or items are designed to be asked in the same way every time to get the most reliable results is called a ________________.

2. A(n)______________ is a visual, auditory, multimedia or print announcement or notice that is intended to make a consumer aware of, or interested in purchasing a particular product.

3. ________________ are an effect from a force of nature or weather event such as fire, flood, tornado, etc. that has damaged the environment.

4. The process of using unwanted or refuse materials to create a new product, generally of better quality or extended use is called ________________.
5. The behavior, attitude or beliefs of a particular group that one identifies with is called ________________.

6. In surveys, the entire group that could possibly represent the kind of people that the researcher would like to study is called the ________ ____________.

7. Humans as they interact with each other based on their community and people around them are reacting to their surroundings in a _________________ way.

8. _________________ is the collection, transport, processing and disposal of unwanted or refuse materials. This can also include recycling and monitoring of hazardous materials.

9. A(n) __________________________ is a questionnaire or interview sheet that has been developed to be used to collect data from a specific group of people.

10. A community or group of people that live and work together, following a common set of rules and laws is called a(n) __________________________.

11. A(n) __________________________ is a question, phrase or statement that is asked, on paper, on the computer or in person to the person completing the survey.

12. The __________________________ is the surroundings, location or conditions where people, plants and animals live and work.

13. The compiled results of the completed survey are called the _________________.

14. __________________________ is a term used to describe the process of trying to generate a variety of ideas to meet a particular need or solve a problem.

15. Many surveys are administered to a smaller group of the population that the survey would like to measure that is selected randomly to achieve a certain number. This group is called the ________ ____________.

16. The financial and material prosperity of a group of people, region or country is referred to as ________________________.

17. If a survey was mailed to 10 people, and only 8 of those people sent it back complete, the __________________________ would be 8.

18. __________________________ are often completed in multiples during brainstorming.

**Short Answer: Using complete sentences, choose three of the following and respond in your own words:**

1. Describe how an ad can be both positive and negative.
2. List three guidelines for developing a survey.

3. Describe the purpose of advertisements in your own words.

4. Describe in your own words the process of upcycling.

5. Why is it important to consider waste management in our society?

Scientific Notation: Complete these problems, expressing your answer in scientific notation:

1. $74.3 \times 10^{-9} = \underline{7.43} \times 10^{-10}$
2. $16.2 \times 10^{11} = \underline{1.62} \times 10^{12}$
3. $19.3 \times 10^{16} = \underline{1.93} \times 10^{17}$
4. $17.586 \times 10^{-7} = \underline{1.7586} \times 10^{-8}$

Complete these problems, expressing your answer in decimal form:

1. $5 \times 10^9 = \underline{500000000}$
2. $2.76 \times 10^6 = \underline{2760000}$
3. $14 \times 10^{-8} = \underline{0.0000014}$
4. $394567 \div 10^4 = \underline{39.4567}$
Graphing: Based on the following descriptions, sketch a graph of what the function might look like. Your graph should show if the function is increasing or decreasing, linear or non-linear.

1. A function with an output that is equal to two times the input.

2. All points of distance 2 from the origin.
Unit #3: Technological System Interaction

Overview

This course will investigate technological systems through their function, design, development, interaction and maintenance. Systems included in this exploration include communications, construction, manufacturing, bio-medical and power energy.

Big Idea
Technological Systems are designed to meet a specific need and can address this need through a variety of functions, processes and interactions with other systems.

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

Purpose of the Unit

This unit introduces the idea of technological systems. Issues of design and development constraints, functions and processes within a system and the interaction of two or more systems are addressed.
### Standards/Benchmarks

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

<table>
<thead>
<tr>
<th>STL 2P</th>
<th>Technological systems can be connected to one another.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2Q</td>
<td>Malfunctions of any part of a system may affect the function and quality of the system.</td>
</tr>
<tr>
<td>2T</td>
<td>Different technologies involve different sets of processes.</td>
</tr>
<tr>
<td>3D</td>
<td>Technological systems often interact with one another.</td>
</tr>
<tr>
<td>3E</td>
<td>A product, system, or environment developed for one setting may be applied to another setting.</td>
</tr>
<tr>
<td>3F</td>
<td>Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.</td>
</tr>
<tr>
<td>11L</td>
<td>Make a product or system and document the solution.</td>
</tr>
</tbody>
</table>

**Mathematics:** Common Core Standards for Mathematics *(CCSM, 2011)*

**Geometry Standard** *(CCSM, Grade 7)*

| 7.G.1 | Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. |

**Expressions & Equations Standard** *(CCSM, Grade 8)*

| 8.EE  | Expressions and equations work with radicals and integer exponents. |
| 8.EE  | Understand the connections between proportional relationships, lines and linear equations. |
| 8.EE  | Analyze and solve linear equations and pairs of simultaneous linear equations. |

**Functions Standard** *(CCSM, Grade 8)*

| 8.F   | Define, evaluate and compare functions. |
| 8.F   | Use functions to model relationships between quantities. |

**English Language Arts:** Common Core Standards for English Language Arts *(CCSELA, 2011)*

**Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)**

| RST.6-8.1 | Cite specific textual evidence to support analysis of science and technical texts. |
| RST.6-8.3 | Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. |
### Common Themes

<table>
<thead>
<tr>
<th>11A/M3</th>
<th>Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a sub-system of a larger system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11A/M5</td>
<td>Systems are defined by placing boundaries around collections of interrelated things to make them easier to study. Regardless of where the boundaries are placed, a system still interacts with its surrounding environment. Therefore, when studying a system, it is important to keep track of what enters or leaves the system.</td>
</tr>
</tbody>
</table>

### The Designed World

| 8E/M3   | Computer control of mechanical systems can be much quicker than human control. In situations where events happen faster than people can react, there is little choice but to rely on computers. Most complex systems still require human oversight, however, to make certain kinds of judgments about the readiness of the parts of the system (including the computers) and the system as a whole to operate properly, to react to unexpected failures, and to evaluate how well the system is serving its intended purposes. |

### The Nature of Science

<table>
<thead>
<tr>
<th>1C/M1</th>
<th>Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1C/M3</td>
<td>No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world.</td>
</tr>
</tbody>
</table>

### Unit Objectives

#### Lesson 1: System Functions, Processes and Interactions

Students learn to:
- Compare processes within technological systems
- Understand the impact of malfunction within a system
- Describe the function and quality of a system when a malfunction occurs
- Understand and demonstrate the interaction that can occur between two or more systems
- Design a product or system that connects two or more systems

#### Student Assessment

- Engineering Design Journal
- Constructed Response items
- Performance Rubrics
- End of unit quiz

#### Lesson 2: System Design and Development

Students learn to:
- Understand and explain that knowledge gained from other fields has a direct impact on the development of products and systems
- Design a product, system and explain the potential application to another system
- Develop a product or system and document the solution

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1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Student Assessment

- Engineering Design Journal
- Presentation
- Research Projects
- Performance Rubrics
- Constructed Response Items
- End of unit quiz
Lesson 1: System Functions and Processes

Lesson Snapshot

Overview
Big Idea: Processes within systems serve different functions and can cause problems with the performance of the system if there is a malfunction.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn that processes within systems serve different functions. Malfunction within a system can be investigated and potentially repaired. System function can be impaired by improperly working components. Technological Systems can be connected to interact.

Lesson Duration: 4 hours, plus 1 enrichment hour.

Activity Highlights

Engagement
Students will develop and participate as part of a “human system”, with multiple subsystems interacting to form a larger system.

Exploration
Working in Engineering Design Teams, students will research system malfunctions and troubleshooting, sharing their information in class.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject.

Extension
Working in Engineering Design Teams, students will develop a system to package a series of materials and “ship” it another location, simulating shipping an online order from a warehouse.

Enrichment
Students will mail or ship completed packages to another location to determine survivability of cargo in the shipping container as designed.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, and an End of unit quiz.
Lesson 1: System Functions and Processes

Lesson Overview

Lesson Duration
4 hours, plus 1 enrichment hour.

Standards/Benchmarks

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

<table>
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<td>Technological systems often interact with one another.</td>
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**Mathematics:** Common Core Standards for Mathematics (CCSM, 2011)

**Expressions & Equations Standard (CCSM, Grade 8)**

| 8.EE - 1 | Expressions and equations work with radicals and integer exponents. |
| 8.EE - 2 | Understand the connections between proportional relationships, lines and linear equations. |
| 8.EE - 3 | Analyze and solve linear equations and pairs of simultaneous linear equations. |

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| 7.G.1 | Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. |
**English Language Arts:** Common Core Standards for English Language Arts (CCSELA, 2011)

**Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)**

RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

**Science:** Benchmarks for Science Literacy (AAAS, 1993/2009)

**The Designed World**

8E/M3  Computer control of mechanical systems can be much quicker than human control. In situations where events happen faster than people can react, there is little choice but to rely on computers. Most complex systems still require human oversight, however, to make certain kinds of judgments about the readiness of the parts of the system (including the computers) and the system as a whole to operate properly, to react to unexpected failures, and to evaluate how well the system is serving its intended purposes.

**Common Themes**

11A/M3  Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a sub-system of a larger system.

11A/M5  Systems are defined by placing boundaries around collections of interrelated things to make them easier to study. Regardless of where the boundaries are placed, a system still interacts with its surrounding environment. Therefore, when studying a system, it is important to keep track of what enters or leaves the system.

---

1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Learning Objectives
Students learn to:
1. Compare processes within technological systems
2. Understand the impact of malfunction within a system
3. Describe the function and quality of a system when a malfunction occurs
4. Understand and demonstrate the interaction that can occur between two or more systems
5. Design a product or system that connects two or more systems Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
6. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
7. Work safely and accurately with a variety of tools, machines, and materials.
8. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials
1. NTDTV, Road Testing for German Self-Driving Car, Retrieved on 05/01/12 from http://www.youtube.com/watch?v=SP0MWeoKmbg&feature=fvst (permission to link requested)
2. FSH Houston, Explanation of Different Hip Implant Designs, Retrieved on 05/01/12 from http://www.youtube.com/watch?v=k-QOqOayBUQ&feature=related (permission to link requested)

Print Materials

Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. System functions
   b. Troubleshooting
   c. Quality control
3. Troubleshooters.com, The Universal Troubleshooting Process(UTP), Retrieved on 05/01/12 from http://www.troubleshooters.com/tuni.htm#_The_10_step_Universal_Troubleshooting (permission to link requested)
4. Troubleshooters.com, Universal Troubleshooting Process Completion Form, Retrieved on 05/01/12 from http://www.troubleshooters.com/utp/utp_guide_form.pdf (permission to link requested)

Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software.
Unit 3: Technological System Interaction

Lesson 1: System Functions and Processes

5-E Lesson Plan

Teacher’s Note: This unit will require students to be up and moving around in the classroom to interact within their “systems”. Providing open floor space and removing obstacles may make this easier to facilitate. In the extension section, provide students with a variety of materials, differing in size, shape, material and weight to complete their “packages”.

Engagement
Students will develop and participate as part of a “human system”, with multiple subsystems interacting to form a larger system.

- The teacher will provide an object for each subsystem, any non-fragile object will work, but similar objects in varying colors such as balls will aid in providing directions.
- Each small group will form a circle and develop a process and speed for passing the object within their circle or “system”.
- As each “system” becomes proficient with an even speed and process, begin to join systems into a larger system, by bringing “systems” together. At least one person from each “system” should become a component in the system they are joining, participating in both systems.
- Continue joining systems until all systems are connected.
- If the overall system is functioning well, have some “subsystems” change direction or speed to see the impact on the overall system.
- Discuss the results of the interaction of “systems” as a class.
- In their Engineering Design Journals, students will note systems around them and create a sketch or diagram of at least 1 system that they can observe.

Exploration
Working in Engineering Design Teams, students will research system malfunctions and troubleshooting, sharing their information in class.

- The teacher will assign a general category for research, such as land transportation or bio-medical systems.
- Each Engineering Design Team will have 15-20 minutes to complete their search, documenting what the system was, what it was intended to do, and where it may fail in their Engineering Design Journals.
- Students will share the results with the class.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- There are times that we endure a less than ideal system because other constraints such as time, finances and access to materials make it difficult to properly repair.
The teacher will lead students in small group discussions about systems that needed troubleshooting or failed and how problems were addressed.
- Ideas from the manufacturing/production side included in the discussion should include, customer service, cost of repair, replacement parts and servicing.
- Ideas from the consumer side should include warranty, brand loyalty, service and cost compared to functionality.
- Students will consider both the manufacturing/production and consumer sides as they prepare their solution to the extension problem.

Extension
Working in Engineering Design Teams, students will develop a system to package a series of materials and “ship” it another location, simulating shipping an online order for components for assembly from a warehouse.
- The teacher will determine the objects to be shipped and the appropriate number for each “package”.
- Once materials to be shipped have been determined, Engineering Design Teams will develop a packaging system or shipping container for the items in their Engineering Design Journals and construct the final design.
- Each Engineering Design Team in the class will serve as a location for adding a component to the completed product for shipping.
- The starting team will be determined by the teacher. Each team will need to assemble and ship their product to the next team, integrating the components from previous teams.
- The final team will ship their completed product to the starting team.
- The class will discuss the function of the overall system, breakdowns and troubleshooting of the system.

Enrichment
Students will mail or ship completed packages to another location to determine survivability of cargo in the shipping container as designed.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
## Teacher Resource 3.1.1: Brief Constructed Response Writing Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
Teacher Resource 3.1.2: Class Participation Rubric

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

Comments:

Grade:
Assessment Resource 3.1.1: Engineering Design Journal Rubric

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
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<tbody>
<tr>
<td>Complete All areas addressed</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most areas well done</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Some areas well done</td>
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<tr>
<td>Minimal effort</td>
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<tr>
<td>Not attempted, missing</td>
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Activity 1 - sketch or diagram of an observable system

Activity 2 - documentation of research

Shipping activity sketches

Shipping activity notes - materials, planning, constraints

Improvement in drawing skills over time

Includes notes and comments

Ability to understand and interpret images, notes and sketches

Bonus: Additional materials

Total

Comments:

Grade:
### Assessment Resource 3.1.2: Packing and Shipping Components Rubric

**Engineering Design Team Members**

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<thead>
<tr>
<th>Assessment:</th>
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<tr>
<td>Evidence of planning - sketches, notes, materials for package</td>
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<tr>
<td>Survival of cargo – Arrived intact and assembled as planned</td>
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<tr>
<td>Use of materials - followed design constraints</td>
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<td>Use of materials - economical choices</td>
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<td>Component(s) or subassemblies could be easily removed from the container</td>
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<td>Assembled received components with new component as directed</td>
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<td>Participation – active in the shipping process, not just watching</td>
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<td><strong>Bonus:</strong></td>
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<tr>
<td>Evidence of testing designs</td>
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<td>Shape other than cubic or rectangular</td>
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<tr>
<td>Mechanism to open or seal package other than standard tape</td>
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<tr>
<td>Provided directions for assembly or opening package</td>
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<td></td>
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<td></td>
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<tr>
<td>Use of unique materials</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Total</strong></td>
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</table>

**Comments:**

Grade:
Unit 3: Technological System Interaction

Lesson 1: System Functions and Processes

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content. Gather recyclable materials to represent a variety of categories.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations which may use word processing, presentation and design software. This unit will require students to be up and moving around in the classroom to interact within their “systems”. Providing open floor space and removing obstacles may make this easier to facilitate. In the extension section, provide students with a variety of materials, differing in size, shape, material and weight to complete their “packages”.

If a manufacturing or construction laboratory is available and appropriate for use with this class, consider creating larger prototypes and utilizing wood, metal and other materials, or on a larger scale.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and shipping companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Engineering Design Journals or blank paper
4. A small non-fragile item such as a bouncy ball for each Engineering Design Team
5. Corrugated cardboard, approximately 8” X 10”, 10-15 pieces per class
6. Used file folders, 25 per class
7. Salvaged packing materials such as Styrofoam and bubble wrap
8. Balsa Wood Economy Bag, 3 per class
9. Construction paper multi-colored pack
10. 18”X24” self-healing cutting mats
11. Scissors, 1 pair per student
12. 12” rulers, 1 per student
13. X-Acto knives, 1 per student, with replacement blades
14. Gift wrap tape, 1-2 rolls per group
15. Masking tape, 1”, 1 roll per group
16. School glue, 4 oz, 1-2 per group
17. Hot melt glue guns, 10 per class
18. Hot melt glue sticks, 50 packs
19. Glue sticks, 1 per student
20. Duck brand tape, 20 yd roll, 3 per class
21. Graph paper, 80 sheet pack
22. Balsa Wood Easy cutter, 3 per class
23. Assorted sandpaper

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
• Teacher Resource 3.1.1: Brief Constructed Response Writing Rubric
• Teacher Resource 3.1.2: Class Participation Rubric
• Teacher Resource 3.1.3: Brief Constructed Response Quiz Answer Key
• Teacher Resource 3.1.4: Geometry and Relationships within Systems Answer Key

Student Resources
• Student Resource 3.1.1: Unit PowerPoint
• Student Resource 3.1.2: Lesson Glossary
• Student Resource 3.1.3: Engineering Design Journal Guidelines
• Student Resource 3.1.4: Researching System Malfunctions and Troubleshooting
• Student Resource 3.1.5: Geometry and Relationships within Systems
• Student Resource 3.1.6: Packing and Shipping Components
• Student Resource 3.1.7: Brief Constructed Response Quiz
• Student Resource 3.1.8: Lesson Design Brief

Assessment Resources
• Assessment Resource 3.1.1: Engineering Design Journal Rubric
• Assessment Resource 3.1.2: Packing and Shipping Components Rubric
## Unit 3: Technological System Interaction

**Lesson 1: System Functions and Processes**

**Teacher Resource 3.1.1: Brief Constructed Response Writing Rubric**

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
## Teacher Resource 3.1.2: Class Participation Rubric

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

Comments:

Grade:
Lesson 1: System Functions and Processes

Teacher Resource 3.1.3: Brief Constructed Response Quiz Answer Key

Using the scenarios described below, complete the items as directed. For short answer responses, write a paragraph. Use the back of the sheet if needed.

Scenario 1: You have just been hired as a product tester and shipping specialist for a small company that manufactures custom skateboards. There have been problems in getting completed skateboards to the customers by the date given through the ordering website.

1. Describe the system that you would use to troubleshoot the shipping delays.

Student responses will vary but should include looking for the problem, documenting when and why the problem occurs and developing potential solutions for the problem.

2. If the delays in shipping were the result of not receiving materials in time to produce the skateboard by the shipping date listed on the website, how would you adjust the production system?

Student responses will vary but can include changing the timing of production, ordering materials earlier, or providing a later date on the website.

3. As a product tester, you notice that there is a problem with the grip tape not adhering well at all the edges of the deck. What do you expect to happen when you report this to the manager?

Student responses will vary but could include, checking the grip tape and the sample decks for signs of wear or poor materials used in making the grip tape, checking on the process of adhering the grip tape to the decks and discussing it with the person who does the application of the grip tape.

Scenario 2: You purchased a new pair of athletic shoes from your favorite brand. They were the size, color and price that you wanted. You have had them for two weeks and the sole has cracked.

1. What would you do to troubleshoot the problem with your shoe?

Student responses will vary, but should include troubleshooting procedures, such as walking with the shoe on to determine how and when the crack happened or gets worse, attempting to repair the shoe or contacting the store.

2. You have decided that the shoes should be returned to the store, but you cannot find the receipt. What do you do?

Student responses will vary depending on preference.
3. If you were the manager of the shoe store, what would you do?

Student responses will vary, but after learning about the concept of customer service, the response should include a professional and courteous response such as exchanging the shoe, looking up the transaction on the computer or refunding the purchase with a store credit. Responses may also refer to store policy.

**Scenario 3:** You have moved to a design and construction position in the skateboard company. The manager has asked you design a new system to laminate the seven layers of the skateboard material into one complete deck. He is not happy with the speed or space needed by the current system, and he wants you to make something better.

1. The current machine requires air systems, heat provided by the press, and the individual layers or laminations of the deck must be coated with glue prior to placing them in the press. What could be done to speed up this process?

   Student responses will vary but may include a hydraulic press to open and close the deck press, a process for gluing the layers prior to inserting them, a shorter drying time, or a method for applying the glue inside the machine such as a sprayer. Other reasonable responses should also be accepted.

2. If you had the option of including robotic or computer controlled components, how could they help speed up this process?

   Student responses will vary but may include actions connected to opening and closing the press, applying glue, inserting and stacking layers.

3. What would be the advantages of your new production system?

   Student responses will vary but may include faster production time, larger output, less physical work in cranking the press, smaller area for equipment, etc.
Lesson 1: System Functions and Processes

Teacher Resource 3.1.4: Geometry and Relationships within Systems

Find the value of the function $f(x)$ for the given value of $x$ in the following.

1. $f(x) = x^2 + x + 1$, $x = 3$, $f(3) = 13$
2. $f(x) = x^2 - 6x + 9$, $x = 2$, $f(2) = 1$
3. $f(x) = x^3 + 3x^2 - 4x + 7$, $x = 3$, $f(3) = 49$
4. $f(x) = x^2 - 2x^{1/2} + 3$, $x = 9$, $f(9) = 78$
5. $f(x) = 4x^3 + 2x - 3$, $x = 5$, $f(5) = 507$

Examine the following sets of points to determine if they represent linear relationships or not. Explain why or why not (it may be helpful to graph each set).

1. $\{(0,0),(3,2),(-3,-2)\}$, yes, all three lie on the same line.
2. $\{(1,1),(1,-1),(-1,1)\}$, no, the points form a triangle.
3. $\{(-1,-2),(1,1),(4,3)\}$, yes, all lie on the same line.
4. $\{(1,2),(2,3),(3,6)\}$, no as the line that passes through $(1,2)$ and $(2,3)$ would pass through $(3,4)$, not $(3,6)$.
5. $\{(3,1),(-1,2),(11,-1)\}$, yes, all three lie on the same line.

Solve the following systems of linear equations.

1. $3x + y = 5$, $2x - 3y = 7$, $x = 2$, $y = -1$
2. $x - y = 8$, $2x + 2y = 40$, $x = 14$, $y = 6$
3. $x - y = 8$, $7x - 3y = 40$, $x = 4$, $y = -4$
4. $3x + y = 23$, $-2x - 3y = 1$, $x = 10$, $y = -7$
5. $3x - 2y = -10$, $3y - 10x = 15$, $x = 0$, $y = 5$
Measure the following figures and determine their respective areas, then reproduce each at half scale.

Rectangle: 2 inches x 1.5 inches, area 3 square inches
Triangle: base 2 inches, height 2 inches, area 2 square inches
Circle: diameter: 2.5 inches, radius: 1.25 inches, area = 3.14 \times 1.25^2 = 4.91
Unit 3: Technological System Interaction

Lesson 1: System Functions and Processes

Student Resource 3.1.2: Lesson Glossary

Assembly A group of components that are put together to make a system or subsystem.

Brand Loyalty When a consumer generally purchases products or services from or made by the same manufacturer.

Breakdown When a component or system is not functional, is worn out or used up.

Computer Control A manufacturing procedure that allows a designer to develop and program a piece of equipment to complete parts using the computer to control the machine components.

Custom Manufacturing Custom manufacturing is a process that involves specialization in the process of creating a specific product. The completed product is created in small batches or individually to meet a specific need, rather than for mass production and sales.

Customer Service Providing a service experience to the consumer, before, during and after a purchase, such as helping someone to decide on a product, treating the customer with respect during the sale and providing replacement parts.

Functionality The quality of a product or service that meets the needs or purpose of the consumer well.

Interaction The direct effect that one component or subsystem has on another system.

Malfunction When a component, system or subsystem malfunctions, it is no longer working properly or as it should.

Robotics A machine that is capable of doing the work of a person, controlled by programming or hardware to complete a specific task, often one that is repetitive, difficult or dangerous for a person. For example, a robotic arm on an assembly line can weld in places that are difficult or dangerous for a person to be.

Service In this case, service is referring to the continued customer service after a sale, such as visiting a home to repair a malfunctioning appliance.

Subsystem A smaller system that is part of larger system, such as a braking system being part of the larger system of a car.

Troubleshooting The process of finding problems or malfunctions within a system and correcting them to restore system functionality.

Warehouse A storage facility for goods and services, a central location for shipping.

Warranty A written guarantee or promise from the manufacturer to the consumer to repair or replace a product if it proves to be faulty.
Lesson 1: System Functions and Processes

Student Resource 3.1.3: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 3: Technological System Interaction

Lesson 1: System Functions and Processes

Student Resource 3.1.4: Researching System Malfunctions and Troubleshooting

Working with your Engineering Design Team, you have been assigned a technological subject for research. Assume that you are a technician working on a special project in the area you were assigned. If you are not able to determine the malfunction in your system and troubleshoot it in time, your system will destroy itself, along with all of your work.

The Challenge: You have 15 minutes working with your Engineering Design Team to find as many possible system malfunctions and potential ways to address them as possible.

<table>
<thead>
<tr>
<th>System</th>
<th>Product or Object</th>
<th>Component</th>
<th>Malfunction</th>
<th>Potential solution</th>
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At the end of your 15 minutes, meet with your Engineering Design Team to compare results. Share your combined results with the rest of the class. Record how this assignment could be applied to other systems in your Engineering Design Journal.
Lesson 1: System Functions and Processes

Student Resource 3.1.5: Geometry and Relationships within Systems

Find the value of the function f(x) for the given value of x in the following. Show your work.

1. f(x) = x^2 + x + 1, x = 3

2. f(x) = x^2 - 6x + 9, x = 2

3. f(x) = x^3 + 3x^2 - 4x + 7, x = 3

4. f(x) = x^2 - 2x^{1/2} + 3, x = 9

5. f(x) = 4x^3 + 2x - 3, x = 5
Examine the following sets of points to determine if they represent linear relationships or not. Explain why or why not (it may be helpful to graph each set).

1. {\((0,0),(3,2),(\text{-}3,\text{-}2)\)},

2. {\((1,1),(\text{-}1,\text{-}1),(\text{-}1,1)\)},
3. \{(-1, -2), (1, 1), (4, 3)\},

4. \{(1,2), (2,3), (3,6)\},
5. \{(3, 1), (-1, 2), (11, -1)\},

Solve the following systems of linear equations. Show your work.

1. \[3x + y = 5, \quad 2x - 3y = 7\]

2. \[x - y = 8, \quad 2x + 2y = 40,\]

3. \[x - y = 8, \quad 7x - 3y = 40,\]

4. \[3x + y = 23, \quad -2x - 3y = 1,\]

5. \[3x - 2y = -10, \quad 3y - 10x = 15,\]
Measure the following figures and determine their respective areas, then reproduce each at half scale.
Objective: You work in a small manufacturing company where you and your Engineering Design Team have designed some fragile, custom components for a customer and now must devise a way to safely and economically ship the components to the next manufacturer to complete the assembly of the system.

The components must arrive at their destination intact, be possible to easily remove from the shipping container and not require special handling to transport.

The teacher will describe the components that must be added to each package and how the new components will be incorporated into the system.

For example, Team A will start the process, designing a shipping package that can contain Component 1. Their completed package will be “shipped” to Team B, who will have a package designed to contain Component 1 and Component 2, assembled as directed by the teacher. This will continue through the final Engineering Design Team, who will pass their completed package with all components assembled to Team A, who will have to open the package and remove the components, assembling any subassemblies into the final product.

Design Constraints:
No existing containers can be used in their original state, but may be used as materials in creating a new container. For example, a small box may be cut up and made into a new container, but cannot be used as the original box.

Things to consider:
- Containers are generally cubic or rectangular to ease stacking of materials, but other shapes are also permissible.
- What can you do to help the next team to receive your component and package? Would it help to label the container or include directions?
- Can you develop a mechanism to make it easier to open the package?
- We generally think of shipping containers as corrugated cardboard boxes, but many other materials can hold up to the rigors of shipping.
- Sketching is part of the design process, but what about building a model and testing it? Where could you test a package design that is easily accessible to you?
- When a package is shipped it may be marked as fragile, but it may not be handled with care. Can your package survive a less than careful delivery?
Lesson 1: System Functions and Processes

Student Resource 3.1.7: Brief Constructed Response Quiz

Name:_________________________________

Using the scenarios described below, complete the items as directed. For short answer responses, write a paragraph. Use the back of the sheet if needed.

Scenario 1: You have just been hired as a product tester and shipping specialist for a small company that manufactures custom skateboards. There have been problems in getting completed skateboards to the customers by the date given through the ordering website.

1. Describe the system that you would use to troubleshoot the shipping delays.

2. If the delays in shipping were the result of not receiving materials in time to produce the skateboard by the shipping date listed on the website, how would you adjust the production system?

3. As a product tester, you notice that there is a problem with the grip tape not adhering well at all the edges of the deck. What do you expect to happen when you report this to the manager?

Scenario 2: You purchased a new pair of athletic shoes from your favorite brand. They were the size, color and price that you wanted. You have had them for two weeks and the sole has cracked.

1. What would you do to troubleshoot the problem with your shoe?

2. You have decided that the shoes should be returned to the store, but you cannot find the receipt. What do you do?
3. If you were the manager of the shoe store, what would you do?

Scenario 3: You have moved to a design and construction position in the skateboard company. The manager has asked you design a new system to laminate the seven layers of the skateboard material into one complete deck. He is not happy with the speed or space needed by the current system, and he wants you to make something better.

1. The current machine requires air systems, heat provided by the press, and the individual layers or laminations of the deck must be coated with glue prior to placing them in the press. What could be done to speed up this process?

2. If you had the option of including robotic or computer controlled components, how could they help speed up this process?

3. What would be the advantages of your new production system?
Unit 1: Technological Systems: How They Work

Lesson 1: System Functions and Processes
Student Resource 3.1.8: Lesson Design Brief

The Problem: You work for a company that designs custom parts for electronics and manufacturing companies. Now that you have designed a custom part, you have to get it assembled and to your customer. Working in Engineering Design Teams, students will develop a system to package a series of materials and “ship” it another location, simulating shipping an online order for components for assembly from a warehouse.

Design Constraints: Your Engineering Design Team is one step in the assembly and shipping process. Each team will add a component to the shipping container, but the component does not have to be assembled with previous components.

The teacher will determine the objects to be shipped and the appropriate number for each “package”.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

Where does your Engineering Design Team fall in the order of components to be added?

How does this order affect your plans?

Does your container include the other components inside or outside the section designed to house your component?

How will multiple components fit together in your design?

Will you need to include specific instructions for the next team?

Human values and limitations will impact the success of your design. How will your Engineering Design Team work to address these issues?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, hot melt glue guns and sticks, X-Acto knives, scissors, rulers, corrugated cardboard, file folders, packing materials, 1. A small non-fragile item such as a bouncy ball for each Engineering Design Team, construction paper, glue sticks, Duck brand tape, graph paper, Balsa wood cutters, assorted sandpaper and Balsa Wood. Other materials may be used - consult your teacher.

The Process: One team is selected to start. This team designs a package that safely houses their object to be shipped, places the object in the container, and “ships” it to the next team. Each team continues this process, adding their object in an appropriate container, and “shipping” it to the next team. The final team “ships” it to the first team, who will open it, and the class will determine the survivability of the cargo.
Lesson 1: System Functions and Processes

Assessment Resource 3.1.1: Engineering Design Journal Rubric

Name______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

4. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

5. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

6. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
<td></td>
</tr>
</tbody>
</table>

Activity 1 - sketch or diagram of an observable system

Activity 2 - documentation of research

Shipping activity sketches

Shipping activity notes - materials, planning, constraints

Improvement in drawing skills over time

Includes notes and comments

Ability to understand and interpret images, notes and sketches

Bonus: Additional materials

Total

Comments:

Grade:
# Assessment Resource 3.1.2: Packing and Shipping Components

**Rubric**

**Engineering Design Team Members**

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence of planning - sketches, notes, materials for package</td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Survival of cargo – Arrived intact and assembled as planned</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Use of materials - followed design constraints</td>
<td></td>
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<tr>
<td>Use of materials - economical choices</td>
<td></td>
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<tr>
<td>Component(s) or subassemblies could be easily removed from the container</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Assembled received components with new component as directed</td>
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<tr>
<td>Participation – active in the shipping process, not just watching</td>
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</tbody>
</table>

**Bonus:**

- Evidence of testing designs
- Shape other than cubic or rectangular
- Mechanism to open or seal package other than standard tape
- Provided directions for assembly or opening package
- Use of unique materials

**Total**

**Comments:**

Grade:
Lesson 2: System Design and Development

Lesson Snapshot

Overview

Big Idea: Knowledge from a variety of fields is used in the development of products and systems and the completed system can be used in multiple applications.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn that knowledge gained in one content area can be applied to another content area to address a different kind of problem. Products and systems are developed using a variety of knowledge and considering many factors.

Lesson Duration: 4 hours, plus 1 enrichment hour.

Activity Highlights

Engagement
The students will discuss prior knowledge and how it can be applied to new situations, making note of the contributions that they can make to specific situations.

Exploration
Using library and internet resources, students will complete a research project, documenting the invention and history of an object of their choice.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject and how it can be integrated into the design build project.

Extension
Working in Engineering Design Teams, students will design, build and document a system for a specific purpose that can be applied to another purpose or setting.

Enrichment
Engineering Design Teams will present their completed systems and the applications to another setting to parents and guests.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Presentations, Research Projects, Performance Rubrics, Constructed Response Items, and an End of unit quiz.
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Lesson Overview

Lesson Duration
4 hours, plus 1 enrichment hour.

Standards/Benchmarks

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>STL 3E</td>
<td>A product, system, or environment developed for one setting may be applied to another setting.</td>
</tr>
<tr>
<td>STL 3F</td>
<td>Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.</td>
</tr>
<tr>
<td>STL 11L</td>
<td>Make a product or system and document the solution.</td>
</tr>
</tbody>
</table>

| Mathematics: Common Core Standards for Mathematics (CCSM, 2011) |
|---|---|
| Geometry Standard (CCSM, Grade 7) |
| 7.G.1 | Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. |
| Functions Standard (CCSM, Grade 8) |
| 8.F.1 | Define, evaluate and compare functions. |
| 8.F.2 | Use functions to model relationships between quantities. |

| English Language Arts: Common Core Standards for English Language Arts (CCSELA, 2011) |
|---|---|
| Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12) |
| RST.6-8.1 | Cite specific textual evidence to support analysis of science and technical texts. |
| RST.6-8.3 | Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. |

| Science: Benchmarks for Science Literacy (AAAS, 1993/2009) |
|---|---|
| The Nature of Science |
| 1C/M1 | Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times. |
| 1C/M3 | No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world. |

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1 Material reprinted from Benchmarks for Science Literacy (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Learning Objectives
Students learn to:
1. Understand and explain that knowledge gained from other fields has a direct impact on the development of products and systems
2. Design a product, system and explain the potential application to another system
3. Develop a product or system and document the solution
4. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
5. Work safely and accurately with a variety of tools, machines, and materials.
6. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials
2. Mathademics, Scale Drawing, Retrieved on 05/06/12 from http://www.youtube.com/watch?v=N8jbxWKCygA (Permission to link requested)
3. TenMarks, How to Find the Scale of Scale Drawings, Retrieved on 05/06/12 from http://video.answers.com/how-to-find-the-scale-of-scale-drawings-285025206 Used by permission.

Print Materials

Internet Search Terms and Suggested Sites
8. Internet Search Items:
   a. Knowledge integration
   b. applying knowledge to new situations
   c. scale drawings
9. Clemens, M. Idiagram: Knowledge Integration, Retrieved on 05/06/12 from http://www.idiagram.com/ideas/knowledge_integration.html Used by permission
11. Math is Fun, Scale Drawing, Retrieved on 05/06/12 from http://www.mathsisfun.com/definitions/scale-drawing.html Used by permission.

Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. Skills in scale drawing are building from Lesson One.
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

5-E Lesson Plan

Teacher’s Note: Chalk, markers or sticky notes may be used to document student contributions in the Engagement activity. If possible, take pictures of the completed boards or keep the large paper sheets. Later in the course, bring them out to discuss the changes in knowledge that students have since the activity.

Engagement
The students will discuss prior knowledge and how it can be applied to new situations, making note of the contributions that they can make to specific situations.

- The teacher will begin the discussion, talking about situations where prior knowledge has been useful in new situations in his or her life.
- A context for knowledge application will be established, allowing students to share ideas.
- Using large spaces on dry erase or chalkboards or on large paper, the teacher will list 5-6 tasks or areas of knowledge, such as walking a dog or computers.
- Each student will have the opportunity to add their prior knowledge about the subject to the board or sheet, using markers or other marking objects.
- Student contributions may be simple such as, “leash laws” in the example of walking a dog, or more complicated like “I have a Core i7 processor in my computer”.
- Once students have had the opportunity to add their contributions, the class will discuss the items listed for each activity and prepare to integrate knowledge from a variety of sources.
- In their Engineering Design Journals, students will make note of things that they learned from the discussion and how their individual knowledge can be applied to other settings and applications.

Exploration
Using library and internet resources, students will complete a research project, documenting the invention and history of an object of their choice.

- The teacher will aid students in selecting objects, with a broad focus such as “mp3 player” rather than “iPod”. This will allow for a more diverse history a wider variety of resources.
- The completed research project should include a minimum of 5 references, properly cited, use standard grammar and English and include images.
- In completing their research projects, students should note that important contributions to STEM fields have come from all kinds of people from all over the world.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:
• The teacher will facilitate a small group discussion about the research projects and what students learned about their objects.
• Using the knowledge gained through the research project, students will begin to brainstorm ideas of how that technology could be applied to another setting.
• In their Engineering Design Journals, students will sketch methods for adapting the technology to another setting.
• In preparing to make changes, students will practice scale drawing and use functions to model relationships between quantities.

Extension
Working in Engineering Design Teams, students will design, build and document a system for a specific purpose that can be applied to another purpose or setting.
• The students in the Engineering Design Team will bring their information from the research project together.
• Using the information gathered, Engineering Design Teams will select a system from the products, develop an innovated version of the system for one application, and develop potential new applications for the system.
• The Engineering Design Team, using materials available for modeling, or planned actual materials if possible, will build a prototype of the system.
• The completed project will consist of a prototype system, documentation of the development process in Engineering Design Journals (sketches, notes, pictures, etc.) suggested applications for other settings and a presentation of the process and completed prototype to the class.

Enrichment
Engineering Design Teams will present their completed systems and the applications in another setting to parents and guests.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Presentations, Research Projects, Performance Rubrics, Constructed Response Items, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td>Curiosity</td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td>Use of Time</td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
Assessment Resource 3.2.1: Engineering Design Journal Rubric

Name______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1- notes on applying knowledge to other settings</td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Sketches for adapting technology to another setting</td>
<td></td>
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<tr>
<td>Evidence of planning in system development</td>
<td></td>
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<tr>
<td>Prototype drawings</td>
<td></td>
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<tr>
<td>New applications for system</td>
<td></td>
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<tr>
<td>Improvement in drawing skills over time</td>
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<tr>
<td>Includes notes and comments</td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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<tr>
<td>Bonus: Additional materials</td>
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<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

Comments:

Grade:
## Assessment Resource 3.2.2: Research Project Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
</tbody>
</table>

- Cited at least 5 sources
- Sources are cited correctly
- Correct grammar, spelling and punctuation
- Includes images with captions
- Uses both internet and print resources
- Notes contributions from a variety of people

Comments:

Grade:
Assessment Resource 3.2.3: Designing and Building a System for Multiple Applications Rubric

Engineering Design Team Members

<table>
<thead>
<tr>
<th></th>
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<th>3</th>
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<th>1</th>
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</thead>
<tbody>
<tr>
<td>Explained goals of the system</td>
<td></td>
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</tr>
<tr>
<td>Evidence of Planning in Engineering Design Journal - Notes, sketches</td>
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<tr>
<td>Addressed design constraints</td>
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<tr>
<td>Used an appropriate scale for the prototype</td>
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<tr>
<td>Prototype was well constructed, neat</td>
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<tr>
<td>Used appropriate materials for the prototype</td>
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<tr>
<td>Prototype demonstrates proof of concept</td>
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<tr>
<td>Prototype was tested</td>
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<tr>
<td>Personalized presentation through individualized information</td>
<td></td>
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<tr>
<td>Participation – active in the presentation, not just reading</td>
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<tr>
<td>Total</td>
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<tr>
<td>Comments:</td>
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<td>Grade:</td>
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</tbody>
</table>
## Assessment Resource 3.2.4: Presentation Rubric

<table>
<thead>
<tr>
<th>Presenter(s)</th>
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</table>

<table>
<thead>
<tr>
<th></th>
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<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete</td>
<td>All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Explained goal of the system</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Explained how system would be used in another setting</td>
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<tr>
<td>Demonstrated prototype</td>
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<tr>
<td>Was the presentation professional? (as if family were in the audience)</td>
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</tr>
<tr>
<td>Use of visuals - pictures, graphs, sketches, objects</td>
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<tr>
<td>Use of text information - handouts, notes, lists</td>
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<tr>
<td>Use of audiovisual information - videos, websites, sounds</td>
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<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
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<tr>
<td>Slides or other visuals – relevant and clear</td>
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<tr>
<td>Addressed all relevant information</td>
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<tr>
<td>Personalized presentation through individualized information</td>
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<td>Participation – active in the presentation, not just reading</td>
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<tr>
<td>Comments:</td>
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</tbody>
</table>

Grade:
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content. Gather recyclable materials to represent a variety of categories.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

If a manufacturing or construction laboratory is available and appropriate for use with this class, consider creating larger prototypes and utilizing wood, metal and other materials, or on a larger scale.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and graphic design companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Engineering Design Journals or blank paper
4. Safety glasses, 1 pair per student
5. Large paper or dry erase or chalk board space
6. Markers or chalk
7. Access to library and/or computer lab
8. Graph paper, 80 sheet pack
9. 12” Rulers, 1 per student
10. Scissors, 1 pair per student
11. X-Acto knives, 1 per student, with replacement blades
12. Coping saws, 5 per class, with replacement blades
13. 18” X 24” self-healing cutting mats, 10 per class
14. Gift wrap tape, 1-2 rolls per group
15. Masking tape, 1”, 1 roll per group
16. School glue, 4 oz, 2 per group
17. Hot melt glue guns, 10 per class
18. Hot melt glue sticks, 50 pack
19. Paper fasteners, (brads) 1 box
20. Balsa Wood economy bag, 3 per class
21. Construction paper, multi-color pack
22. Assorted sandpaper
23. Balsa Wood Easy Cutter, 3 per class
24. Used file folders, 1 per student
25. Corrugated cardboard, approximately 8” X 10”, 1 per student
26. Empty plastic containers, 1 per student
27. Optional: Styrofoam sheets or packaging

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
- Teacher Resource 3.2.1: Class Participation Rubric
- Teacher Resource 3.2.2: Scale Drawing and Quantity Relationships Answer Key
- Teacher Resource 3.2.3: End of Unit Quiz Answer Key

Student Resources
- Student Resource 3.2.1: Lesson Glossary
- Student Resource 3.2.2: Engineering Design Journal Guidelines
- Student Resource 3.2.3: Research Project Guidelines
- Student Resource 3.2.4: Scale Drawing and Quantity Relationships
- Student Resource 3.2.5: Design Brief: Designing & Building a System for Multiple Applications

Assessment Resources
- Assessment Resource 3.2.1: Engineering Design Journal Rubric
- Assessment Resource 3.2.2: Research Project Rubric
- Assessment Resource 3.2.3: Designing & Building a System for Multiple Applications Rubric
- Assessment Resource 3.2.4: Presentation Rubric
- Assessment Resource 3.2.5: End of Unit Quiz
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Teacher Resource 3.2.1: Class Participation Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
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<tbody>
<tr>
<td>Preparation</td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td>Curiosity</td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td>Use of Time</td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Teacher Resource 3.2.2: Scale Drawing and Quantity Relationships

Answer Key

Measure the following figures and reproduce at the specified scale.

Create a 1:3 scale reproduction

Create a 1:1.5 scale reproduction

Create a 1.5:1 scale reproduction
Create a 3:1 scale reproduction

Create a 1:1 scale reproduction

Evaluate the 2 functions for each value of $x$.

$g(x) = x^2 - 2x + 1$ and $f(x) = 3x - 2$

<table>
<thead>
<tr>
<th>$x$</th>
<th>$g(x)$</th>
<th>$f(x)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>-2</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>81</td>
<td>28</td>
</tr>
<tr>
<td>20</td>
<td>361</td>
<td>58</td>
</tr>
</tbody>
</table>
Based on the completed table, describe the difference between the two functions. Are the functions linear or not? Why might one increase in value faster than the other?

f(x) is linear, while g(x) is not. g(x) increases faster as it contains a squared term (x²).

Use the following table to determine a linear function that describes the relationship between x and y.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>10</td>
<td>43</td>
</tr>
<tr>
<td>15</td>
<td>63</td>
</tr>
</tbody>
</table>

y = 4x + 3

Use the following table to determine a linear function that describes the relationship between x and y.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>-5</td>
</tr>
<tr>
<td>2</td>
<td>-11</td>
</tr>
<tr>
<td>-5</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>-21</td>
</tr>
<tr>
<td>-10</td>
<td>13</td>
</tr>
<tr>
<td>15</td>
<td>-37</td>
</tr>
</tbody>
</table>

y = -2x - 7
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Teacher Resource 3.2.3: End of Unit Quiz Answer Key

1. A(n)__________________ happens when a component, system or subsystem is no longer working properly or as it should.
   a. Prototype   b. obsolete   c. malfunction   d. model

2. ________________ is a manufacturing procedure that allows a designer to develop and program a piece of equipment to complete parts using the computer to control the machine components.
   a. prototype   b. proof of concept   c. subsystem   d. computer control

3. When a consumer generally purchases products or services from or made by the same manufacturer is ________________.
   a. warranty   b. customer service   c. brand loyalty   d. rewards program

4. The original model of a product or system, used to plan production and troubleshoot problems is a(n)______________.
   a. proof of concept   b. thumbnail sketch   c. Engineering Design   d. prototype

5. A(n) __________________occurs when a component or system is not functional, is worn out or used up.
   a. breakdown   b. obsolete   c. subsystem   d. innovation

6. A test of an idea, demonstrated by a completed prototype, showing how an object or system will function is a(n)_________________________.
   a. Thumbnail Sketch   b. Prototype   c. Proof of Concept   d. adaptation

7. The process of finding problems or malfunctions within a system and correcting them to restore system functionality is called__________________.
   a. Repairing   b. troubleshooting   c. proof of concept   d. breakdown

8. A product that is no longer in use, old-fashioned or out of date. It is important to note that the product can be functional, but it becomes unfashionable or unusable due to product needs is ________________.
   a. obsolete   b. breakdown   c. warranty   d. malfunction

   a. robotics   b. state of the art   c. STEM   d. subsystem
10. Production or other processes using machines that are capable of doing the work of a person, controlled by programming or hardware to complete a specific task, often one that is repetitive, difficult or dangerous for a person.

- a. subsystem
- b. model
- c. prototype
- d. robotics

Measure the following figures and reproduce at the specified scale.

Create a 1:4 scale reproduction

Create a 1:1.5 scale reproduction

Create a 2:1 scale reproduction
Find the value of the function $f(x)$ for the given value of $x$ in the following.

1. $f(x) = x^2 + x + 1$, $x = 3$, $f(3) = 13$

2. $f(x) = x^2 - 6x + 9$, $x = 2$, $f(2) = 1$

3. $f(x) = x^3 + 3x^2 - 4x + 7$, $x = 3$, $f(3) = 49$

4. $f(x) = x^2 - 2x^{1/2} + 3$, $x = 9$, $f(9) = 78$

5. $f(x) = 4x^3 + 2x - 3$, $x = 5$, $f(5) = 507$

6. Use the following table to determine a linear function that describes the relationship between $x$ and $y$.

<table>
<thead>
<tr>
<th>$x$</th>
<th>$y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>-5</td>
</tr>
<tr>
<td>2</td>
<td>-11</td>
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<tr>
<td>-5</td>
<td>3</td>
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<td>7</td>
<td>-21</td>
</tr>
<tr>
<td>-10</td>
<td>13</td>
</tr>
<tr>
<td>15</td>
<td>-37</td>
</tr>
</tbody>
</table>

7. $y = -2x - 7$

Examine the following sets of points to determine if they represent linear relationships or not. Explain why or why not (it may be helpful to graph each set).

8. $\{(0,0),(3,2),(-3,-2)\}$, yes, all three lie on the same line.

9. $\{(1,1),(1,-1),(-1,1)\}$, no, the points form a triangle.

10. $\{(-1,-2),(1,1),(4,3)\}$, yes, all lie on the same line.

11. $\{(1,2),(2,3),(3,6)\}$, no as the line that passes through $(1,2)$ and $(2,3)$ would pass through $(3,4)$, not $(3,6)$.

12. $\{(3,1),(-1,2),(11,-1)\}$, yes, all three lie on the same line.
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Student Resource 3.2.1: Lesson Glossary

Adaptation When a product or system is changed or innovated to meet a new purpose, it is adapted.

Model A three-dimensional representation of a product or system.

Obsolete A product that is no longer in use, old-fashioned or out of date. It is important to note that the product can be functional, but it becomes unfashionable or unusable due to product needs. For example, a cassette tape player may be functional, but it becomes unusable because cassette tapes are no longer produced.

Proof of Concept A test of an idea, demonstrated by a completed prototype, showing how an object or system will function.

Prototype The original model of a product or system, used to plan production and troubleshoot problems.

Scale Drawing A drawing that represents a person, place, object or system and is proportional to the original item. For example, it is possible to draw a full size, accurately measured drawing of a house, but it is much easier to use a scaled drawing to convey ideas.

State of the Art The most current, highest level of development in a product service or system now.

STEM The integration of Science, Technology, Engineering and Math in teaching and learning.
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Student Resource 3.2.2: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Student Resource 3.2.3: Research Project Guidelines

The purpose of the research project is to introduce the history of invention and innovation as seen through a specific product. Over time, the needs and wants of consumers change and products must change to meet these needs or become obsolete.

In completing your research project:

1. A broader category, such as “mp3 players” will provide more resources and opportunities to see the history of the technology than a specific product such as “iPod”.

2. Use both internet and print resources to document your research.

3. Cite at least 5 sources in your completed research project.

4. Note that important contributions to STEM fields have come from all kinds of people from all over the world.

5. Remember that spell check finds misspelled words; it does not find incorrect words. Read your project carefully, or have someone else read it before turning it in.

6. Check with your teacher about how to include images in your research project. Depending on the format, they can be on the same page as the text that refers to them, or in a separate section in the back. Remember to include labels or captions for the images.

Citing References:

When citing an electronic document such as a website, blog, or YouTube video, use this format in the References list:

Author, Title, Retrieved on date from http://

When citing print materials, use this format in the References list:

Author. (Year of Publication). Title, City of Publisher, State of Publisher: Name of Publishing Company

When citing a reference in the text of your research project, use this format for both print and electronic publications:

“statement”, (Author, p.#, year of publication).

The quotation marks are only needed for a direct quote.
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Student Resource 3.2.4: Scale Drawing and Quantity Relationships

Name:_________________________________________________

Measure the following figures and reproduce at the specified scale.

Create a 1:3 scale reproduction

Create a 1:1.5 scale reproduction

Create a 1.5:1 scale reproduction
Create a 3:1 scale reproduction

Create a 1:1 scale reproduction

Evaluate the 2 functions for each value of x.

\[ g(x) = x^2 - 2x + 1 \] and \[ f(x) = 3x - 2 \]

<table>
<thead>
<tr>
<th>x</th>
<th>g(x)</th>
<th>f(x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</tbody>
</table>
Based on the completed table, describe the difference between the two functions. Are the functions linear or not? Why might one increase in value faster than the other?

Use the following table to determine a linear function that describes the relationship between x and y.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
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<td>5</td>
<td>23</td>
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<tr>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>10</td>
<td>43</td>
</tr>
<tr>
<td>15</td>
<td>63</td>
</tr>
</tbody>
</table>

Use the following table to determine a linear function that describes the relationship between x and y.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>-5</td>
</tr>
<tr>
<td>2</td>
<td>-11</td>
</tr>
<tr>
<td>-5</td>
<td>3</td>
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<tr>
<td>7</td>
<td>-21</td>
</tr>
<tr>
<td>-10</td>
<td>13</td>
</tr>
<tr>
<td>15</td>
<td>-37</td>
</tr>
</tbody>
</table>
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Student Resource 3.2.5: Design Brief
Designing and Building a System for Multiple Applications

The Problem: Your Engineering Design team has been assigned to develop an adaptation or an existing product. Once it has been adapted, it must be applied to another setting.

Using the knowledge that each member of your team has, develop a system to meet these criteria for design.

Design Constraints: You have limited time and a small budget to develop the idea, but if the idea is successful, full production in a state-of-the-art facility will be possible.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

Will you choose a simple or complicated system to adapt? There are pros and cons to both choices. A more complicated system gives you a variety of materials and components to work with, but a simple system may be easier to model and apply to a new situation.

If you have chosen a very small product or system to adapt, your Engineering Design Team may want to make a larger scale model to demonstrate the function and application that you are trying to achieve.

Always use appropriate safety equipment.

Materials:
When building your prototype, you will likely not have the same materials available as you would want to use in actually manufacturing your system. Use the materials available to demonstrate your concept, paying attention to function and scale rather than the true materials.

Simulate the true materials when possible, using something of the correct shape or structural qualities as the planned material for production. For example, a section of a wooden dowel could simulate a steel rod in the prototype.

Available Materials: Engineering Design Journals or blank paper, graph paper, rulers, scissors, X-Acto knives, coping saws, gift wrap tape, masking tape, school glue, holt melt glue guns and sticks, Paper fasteners (brads), balsa wood, construction paper, sandpaper, balsa wood cutters, file folders, corrugated cardboard, empty plastic containers, and Styrofoam. Other materials may be used – consult your teacher.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation.

The Presentation: When presenting your system, describe your development process, the plans that your Engineering Design Team has for the system, successes and failures in the design and how each team member was involved throughout the process.
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Assessment Resource 3.2.1: Engineering Design Journal Rubric

Name______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

4. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

5. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

6. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
<td></td>
</tr>
<tr>
<td>Activity 1- notes on applying knowledge to other settings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sketches for adapting technology to another setting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evidence of planning in system development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prototype drawings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New applications for system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improvement in drawing skills over time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Includes notes and comments</td>
<td></td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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</tr>
<tr>
<td>Bonus: Additional materials</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Comments:

Grade:
### Unit 3: Technological System Interaction

**Lesson 2: System Design and Development**

**Assessment Resource 3.2.2: Research Project Rubric**

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complete</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
</tbody>
</table>

- Cited at least 5 sources
- Sources are cited correctly
- Correct grammar, spelling and punctuation
- Includes images with captions
- Uses both internet and print resources
- Notes contributions from a variety of people

Comments:

Grade:
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Assessment Resource 3.2.3: Designing and Building a System for Multiple Applications Rubric

Engineering Design Team Members

<table>
<thead>
<tr>
<th></th>
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<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explained goals of the system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Evidence of Planning in Engineering</td>
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<tr>
<td>Design Journal- Notes, sketches</td>
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</tr>
<tr>
<td>Demonstrated prototype</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Addressed design constraints</td>
<td></td>
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<tr>
<td>Used an appropriate scale for the</td>
<td></td>
<td></td>
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<tr>
<td>prototype</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Prototype was well constructed, neat</td>
<td></td>
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<tr>
<td>Used appropriate materials for the</td>
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<tr>
<td>prototype</td>
<td></td>
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<tr>
<td>Prototype demonstrates proof of concept</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Prototype was tested</td>
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<tr>
<td>Personalized presentation through</td>
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<tr>
<td>individualized information</td>
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<tr>
<td>Participation – active in the</td>
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</tr>
<tr>
<td>presentation, not just reading</td>
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<td>Total</td>
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<tr>
<td>Comments:</td>
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</table>

Grade:
### Lesson 2: System Design and Development

#### Assessment Resource 3.2.4: Presentation Rubric

**Presenter(s)**

<table>
<thead>
<tr>
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<th>3</th>
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</thead>
<tbody>
<tr>
<td><strong>Explained goal of the system</strong></td>
<td></td>
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<tr>
<td><strong>Explained how system would be used in another setting</strong></td>
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<tr>
<td><strong>Demonstrated prototype</strong></td>
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<tr>
<td><strong>Was the presentation professional? (as if family were in the audience)</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Use of visuals - pictures, graphs, sketches, objects</strong></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Use of text information - handouts, notes, lists</strong></td>
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<tr>
<td><strong>Use of audiovisual information - videos, websites, sounds</strong></td>
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<tr>
<td><strong>Vocal presentation - clear, relevant, answered questions</strong></td>
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<td><strong>Slides or other visuals - relevant and clear</strong></td>
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<td><strong>Addressed all relevant information</strong></td>
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<td><strong>Personalized presentation through individualized information</strong></td>
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<td><strong>Participation - active in the presentation, not just reading</strong></td>
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**Grade:**
Unit 3: Technological System Interaction

Lesson 2: System Design and Development

Assessment Resource 2.5.: End of Unit Quiz

Name:_____________________________________

Multiple Choice: Select the answer that best fits the statement.

1. A(n)______________ happens when a component, system or subsystem is no longer working properly or as it should.
   a. Prototype  b. obsolete  c. malfunction  d. model

2. ____________ is a manufacturing procedure that allows a designer to develop and program a piece of equipment to complete parts using the computer to control the machine components.
   a. prototype  b. proof of concept  c. subsystem  d. computer control

3. When a consumer generally purchases products or services from or made by the same manufacturer is ________________.
   a. warranty  b. customer service  c. brand loyalty  d. rewards program

4. The original model of a product or system, used to plan production and troubleshoot problems is a(n)______________.
   a. proof of concept  b. thumbnail sketch  c. Engineering Design  d. prototype

5. A(n) ________________ occurs when a component or system is not functional, is worn out or used up.
   a. breakdown  b. obsolete  c. subsystem  d. innovation

6. A test of an idea, demonstrated by a completed prototype, showing how an object or system will function is a(n)________________.__
   a. Thumbnail Sketch  b. Prototype  c. Proof of Concept  d. adaptation

7. The process of finding problems or malfunctions within a system and correcting them to restore system functionality is called__________.
   a. Repairing  b. troubleshooting  c. proof of concept  d. breakdown

8. A product that is no longer in use, old-fashioned or out of date. It is important to note that the product can be functional, but it becomes unfashionable or unusable due to product needs is ________________.
   a. obsolete  b. breakdown  c. warranty  d. malfunction

   a. robotics  b. state of the art  c. STEM  d. subsystem
10. Production or other processes using machines that are capable of doing the work of a person, controlled by programming or hardware to complete a specific task, often one that is repetitive, difficult or dangerous for a person.
   a. subsystem        b. model        c. prototype        d. robotics

Measure the following figures and reproduce at the specified scale.

Create a 1:4 scale reproduction

Create a 1:1.5 scale reproduction

Create a 2:1 scale reproduction
Find the value of the function \( f(x) \) for the given value of \( x \) in the following.

1. \( f(x) = x^2 + x + 1, \ x = 3, \)

2. \( f(x) = x^2 - 6x + 9, \ x = 2, \)

3. \( f(x) = x^3 + 3x^2 - 4x + 7, \ x = 3, \)

4. \( f(x) = x^2 - 2x^{1/2} + 3, \ x = 9, \)

5. \( f(x) = 4x^3 + 2x - 3, \ x = 5, \)

6. Use the following table to determine a linear function that describes the relationship between \( x \) and \( y \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
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<tbody>
<tr>
<td>-1</td>
<td>-5</td>
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<tr>
<td>2</td>
<td>-11</td>
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<td>7</td>
<td>-21</td>
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<td>-10</td>
<td>13</td>
</tr>
<tr>
<td>15</td>
<td>-37</td>
</tr>
</tbody>
</table>

Examine the following sets of points to determine if they represent linear relationships or not. Explain why or why not (it may be helpful to graph each set).

1. \( \{(0,0),(3,2),(-3,-2)\}, \)
2. \{ (1,1), (1,-1), (-1,1) \},

3. \{ (-1, -2), (1,1), (4,3) \},
4. \{(3, 1), (-1, 2), (11, -1)\},

5. \{(1, 2), (2, 3), (3, 6)\},
Lesson 1: Understanding Technical Information

Lesson Snapshot

Overview
Big Idea: Technical information comes from a variety of sources and is used to maintain systems and understand how they work.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn that there are many forms of technical information, including manuals, websites and experienced people. Technical information contains data on how a system operates and how to maintain it.

Lesson Duration: 5 hours, plus 2 enrichment hours.

Activity Highlights

Engagement
Students will interpret a variety of different types of directions to complete a project.

Exploration
Using library resources, students will research, develop and write a system procedure to maintain an object of their choice, such as a bicycle, electronic device or other item.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject.

Extension
Working with a partner, students will develop a set of directions to assemble an object. The materials and directions will be shared with another team, who will follow the directions to complete the assembly.

Enrichment
Using appropriate technical terminology, students will develop an introduction guide for new students in their Technology Education program.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Multiple Choice Response items, Research projects, Performance Rubrics, and an End of unit quiz.
Lesson 1: Understanding Technical Information

Lesson Overview

Lesson Duration
5 hours, plus 2 enrichment hours.

Standards/Benchmarks

<table>
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<tbody>
<tr>
<td><strong>STL 2U</strong> Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.</td>
</tr>
<tr>
<td><strong>12H</strong> Use information provided in manuals, protocols or by experienced people to see and understand how things work.</td>
</tr>
</tbody>
</table>

English Language Arts: Common Core Standards for English Language Arts (CCSELA, 2011)

Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)

RST.6-8.2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Science: Benchmarks for Science Literacy (AAAS, 1993/2009)

Habits of Mind

12D/M3 Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer databases.

Learning Objectives

Students learn to:
1. Understand and evaluate technical information to understand how a technology system works.
2. Design a set of instructions for system maintenance.
3. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
4. Work safely and accurately with a variety of tools, machines, and materials.
5. Actively participate in group discussions, ideation exercises, and debates.

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1 Material reprinted from Benchmarks for Science Literacy (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Resource Materials
Audiovisual Materials
1. Pavelka, P., Writing Directions, Retrieved on 05/03/12 from www.youtube.com/watch?v=nqJYR_bDzVY Used by permission.


Print Materials

Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. Technical writing
   b. Reading technical information
   c. Writing Directions
   d. Manuals
   e. Maintenance of tools and equipment for kids
3. Power to Learn, Computers & Homework: How to Write a Set of Directions, Retrieved on 05/03/12 from http://www.powertolearn.com/articles/computers_and_homework/article.shtml?ID=49 (permission to link requested)
4. Wetherington, M., Technologies of Writing, Volume 2, Issue 1, How to Write Instructions, Retrieved on 05/03/12 from http://class.georgiasouthern.edu/writling/professional/TechWrite/2-1/wetherington/index.html Used by permission.
5. Origami Fun, Origami Crane Instructions, retrieved on 05/10/12 from http://www.origami-fun.com/support-files/origami-crane-print.pdf Used by permission

Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software.
Lesson 1: Understanding Technical Information

5-E Lesson Plan

Teacher’s Note: Academic language is critical to student success in this lesson. Be sure to allow time for students to learn correct technical terms, as well as academic terms that may be unfamiliar or unclear. For the extension activity, any materials may be used, but uniform building materials such as LEGO's may be easier for some students to use and interpret in diagrams.

Engagement
The students will interpret a variety of different types of directions to complete a project.

- The teacher will provide each student with 4 squares of origami paper of any size, explaining that they are each going to make some origami sculptures.
- The teacher will begin by quickly folding a paper crane, minimally explaining the process, while students are attempting to fold their own cranes.
- Copies of picture instructions (only a diagram, no text, or only foreign language text) will be distributed to the students. The teacher will ask them to start a new sculpture, following the picture directions.
- After a few minutes, the teacher will ask students to begin a new sculpture, using directions with improved diagrams or minimal text, such as Origami Fun (See internet resource 5), with text covered.
- For the final sculpture, students will begin with a new piece of origami paper and the complete instructions from Origami Fun (See internet resource 5).
- After making all attempts, students will discuss their observations about reading directions, understanding diagrams and assumptions about how a reader will understand directions.
- In their Engineering Design Journals, students will write about the experience, using text and diagrams that could improve the directions for a beginner.

Exploration
Using library resources, students will research, develop and write a system procedure to maintain an object of their choice, such as a bicycle, electronic device or other item.

- If students have selected a complicated object, directions should focus on an area or subsystem within the overall object, for example the braking system of a bicycle, rather than maintaining the entire bicycle.
- In their Engineering Design Journals, students will brainstorm a list of objects for potential procedure development. From these objects, students will identify a specific area or subsystem of the object for maintenance.
- Utilizing at least three resources, students will develop a procedure for maintenance of the system, using text and graphics to depict appropriate and necessary information in their Engineering Design Journals.
The final version of the directions will be presented to the class, with a demonstration of the procedure, if possible.

**Explanation**

The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- Needs within instructions are identified: clarity, explanations of technical terms, accuracy, not skipping steps, visual references such as pictures or drawings, additional resources such as rotatable online images, etc.
- Other considerations for directions: language barriers, lack of experience, new equipment or materials, care for fragile or essential objects like medical equipment
- Working with partners, students will address the question, “How can someone writing directions be sure that they meet all of the listed needs?” in their Engineering Design Journals. Results from each pair will be shared with the class.

**Extension**

Working with a partner, students will develop a set of directions to assemble an object.

- In their Engineering Design Journals, students will work with partners to develop a completed assembly. The object may be functional or non-functional, at the discretion of the teacher.
- Materials used in the object assembly will vary. Use of uniform building materials such as LEGO’s is optional.
- Students will need access to materials in developing the directions for their assemblies. A prototype will be assembled during the development of instructions and procedures.
- Sketches of assemblies should be completed in the Engineering Design Journal to aid in assembly by the students who will receive the directions.
- Completed instructions for assembly should be as specific as possible, include a list of needed materials and tools, diagrams or pictures for further clarity, and provide a step-by-step procedure.
- Once the directions are complete, materials needed for assembly will be collected, and exchanged with another pair, who will follow the directions given to assemble the object, without additional guidance from the authors.
- Teams will compare the final assembly with the prototype, documenting both in the Engineering Design Team rubric.

**Enrichment**

Using appropriate technical terminology, students will develop an introduction guide for new students in their Technology Education program, including requirements for participation in the student organization.

**Evaluation**

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Multiple Choice Response items, Research projects, Performance Rubrics, and an End of unit quiz.
The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
Teacher Resource 4.1.1: Class Participation Rubric

<table>
<thead>
<tr>
<th>Category</th>
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<td>Preparation</td>
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<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
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<td>Makes good use of class time to work on assignments and projects.</td>
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</table>

Comments:

Grade:
Assessment Resource 4.1.1: Engineering Design Journal Rubric

Name ______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

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<tr>
<td>Complete All areas addressed</td>
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<tr>
<td>Most areas well done</td>
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<tr>
<td>Not attempted, missing</td>
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</table>

Activity 1- identified ways to improve instructions

Activity 1- brainstorming, draft of directions

Activity 2- addressed question

Activity 2- System relationships & process

Activity 3- directions developed

Activity 4- Sketches of prototype

Improvement in drawing skills over time

Includes notes and comments

Ability to understand and interpret images, notes and sketches

Bonus: Additional materials

Total

Comments:

Grade:
# Assessment Resource 4.1.2: Research Project and Presentation Rubric

**Presenter(s)**

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<tr>
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- Explained purpose of the system and the object
- Explained maintenance procedure
- Explained necessary tools and materials
- Documented three sources of information
- Was the presentation professional? (as if family were in the audience)
- Use of visuals - pictures, graphs, sketches, objects
- Use of text information - handouts, notes, lists
- Use of audiovisual information - videos, websites, sounds
- Vocal presentation - clear, relevant, answered questions
- Slides or other visuals – relevant and clear
- Addressed all relevant information
- Personalized presentation through individualized information
- Participation – active in the presentation, not just reading
- Total

**Comments:**

**Grade:**

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Technological Systems, Third Edition
Unit 4: Maintaining Technological Systems

Lesson 1: Understanding Technical Information

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content. Gather recyclable materials to represent a variety of categories.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work which will require writing and drawing space, developing and building systems, which will require building materials and tools and presentations which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and construction companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment

1. Computer w/Internet access
2. Presentation projector
3. Safety glasses, 1 pair per student
4. Engineering Design Journals or blank paper
5. Origami paper, 5 7/8” square, 100 sheet pack
6. Library resources such as books, magazines, CDs and manuals
7. Scissors, 1 pair per student
8. 12” rulers, 1 per student
9. X-Acto knives, 1 per student with replacement blades
10. 18” X 24” self-healing cutting mats, 10 per class
11. Coping saws, 5 per class, with replacement blades
12. Gift wrap tape, 1-2 per group
13. Masking tape 1”, 1 roll per group
14. School Glue, 40z, 2 per group
15. Hot melt glue guns, 10 per class
16. Hot melt glue sticks, 50 pack
17. Paper fasteners (brads), 1 box per class
18. Balsa wood economy bag, 3 per class
19. Construction paper, multi-color pack
20. Precision screwdriver sets, 10 per class
21. Assorted sandpaper
22. Balsa wood easy cutter, 3 per class
23. Used file folders
24. Corrugated cardboard, approximately 8” X 10”, 1 per student
25. Empty plastic containers, 1 per student
26. Optional: Styrofoam sheets or packaging

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
- Teacher Resource 4.1.1: Class Participation Rubric
- Teacher Resource 4.1.2: Technical Writing in Directions and Procedures
- Teacher Resource 4.1.3: Multiple Choice Quiz Answer Key

Student Resources
- Student Resource 4.1.1: Unit PowerPoint
- Student Resource 4.1.2: Lesson Glossary
- Student Resource 4.1.3: Engineering Design Journal Guidelines
- Student Resource 4.1.4: Research Project Guidelines
- Student Resource 4.1.5: Developing Directions to Assemble an Object
- Student Resource 4.1.6: Multiple Choice Quiz
- Student Resource 4.1.7: Lesson Design Brief

Assessment Resources
- Assessment Resource 4.1.1: Engineering Design Journal Rubric
- Assessment Resource 4.1.2: Research Project and Presentation Rubric
- Assessment Resource 4.1.3: Engineering Design Team Rubric
- Assessment Resource 4.1.4: Object Assembly Directions Rubric
# Unit 4: Maintaining Technological Systems

## Lesson 1: Understanding Technical Information

### Teacher Resource 4.1.1: Class Participation Rubric

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Comments:

Grade:
Unit 4: Maintaining Technological Systems

Lesson 1: Understanding Technical Information

Teacher Resource 4.1.2: Technical Writing in Directions and Procedures

As a professional Technology Educator, there are many terms, concepts and formulas that are often taken for granted. Consumers expect that when they purchase a product that must be assembled or otherwise prepared, it will include clear instructions. For this lesson, you are the conduit between students developing and understanding directions and the future consumers of a product.

In guiding students in completing their directions, here are some areas that will help keep them on track:

- Maintain a balance between being clear and being brief. Short, explicit directions are more likely to be read and retained than longer overly detailed ones.

- Details are important. Directions should describe what is being used, how it is used and where it is used. Consider the following examples:
  1. Tape the sides together.
  2. Using a 1-inch piece of tape, connect sides A and B, right sides together, as shown in the diagram below.

For the person who is building the object and creating the pieces for assembly, the first statement is perfectly clear. For someone who is unfamiliar with the product and the assembly process, the second statement may be more helpful.

- Pictures really are worth a thousand words. Images of the assembly process through sketches, diagrams and photographs will help all readers, especially where something is difficult to see, very fragile or easily misassembled.

- When possible, keep directions limited to one page. They should be easily legible, without crowding or shrinking of text and images, but fewer pages are more likely to be read and less likely to be lost.

- Remind students that although they may know a system or object inside and out, they will need to think as though they have never seen or used that object before as they are writing their directions.

- Encourage students to have other people review their directions for clarity and understanding.
Lesson 1: Understanding Technical Information

Teacher Resource 4.1.3: Multiple Choice Quiz Answer Key

1. ___________ is a Japanese art form involving intricately folded paper.
   a. sculpture  b. intricate  c. origami  d. accuracy

2. Something that is detailed or complicated, something with many components or steps could be described as___________.
   a. sculpture  b. intricate  c. origami  d. accuracy

3. An object that is designed to be ________________ has a specific use or purpose.
   a. non-functional  b. useful  c. sculptural  d. functional

4. The correctness or precision of an object is referred to as _________________.
   a. accuracy  b. clarity  c. preciseness  d. measurement

5. Information relating to the manmade development of materials, processes and systems is referred to as___________.
   a. directions  b. assembly  c. technical  d. instructions

6. Sharing knowledge or information in a specific order is known as___________.
   a. accuracy  b. instructions  c. directions  d. clarity

7. A procedure to be followed, or steps to reach a place or conclusion are known as _________________.
   a. accuracy  b. instructions  c. directions  d. clarity

8. Two or three dimensional objects created by casting, welding, molding or carving material are known as___________.
   a. origami  b. assemblies  c. functional objects  d. sculptures

9. An object that is intended to be visually pleasing rather than for a specific purpose is _________________.
   a. non-functional  b. useful  c. sculptural  d. functional

10. Putting together components into a completed product is called _________________.
    a. sculpture  b. building  c. assembly  d. function

11. Effective communication that is easily understood is said to have __________.
12. A simplified drawing or sketch showing the relevant or important components is called a ____________.
a. diagram  b. chart  c. flow chart  d. thumbnail sketch

13. Keeping a system or object in good working condition is called ____________.
a. troubleshooting  b. instructions  c. maintenance  d. repair

14. Which of the following should be included in directions for assembly?
a. tools  b. visual information  c. procedures  d. lengthy descriptions

15. Which of the following will make it difficult for someone to follow directions?
a. lengthy descriptions  b. lots of technical terms  c. clarity  d. skipping steps

16. ____________ describes a gradual, detailed process, explaining a procedure that takes place in small increments.
a. precise  b. clarity  c. intricate  d. step-by-step

17. An object that is unable to perform the function for which it is intended is ____________.
a. sculptural  b. useful  c. non-functional  d. functional

18. Which of the following words can be used interchangeably?
a. clarity  b. directions  c. instructions  d. precision
Unit 4: Maintaining Technological Systems

Lesson 1: Understanding Technical Information

Student Resource 4.1.2: Lesson Glossary

**Accuracy** The closeness of an object to a true measure, correctness, precision.

**Assembly** Putting together parts or components into a completed product.

**Clarity** The ability to be easily understood, effective communication.

**Diagram** A simplified drawing or sketch showing the relevant or important components.

**Directions** A procedure to be followed, or steps to reach a place or conclusion. May be used interchangeably with instructions.

**Functional** An object that has a specific use or purpose, not necessarily designed to look good.

**Instructions** Sharing knowledge or information, in order. May be used interchangeably with directions.

**Intricate** Detailed or complicated, something with many components or steps.

**Maintenance** Preserving an object or system, keeping it in good working condition.

**Non-functional** Not having a specific use or purpose, or an object that cannot be used as it was intended due to being unable to perform the task that it was designed to do.

**Origami** A Japanese art form involving intricately folded paper.

**Sculpture** Two or three dimensional objects created by casting, welding, molding or carving material.

**Step-by-step** A gradual, detailed process, explaining a procedure that takes place in small increments.

**Technical Information** Information relating to the manmade development of materials, processes and systems.
Lesson 1: Understanding Technical Information

Student Resource 4.1.3: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Lesson 1: Understanding Technical Information

Student Resource 4.1.4: Research Project Guidelines

The purpose of the research project is to develop a set of directions to maintain a system.

In completing your research project:

1. In a larger or more complicated system, it will help to identify a smaller area or subsystem, such as the braking mechanism on a bicycle, rather than maintenance of the entire bicycle.

2. Use both internet and print resources to document your research. Due to the kind of information that you need, a person who has experience can also be considered a resource.

3. Cite at least 3 sources in your completed research project.

4. Note that important contributions to STEM fields have come from all kinds of people from all over the world.

5. Remember that spell check finds misspelled words; it does not find incorrect words. Read your project carefully, or have someone else read it before turning it in.

6. Check with your teacher about how to include images in your research project. Depending on the format, they can be on the same page as the text that refers to them, or in a separate section in the back. Remember to include labels or captions for the images.

Citing References:

When citing an electronic document such as a website, blog, or YouTube video, use this format in the References list:

   Author, Title, Retrieved on date from http://

When citing print materials, use this format in the References list:

   Author. (Year of Publication). Title, City of Publisher, State of Publisher: Name of Publishing Company

When citing a person via conversation, e-mail, text message or other personal communication, use this format:

   First Initial. Last Name (personal communication, month, day, year)

When citing a reference in the text of your research project, use this format for both print and electronic publications:

   “statement”, (Author, p.#, year of publication). For personal communications, replace page number with personal communication.

The quotation marks are only needed for a direct quote.
Lesson 1: Understanding Technical Information

Student Resource 4.1.5: Developing Directions to Assemble an Object

Now that students have become familiar with directions and the necessary parts needed for the user to read and interpret them, it is time to develop a set of assembly directions, working with a partner.

*Teacher’s Note:* The time that students have to devote to this project will help you to determine the number of components in the completed assembly. Objects may be functional or non-functional at your discretion. You may also choose to provide students with a specific kit without the directions. The specific materials used for this activity are very flexible. Use of uniform building materials such as LEGO® is optional, but may be helpful for students at a variety of ability levels.

In their Engineering Design Journals, students will work in Engineering Design Teams to develop a completed assembly, using the design constraints specified by the teacher.

Each team will develop a different assembled object and complete directions for completing the assembly. Once completed, the Engineering Design Teams will exchange directions and components in order to attempt to assemble the completed product using only the materials and directions provided.

A final product for exchange will include the following:

1. A specific, written step-by-step directions to assemble to final product.
2. Sketches or pictures of the completed assembly and critical steps during the assembly process
3. A Bill of Materials for all necessary components to assemble the final product, including any glue or fasteners and necessary tools
4. A “kit” of the necessary components to assemble the final product
5. An Object Assembly Directions Rubric (See Assessment Resource 4.1.4)

In developing the assemblies and directions, students will work in their Engineering Design Journals to develop a process and sketches of components and steps in the assembly. Each team assembles a prototype during the development of instructions and procedures.

In completing the assembly, the team receiving the product to assemble will complete the Object Assembly Directions Rubric (See Assessment Resource 4.1.4) referring to the product they have received.

Using the Engineering Design Team Rubric (See Assessment Resource 4.1.3), teams will assess the participation and contributions of their own team, including themselves.

Teams will compare the final assembly with the prototype, documenting both in their Engineering Design Journals.
Lesson 1: Understanding Technical Information

Student Resource 4.1.6: Multiple Choice Quiz

Name: ______________________________________

1. ________________ is a Japanese art form involving intricately folded paper.
   a. sculpture    b. intricate    c. origami    d. accuracy

2. Something that is detailed or complicated, something with many components or steps could be described as ____________.
   a. sculpture    b. intricate    c. origami    d. accuracy

3. An object that is designed to be ________________ has a specific use or purpose.
   a. non-functional    b. useful    c. sculptural    d. functional

4. The correctness or precision of an object is referred to as ________________.
   a. accuracy    b. clarity    c. preciseness    d. measurement

5. Information relating to the manmade development of materials, processes and systems is referred to as ________________.
   a. directions    b. assembly    c. technical    d. instructions

6. Sharing knowledge or information in a specific order is known as ________________.
   a. accuracy    b. instructions    c. directions    d. clarity

7. A procedure to be followed, or steps to reach a place or conclusion are known as ________________.
   a. accuracy    b. instructions    c. directions    d. clarity

8. Two or three dimensional objects created by casting, welding, molding or carving material are known as ________________.
   a. origami    b. assemblies    c. functional objects    d. sculptures

9. An object that is intended to be visually pleasing rather than for a specific purpose is ________________.
   a. non-functional    b. useful    c. sculptural    d. functional

10. Putting together components into a completed product is called ________________.
    a. sculpture    b. building    c. assembly    d. function
11. Effective communication that is easily understood is said to have ________.
   a. precision    b. clarity    c. accuracy    d. direction

12. A simplified drawing or sketch showing the relevant or important components is called a ____________.
   a. diagram    b. chart    c. flow chart    d. thumbnail sketch

13. Keeping a system or object in good working condition is called ____________.
   a. troubleshooting    b. instructions    c. maintenance    d. repair

14. Which of the following should be included in directions for assembly?
   a. tools    b. visual information    c. procedures    d. lengthy descriptions

15. Which of the following will make it difficult for someone to follow directions?
   a. lengthy descriptions    b. lots of technical terms    c. clarity    d. skipping steps

16. ____________ describes a gradual, detailed process, explaining a procedure that takes place in small increments.
   a. precise    b. clarity    c. intricate    d. step-by-step

17. An object that is unable to perform the function for which it is intended is ____________.
   a. sculptural    b. useful    c. non-functional    d. functional

18. Which of the following words can be used interchangeably?
   a. clarity    b. directions    c. instructions    d. precision
The Problem: Many objects that are purchased require some level of assembly or maintenance on the part of the consumer. If the included directions are difficult to read, in another language or missing, the consumer may struggle to complete the maintenance or assembly tasks correctly. Working with a partner, students will develop a set of directions to assemble an object.

Design Constraints: Materials used in the object assembly will vary. Use of uniform building materials such as LEGO is optional.

Students will need access to materials in developing the directions for their assemblies. A prototype will be assembled during the development of instructions and procedures.

Sketches of assemblies should be completed in the Engineering Design Journal to aid in assembly by the students who will receive the directions.

Things to Consider: Completed instructions for assembly should be as specific as possible, include a list of needed materials and tools, diagrams or pictures for further clarity, and provide a step-by-step procedure.

What can be included in your directions to make it easier for the receiving team to correctly assemble the object?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, Library resources such as books, CDs and manuals, Origami paper, 5 7/8” square gift-wrap tape, masking tape, school glue, paper fasteners (brads), construction paper, precision screwdrivers, assorted sandpaper, Balsa Wood Easy Cutter, Empty plastic containers, hot melt glue guns and sticks, X-Acto knives, coping saws, scissors, rulers, corrugated cardboard, file folders, Styrofoam sheets or packing materials, and Balsa Wood. Other materials may be used - consult your teacher.

The Prototype: In their Engineering Design Journals, students will work with partners to develop a completed assembly. The object may be functional or non-functional, at the discretion of the teacher.

The Process: Once directions are complete and materials to assemble to object have been collected, teams will exchange directions and materials, completing the assembly as described in the directions for the other team’s object.

The Assembly: Once the directions are complete, materials needed for assembly will be collected, and exchanged with another pair, who will follow the directions given to assemble the object, without additional guidance from the authors.

Teams will compare the final assembly with the prototype, documenting both in the Engineering Design Team rubric.
Lesson 1: Understanding Technical Information

Assessment Resource 4.1.1: Engineering Design Journal Rubric

Name __________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

4. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

5. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

6. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
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<tr>
<td>Activity 1- identified ways to improve instructions</td>
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<tr>
<td>Activity 1- brainstorming, draft of directions</td>
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<td>Activity 2- addressed question</td>
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<td>Activity 2- System relationships &amp; process</td>
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<td>Activity 3- directions developed</td>
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<td>Activity 4- Sketches of prototype</td>
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<tr>
<td>Improvement in drawing skills over time</td>
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<tr>
<td>Includes notes and comments</td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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<td>Bonus: Additional materials</td>
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<td>Total</td>
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</table>

Comments: ____________________________

Grade: ____________________________
Lesson 1: Understanding Technical Information

Assessment Resource 4.1.2: Research Project and Presentation Rubric

<table>
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<td>Explained purpose of the system and the object</td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
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<tr>
<td>Explained maintenance procedure</td>
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<td>Explained necessary tools and materials</td>
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<td>Documented three sources of information</td>
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<td>Was the presentation professional? (as if family were in the audience)</td>
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<tr>
<td>Use of visuals - pictures, graphs, sketches, objects</td>
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<tr>
<td>Use of text information - handouts, notes, lists</td>
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<tr>
<td>Use of audiovisual information - videos, websites, sounds</td>
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<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
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<td>Slides or other visuals - relevant and clear</td>
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<tr>
<td>Addressed all relevant information</td>
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<td>Personalized presentation through individualized information</td>
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<td>Participation - active in the presentation, not just reading</td>
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<td>Grade:</td>
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</table>
**Unit 4: Maintaining Technological Systems**

**Lesson 1: Understanding Technical Information**

**Assessment Resource 4.1.3: Engineering Design Team Rubric**

Student Name: ____________________________________________

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
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<tr>
<td>Overall Participation</td>
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<tr>
<td>Contributions to the group</td>
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<td>Focus on project</td>
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<tr>
<td>Teamwork</td>
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<tr>
<td>Strengths and weaknesses</td>
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<td>Special Contributions</td>
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<td>Comments</td>
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<tr>
<td>Overall Grade</td>
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</table>
Lesson 1: Understanding Technical Information

Assessment Resource 4.1.4: Object Assembly Directions Rubric

Students who developed product assembly: ____________________________

Students completing rubric: ________________________________________

As a team, decide where the product you received to assemble fits in each category.

1. Did the product you received contain all of the necessary components? Circle all of the pieces that you received from the other team.
   - A specific, written step-by-step directions to assemble to final product.
   - Sketches or pictures of the completed assembly and critical steps during the assembly process
   - A Bill of Materials for all necessary components to assemble the final product, including any glue or fasteners and necessary tools
   - A “kit” of the necessary components to assemble the final product

2. Were the directions easy to follow? Explain why or why not.

3. Did the included sketches or pictures help in completing the assembly? Explain why or why not.

4. Was the Bill of Materials complete? If not, what was missing?

5. Was the “kit” complete? If not, what was missing?

6. Describe the most helpful part of the directions that you received.

7. What could be changed to improve the directions you received?

8. How did your completed assembly compare to the prototype of the completed object?

9. What Grade would you assign to the team who developed the assembly? Why?
Unit 4: Maintaining Technological Systems

Lesson 2: Problem-Solving Within Systems

Lesson Snapshot

Overview

Big Idea: At times, systems will need to be adjusted or repaired, and tools and equipment must be used safely to maintain these systems.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn when systems need repaired or adjusted, identification and troubleshooting of the problem will be necessary. When attempting the repairs or adjustments, tools and equipment must be used safely.

Lesson Duration: 5 hours, plus 1 enrichment hour.

Activity Highlights

Engagement
Using a variety of multi-media and print resources, students will develop an understanding of the role of maintenance and troubleshooting in product adjustment and repair.

Exploration
Students will explore and disassemble objects to locate potential sources of failure and where and how adjustments may be made to improve or continue performance.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject.

Extension
Students will work in teams to investigate a simple object and make adjustments to improve performance and repair if needed.

Enrichment
The students will visit a local automotive repair or manufacturing facility to observe and discuss maintenance and troubleshooting in larger systems.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, an End of lesson quiz, and an End of unit quiz.
Unit 4: Maintaining Technological Systems

Lesson 2: Problem-Solving Within Systems

Lesson Overview

Lesson Duration
5 hours, plus 1 enrichment hour.

Standards/Benchmarks

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>STL 12I Use tools, materials, and machines safely to diagnose, adjust, and repair systems.</td>
</tr>
<tr>
<td>10F Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.</td>
</tr>
</tbody>
</table>

Mathematics: Common Core Standards for Mathematics (CCSM, 2011)

Expressions & Equations Standard (CCSM, Grade 8)

| 8.EE Expressions and equations work with radicals and integer exponents. |
| 8.EE Understand the connections between proportional relationships, lines and linear equations. |
| 8.EE Analyze and solve linear equations and pairs of simultaneous linear equations. |

Science: Benchmarks for Science Literacy (AAAS, 1993/2009)¹

The Nature of Technology

3B/M4a Systems fail because they have faulty or poorly matched parts, are used in ways that exceed what was intended by the design, or were poorly designed to begin with.

Learning Objectives

Students learn to:
1. Identify and trouble-shoot malfunctions in a system
2. Use tools and equipment safely
3. Diagnose, adjust and repair systems
4. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
5. Work safely and accurately with a variety of tools, machines, and materials.
6. Actively participate in group discussions, ideation exercises, and debates.

¹ Material reprinted from Benchmarks for Science Literacy (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Resource Materials
Audiovisual Materials
1. YouTube Video: Hand Tools \url{http://www.youtube.com/watch?v=4o0tqF0jDdo&feature=related} (permission to link requested)

Print Materials
1. Any manuals from equipment or products

Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. Tool safety
   b. Hand tool safety
   c. Power tool safety
   d. Understanding technical information
2. Odell, D. Ezinearticles: Understanding Technical Writing, Retrieved on 04/30/12 from \url{http://ezinearticles.com/?Understanding-Technical-Writing&id=377202} (permission to link requested)
4. Occupational Safety and Health Administration (OSHA), Hand and Power Tools, Retrieved on 04/30/12 from \url{http://sitemaker.umich.edu/section002group3/ewaste} (permission to link requested)
5. Student Aware Communications, TechEd101, Retrieved on 04/30/12 from \url{http://www.techted101.com/default.htm} (permission to link requested)

Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. Students should demonstrate the ability to wear and use safety equipment as appropriate. Students should understand and demonstrate the safe use of appropriate tools and equipment.
Lesson 2: Problem-Solving Within Systems

5-E Lesson Plan

Teacher’s Note: For the exploration activity, consider using non-functional computer components such as hard drives and CD/DVD drives. There are many potential sources of failure and they should be easily obtainable. If using hard drives, include magnet safety in your safety discussions and preparations. For the extension activity, a lower quality product will yield more potential areas for repair and adjustment.

Engagement

Using a variety of multi-media and print resources, students will develop an understanding of the role of maintenance and troubleshooting in product adjustment and repair.

- Working in teams, students will document in their Engineering Design Journals, a list of everyday objects that require adjustment or repair.
- Students will discuss how the life of the product could be extended or performance improved if adjustment or repair were completed.
- As a class, the teacher and students will discuss appropriate use of tools, safety equipment and complete safety tests or other procedures for equipment used in this lesson.
- Documentation of successful completion of appropriate safety tests or other procedures should be noted in each student's Engineering Design Journal (in addition to other locations) prior to students proceeding to later steps in the lesson.

Exploration

Students will explore and disassemble objects to locate potential sources of failure and where and how adjustments may be made to improve or continue performance.

- Demonstrating proper safety procedures, students will work in Engineering Design Teams to disassemble a product and determine locations where adjustments or repairs could improve performance.
- Documentation of locations, and potential repairs and adjustments, including sketches are completed in individual Engineering Design Journals.
- As a class, discuss the impact of the potential changes on the system.
- Mathematical concepts that will affect performance in some systems will be addressed and practiced.

Explanation

The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject. Potential directions for discussion are listed below:

- Particle board vs. solid wood goods and furniture
- Perceived obsolescence of objects - newer is better, i.e. film vs. digital cameras
- Historical changes that have led to the common practice of replacement over repair
• Craftsmanship and quality of manufacturing
• Safety considerations in repair and adjustment

Extension

Students will work in teams to investigate a simple object and make adjustments to improve performance and repair if needed.
• Using an inexpensively manufactured product (such as a flashlight or other device), students will work in teams to document the performance, assembly and functionality of object.
• Demonstrating understanding and use of appropriate safety materials and procedures, students will experiment and make adjustments to improve the performance of the object.
• Documentation of the object, the individual components, the assembly and adjustments or repairs, and suggestions for improvement are completed in individual Engineering Design Journals.
• Students will complete an Engineering Design Team Rubric, assessing their own performance and that of their teammates.

Enrichment

The students will visit a local automotive repair or manufacturing facility to observe and discuss maintenance and troubleshooting in larger systems.

Evaluation

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, an End of lesson quiz, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
## Assessment Instrument

### Teacher Resource 4.2.1: Class Participation Rubric

Name: ______________________________________________________________________

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments: ____________________________________________________________________________

Grade: ____________________________________________________________________________
Student Resource 4.2.6: Reflective End of Lesson Quiz

Name:__________________________________________________________

Answer each question with a paragraph, using complete sentences.

1. Describe a situation where you would use troubleshooting to repair a product or system.

2. Explain the pros and cons of repairing a product or system as opposed to purchasing or replacing the product or system.

3. Why are safety procedures and equipment important in classroom and industry settings?

4. Think back through the lesson to the items that you repaired or looked to improve. How would you explain your suggested changes to the manufacturer?

5. Imagine that you are helping a friend to use a new video game system that you are familiar with, but he/she has not used before. In the process of setting it up, you discover that there is some kind of problem with the system. How would you address this problem in a way that helps your friend to learn about how to address the problem on his/her own?
## Assessment Resource 4.2.1: Engineering Design Journal Rubric

Name ____________________________________________

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troubleshooting a Device: original sketch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Troubleshooting a Device: disassembly sketch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Troubleshooting a Device: Bill of Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Troubleshooting a Device: thumbnail sketches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusting and Repairing: original sketch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusting and Repairing: component sketches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusting and Repairing: assembly or exploded view</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Adjusting and Repairing: sketches of proposed changes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improvement in drawing skills over time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Includes notes and comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonus: Additional materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grade:
**Assessment Resource 4.2.2: Reflective Writing Rubric**

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td><strong>Ability to apply information gained in class to prior knowledge</strong></td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
### Assessment Resource 4.2.3: Troubleshooting a Device Rubric

**Name:**

Students will explore and disassemble objects to locate potential sources of failure as well as where and how those failures can be located and addressed.

In your individual Engineering Design Journals, complete the following for the device that your team is using for this project:

<table>
<thead>
<tr>
<th></th>
<th>4 Complete All areas addressed</th>
<th>3 Most areas well done</th>
<th>3 Some areas well done</th>
<th>1 Minimal effort</th>
<th>0 Not attempted, missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Described device, including reference information, and purpose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completed sketch prior to disassembly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional sketches during the process, minimum of 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bill of Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Described disassembly process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thumbnail sketches of unique parts, minimum of 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located 2 potential sources of failure</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sketches of 2 potential sources of failure</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Described changes to sources of failure and how they will affect the system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation in class discussion of findings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Grade:
Assessment Resource 4.2.4: Engineering Design Team Rubric

Student Name: ____________________________________________

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson # ______</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributions to the group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus on project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengths and weaknesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Contributions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unit 4: Maintaining Technological Systems
Lesson 2: Problem-Solving Within Systems
Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work, which will require writing and drawing space, assembling and disassembling systems, which will require materials and tools. Students will give presentations, which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and electronics companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Engineering Design Journals or blank paper
4. Safety tests or other safety assessment procedures/instruments
5. Safety glasses, 1 pair per student
6. Protective Hi-Dexterity gloves, 5 pairs per class
7. Precision screwdrivers, 10 sets per class
8. X-Acto knives, 1 per student with replacement blades
9. Coping saws, 5 per class, with replacement blades
10. 18” X 24” self-healing cutting mats
11. Phillips screwdrivers, #1, 1 per student
12. Flat screwdrivers, 1 per student
13. Electrical tape, 1 roll per table
14. Battery tester, 3 per class
15. Economy flashlights, 1 per 2 students
16. Cyanoacrylic all-purpose glue, 8 per class
17. Carpenter’s wood glue, 4 oz, 10 per class
18. Utility Pliers 3 piece set, 4 per class
19. Multi-purpose crimp and strip wire tools, 15 per class
20. D Batteries , 2 per flashlight or as needed for selected devices
21. Replacement bulbs, 2 per flashlight, if using
22. non-functional hard drives or CD/DVD drives, 1 per 2 students
23. Assorted sandpaper
24. Scissors, 1 pair per student
25. Optional: Soldering irons for electronics, 5 per class
26. Optional: Rosin core solder, 60/40, .5 oz tube, 5 per class

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
• Teacher Resource 4.2.1: Class Participation Rubric
• Teacher Resource 4.2.2: Mathematical Issues in System Performance Answer Key
• Teacher Resource 4.2.3: Reflective End of Lesson Quiz Answer Key

Student Resources
• Student Resource 4.2.1: Lesson Glossary
• Student Resource 4.2.2: Engineering Design Journal Guidelines
• Student Resource 4.2.3: Mathematical Issues in System Performance
• Student Resource 4.2.4: Troubleshooting a Device
• Student Resource 4.2.5: Adjusting and Repairing a Product
• Student Resource 4.2.6: Lesson Design Brief
• Student Resource 4.2.7: Reflective End of Lesson Quiz

Assessment Resources
• Assessment Resource 4.2.1: Engineering Design Journal Rubric
• Assessment Resource 4.2.2: Reflective Writing Rubric
• Assessment Resource 4.2.3: Troubleshooting a Device Rubric
• Assessment Resource 4.2.4: Engineering Design Team Rubric
### Lesson 2: Problem-Solving Within Systems

**Teacher Resource 4.2.1: Class Participation Rubric**

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

Comments:

Grade:
Unit 4: Maintaining Technological Systems

Lesson 2: Problem-Solving Within Systems

Teacher Resource 4.2.2: Mathematical Issues in System Performance

Answer Key

For the given value of x, evaluate the following expressions.

<table>
<thead>
<tr>
<th>Expression</th>
<th>x</th>
<th>f(x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>f(x) = 3x^2 - 4x + 3</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>f(x) = 4x^3</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>f(x) = \sqrt{x^2 + 2x + 1}</td>
<td>7</td>
<td>8, -8</td>
</tr>
<tr>
<td>f(x) = x^4 - 16x^2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>f(x) = 3x^2 - 4\sqrt{9x}</td>
<td>4</td>
<td>24, 72</td>
</tr>
<tr>
<td>f(x) = x^3 - 2x^2 + 5x - 7</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>f(x) = (\sqrt{x^2})^2</td>
<td>7</td>
<td>49</td>
</tr>
<tr>
<td>f(x) = x^2 - 2x + 1</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>f(x) = \sqrt{x^2 + x^2 - 2(x^2)}</td>
<td>5</td>
<td>10, -10</td>
</tr>
<tr>
<td>f(x) = \sqrt{8x^3}</td>
<td>2</td>
<td>8, -8</td>
</tr>
</tbody>
</table>

Solve the following pairs of simultaneous linear equations:

1. 4x - 3y = -2, 8x + 2y = 12, x = 1, y = 2
2. 9x + 4y = 19, -4x + 2y = -16, x = 3, y = -2
3. x - y = 11, 2x + 2y = -2, x = 5, y = -6
4. 4x - 7y = 59, 2x - 7y = 33, x = 13, y = -1
5. 4x - 7y = -12, 2x + 7y = 36, x = 4, y = 4
Lesson 2: Problem-Solving Within Systems

Teacher Resource 4.2.3: Reflective End of Lesson Quiz Answer Key

Answer each question with a paragraph, using complete sentences.

1. Describe a situation where you would use troubleshooting to repair a product or system.

   Student responses will vary but should include a situation where the student would be completing the troubleshooting process, such as personal electronics, athletics, etc.

2. Explain the pros and cons of repairing a product or system as opposed to purchasing or replacing the product or system.

   Student responses will vary but should reference the points made in the class discussion during the Explanation section of the lesson.

3. Why are safety procedures and equipment important in classroom and industry settings?

   Student responses should include, safety of self and others, long term health of students and employees, and if discussed in class, to protect the school or company from legal issues.

4. Think back through the lesson to the items that you repaired or looked to improve. How would you explain your suggested changes to the manufacturer?

   Student responses will vary, but should refer to his or her previous work and clearly explain the changes to make and the effect that each will have on the system.

5. Imagine that you are helping a friend to use a new video game system that you are familiar with, but he/she has not used before. In the process of setting it up, you discover that there is some kind of problem with the system. How would you address this problem in a way that helps your friend to learn about how to address the problem on his/her own?

   Student responses should describe a troubleshooting procedure that demonstrates the problem and potential solutions to the friend, through written instructions, demonstrations or visual documentation.
Unit 4: Maintaining Technological Systems

Lesson 2: Problem-Solving Within Systems

Student Resource 4.2.1: Lesson Glossary

**Adjustment**  Making something more suitable to the circumstances, a better fit

**Coping saw**  A particular kind of saw, intended to cut wood, which may cut curves. It has a very narrow blade stretched between a horseshoe-shaped blade, with a handle extending from one side.

**Flat head Screwdriver**  A tool used to drive or remove screws or bolts with a straight slot. Can be used as a hand tool, or in bit form fitted into a drill. This tool is not for use in prying or scraping.

**Maintenance**  The processes, such as cleaning or repairing an object that keep it in good working condition, or prolong the life of the object.

**Obsolete**  A product that is no longer in use, old-fashioned or out of date. It is important to note that the product can be functional, but it becomes unfashionable or unusable due to product needs. For example, a cassette tape player may be functional, but it becomes unusable because cassette tapes are no longer produced.

**Over-clocking**  A process completed on some electronic devices, usually in computers, intended to cause it to run faster than the speed specified by the manufacturer. The purpose of this process is to improve performance speed, but this process also voids the warranty of the device.

**Performance**  The performance of a device is determined by how it is able to complete a task or process, compared to the known ability of the components.

**Phillips Screwdriver**  A tool used to drive or remove screws or bolts with both vertical and horizontal slots, forming a plus sign. Can be used as a hand tool, or in bit form fitted into a drill. This tool is not for use in prying or scraping.

**Product Lifetime**  The lifetime of a product can be determined in two ways: the time during which a product can perform its intended function if properly maintained, or the time until a product becomes obsolete, regardless of its functionality or ability to perform the task it was intended to complete.

**Repair**  To restore an object, device or system to proper working order after usage, damage or wear.

**Replacement**  In a system, replacement requires a component to be replaced with a component that can perform similar functions, as well or better than the previous component.

**Safety Equipment**  Safety equipment includes any object, or device that is employed to prevent harm of any kind to the operator or to other people nearby. An example of safety equipment that protects the operator is a dust mask. A dust collection system protects not
only the operator of the tool generating the dust, but all others in the area that could potentially inhale the dust.

**Troubleshooting** A specific type of repair, involving tracing the performance of each component within a system to locate the source of the problem and develop and implement a solution.
Unit 4: Maintaining Technological Systems

Lesson 2: Problem-Solving Within Systems

Student Resource 4.2.2: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Lesson 2: Problem-Solving Within Systems

Student Resource 4.2.3: Mathematical Issues in System Performance

For the given value of x, evaluate the following expressions.

<table>
<thead>
<tr>
<th>Expression</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>f(x) = 3x^2 - 4x + 3</td>
<td>3</td>
</tr>
<tr>
<td>f(x) = 4x^3</td>
<td>2</td>
</tr>
<tr>
<td>f(x) = √x^2 + 2x + 1</td>
<td>7</td>
</tr>
<tr>
<td>f(x) = x^4 - 16x^2</td>
<td>4</td>
</tr>
<tr>
<td>f(x) = 3x^2 - 4√9x</td>
<td>4</td>
</tr>
<tr>
<td>f(x) = x^3 - 2x^2 + 5x - 7</td>
<td>3</td>
</tr>
<tr>
<td>f(x) = (√x^4)^2</td>
<td>7</td>
</tr>
<tr>
<td>f(x) = x^2 - 2x + 1</td>
<td>5</td>
</tr>
<tr>
<td>f(x) = √x^2 + x^4 - 2(x^2)</td>
<td>5</td>
</tr>
<tr>
<td>f(x) = √8x^3</td>
<td>2</td>
</tr>
</tbody>
</table>

Solve the following pairs of simultaneous linear equations:
1. 4x - 3y = -2, 8x + 2y = 12

2. 9x + 4y = 19, -4x + 2y = -16

3. x - y = 11, 2x + 2y = -2

4. 4x - 7y = 59, 2x - 7y = 33

5. 4x - 7y = -12, 2x + 7y = 36
Unit 4: Maintaining Technological Systems

Lesson 2: Problem-Solving Within Systems

Student Resource 4.2.4: Troubleshooting a Device

Students will explore and disassemble objects to locate potential sources of failure as well as where and how those failures can be located and addressed.

In your individual Engineering Design Journals, complete the following for the device that your team is using for this project:

1. Describe the device that your team will disassemble. List any part numbers, labels or other specific information for that particular device. What is the purpose of the device? Is it functional? Can that be tested?

2. Complete a sketch of the device as you received it, and at least two additional sketches as your team disassembles the device.

3. Create a Bill of Materials, describing each component, especially those removed, as accurately as possible. Create thumbnail sketches of unique parts within your system, such as those with irregular shapes.

4. As your team disassembles your device, locate two areas where there is a potential for failure or malfunction and describe a method to improve the performance or repair the device. Sketch these locations, including labels and write a short description of how those changes will aid the system.

5. Be prepared to discuss the findings of your team with the class.
Lesson 2: Problem-Solving Within Systems

Student Resource 4.2.5: Adjusting and Repairing a Product

For this activity, students will be working in Engineering Design Teams to investigate a simple object and make adjustments to improve performance and repair if needed.

Consider the performance, functionality, and assembly of the object.

Does it work well? Does it work consistently? Is it well assembled and easy to maintain?

What changes will improve the performance, functionality and assembly of the product?

Demonstrating understanding and use of appropriate safety materials and procedures, students will experiment and make adjustments to improve the performance of the object.

Each team member will document the process in his or her Engineering Design Journal.

Sketches should include the original object, separate components and an assembly drawing or “exploded view”; (see the teacher for further instructions on drawing format), and sketches that describe the proposed changes.

Students will complete an Engineering Design Team Rubric, assessing their own performance and that of their teammates.
Unit 1: Technological Systems: How They Work

Lesson 2: Problem-Solving Within Systems
Student Resource 4.2.6: Lesson Design Brief

The Problem: While it may be simpler to replace an object when it no longer functions correctly, many systems can be easily repaired or improved. In Engineering Design Teams, students will investigate a simple object and make adjustments to improve performance and repair if needed.

Design Constraints: The object selected to repair and investigate will limit your abilities somewhat, but should provide you an opportunity to understand the system and ways in which it may need maintenance.

Your Engineering Design Team will have limited time and materials to complete this process, as described by your teacher. Use your time and materials wisely.

Things to Consider: Can you safely address the problem within your system? Do you have the appropriate tools to complete the maintenance and upgrade tasks? Always use appropriate safety equipment.

Materials: Engineering Design Journals, electrical tape, precision screwdrivers, Philipp’s screwdrivers, flat screwdrivers, battery testers, flashlights, replacement light bulbs, cyanoacrylic all-purpose glue, carpenter’s wood glue, assorted sandpaper, X-Acto knives, coping saws, scissors, utility pliers, crimp and strip wire tools, D batteries, non-functional hard drives or CD/DVD drives, optional: soldering irons for electronics, and rosin core solder. Other materials may be used - consult your teacher.

The Procedure: Demonstrating understanding and use of appropriate safety materials and procedures, students will experiment and make adjustments to improve the performance of the object.

Documentation of the object, the individual components, the assembly and adjustments or repairs, and suggestions for improvement are completed in individual Engineering Design Journals.

The Assessment: Students will complete an Engineering Design Team Rubric, assessing their own performance and that of their teammates.
Unit 4: Maintaining Technological Systems

Lesson 2: Problem-Solving Within Systems

Student Resource 4.2.7: Reflective End of Lesson Quiz

Name: __________________________

Answer each question with a paragraph, using complete sentences.

1. Describe a situation where you would use troubleshooting to repair a product or system.

2. Explain the pros and cons of repairing a product or system as opposed to purchasing or replacing the product or system.

3. Why are safety procedures and equipment important in classroom and industry settings?

4. Think back through the lesson to the items that you repaired or looked to improve. How would you explain your suggested changes to the manufacturer?

5. Imagine that you are helping a friend to use a new video game system that you are familiar with, but he/she has not used before. In the process of setting it up, you discover that there is some kind of problem with the system. How would you address this problem in a way that helps your friend to learn about how to address the problem on his/her own?
**Unit 4: Maintaining Technological Systems**

**Lesson 2: Problem-Solving Within Systems**

**Assessment Resource 4.2.1: Engineering Design Journal Rubric**

Name______________________________

4. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

5. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

6. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troubleshooting a Device: original sketch</td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Troubleshooting a Device: disassembly sketch</td>
<td></td>
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<tr>
<td>Troubleshooting a Device: Bill of Materials</td>
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<tr>
<td>Troubleshooting a Device: thumbnail sketches</td>
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<tr>
<td>Adjusting and Repairing: original sketch</td>
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<tr>
<td>Adjusting and Repairing: component sketches</td>
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<td>Adjusting and Repairing: assembly or exploded view</td>
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<tr>
<td>Adjusting and Repairing: sketches of proposed changes</td>
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<tr>
<td>Improvement in drawing skills over time</td>
<td></td>
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<tr>
<td>Includes notes and comments</td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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<tr>
<td>Bonus: Additional materials</td>
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<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

Comments:

Grade:
### Assessment Resource 4.2.2: Reflective Writing Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td>Ability to apply information gained in class to prior knowledge</td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
Lesson 2: Problem-Solving Within Systems  
Assessment Resource 4.2.3: Troubleshooting a Device Rubric  
Name:___________________________________________

Students will explore and disassemble objects to locate potential sources of failure as well as where and how those failures can be located and addressed. In your individual Engineering Design Journals, complete the following for the device that your team is using for this project:

<table>
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<tr>
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<th>4</th>
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<tbody>
<tr>
<td></td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
</tbody>
</table>

Described device, including reference information, and purpose
Completed sketch prior to disassembly
Additional sketches during the process, minimum of 2
Bill of Materials
Described disassembly process
Thumbnail sketches of unique parts, minimum of 3
Located 2 potential sources of failure
Sketches of 2 potential sources of failure
Described changes to sources of failure and how they will affect the system
Participation in class discussion of findings

Total

Comments:

Grade:
Lesson 2: Problem-Solving Within Systems

Assessment Resource 4.2.4: Engineering Design Team Rubric

Student Name: ____________________________________________

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
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<tr>
<td>Overall Participation</td>
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<tr>
<td>Contributions to the group</td>
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<tr>
<td>Focus on project</td>
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<tr>
<td>Teamwork</td>
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<tr>
<td>Strengths and weaknesses</td>
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<tr>
<td>Special Contributions</td>
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<tr>
<td>Comments</td>
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<tr>
<td>Overall Grade</td>
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</tbody>
</table>
**Unit 4: Maintaining Technological Systems**

**Lesson 3: System Testing & Evaluation**

**Lesson Snapshot**

**Overview**

**Big Idea:** Systems are designed with a specific purpose and controls are placed within systems to address their performance.

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

*Teacher’s Suggestion:* For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

**Purpose of Lesson:** This lesson enables students to learn that controls within a system help it to operate as planned or within certain parameters. Changes are made to the performance in a system based on controls that are in place to govern that system.

**Lesson Duration:** 5 hours, plus 1 enrichment hour.

**Activity Highlights**

**Engagement**
Using a variety of multi-media and print resources, students will develop an understanding of the role of failure in engineering design.

**Exploration**
Engineering Design Teams investigate the purpose, functions and practicality of a variety of everyday objects.

**Explanation**
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject.

**Extension**
Using a variety of materials, students will develop a system to complete a series of tasks, with controlled outcomes.

**Enrichment**
Engineering Design Teams connect their creations from the Extension activity into a larger machine, select, and prepare a location for public display of the functional object.

**Evaluation**
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, and an End of unit quiz.
Lesson Duration
5 hours.

Standards/Benchmarks

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

<table>
<thead>
<tr>
<th>STL 2V</th>
<th>Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12K</td>
<td>Operate and maintain systems in order to achieve a given purpose.</td>
</tr>
</tbody>
</table>

**Mathematics:** Common Core Standards for Mathematics (*CCSM, 2011*)

**Functions Standard (CCSM, Grade 8)**

| 8.F.5 | Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. |

**English Language Arts:** Common Core Standards for English Language Arts (*CCSELA, 2011*)

**Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)**

| RST.6-8.2 | Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. |
| RST.6-8.3 | Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. |

**Science:** Benchmarks for Science Literacy (*AAAS, 1993/2009*)

**Common Themes**

| 11C/M3 | Many systems contain feedback mechanisms that serve to keep changes within certain limits. |
| 11B/M3 | Different models can be used to represent the same thing. What model to use depends on its purpose. |

**Learning Objectives**

Students learn to:
1. Explain controls within a system.
2. Understand the changes within a system based on the controls that are in place.

---

1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
3. Design a technological system and test and evaluate its operation for the specified purpose.
4. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
5. Work safely and accurately with a variety of tools, machines, and materials.
6. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials
1. The Physics Tube, Tacoma Narrows Bridge Collapse, Retrieved on 06/04/12 from http://www.youtube.com/watch?v=Az503VJ6kHw&feature=related (permission to link requested)

2. Edison Exploratorium, Automatic Control Systems- Brief History, Retrieved on 06/02/12 from http://www.youtube.com/watch?v=NCLm8pY0EIQ (permission to link requested)


Print Materials


Internet Search Terms and Suggested Sites
8. Internet Search Items:
   a. Necessity is the mother of invention.
   b. The role of failure in engineering design
   c. Control Systems


Required Knowledge and/or Skills
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. They should be able to work in a team environment.
Unit 4: Maintaining Technological Systems

Lesson 3: System Testing & Evaluation

5-E Lesson Plan

Teacher’s Note: Review all materials prior to instruction to ensure background knowledge and appropriate content. For the Exploration section, any small objects may be used, but suggested objects include mousetraps, pull back cars, clothespins and foam paintbrushes. In the Extension section, a variety of materials may be used, and should be selected to align with the available tools and equipment. A potential list of materials is provided.

Engagement

Using a variety of multi-media and print resources, students will develop an understanding of the role of failure in engineering design.

- Suggested sources for investigation: Tacoma Narrows Bridge, Failure in Engineering Design, Invention through necessity
- In their Engineering Design Journals, students will explain in their own words how failure impacted the inventions or locations discussed in class.

Exploration

Engineering Design Teams investigate the purpose, functions and practicality of a variety of everyday objects.

- Using the rubric provided - Testing and Evaluating Everyday Objects, students will work in their Engineering Design Teams to determine the purpose, function and practicality of a variety of objects for their intended purpose.
- Testing and evaluation of objects, in terms of cost, practicality and materials are included.
- Students complete sketches of items under investigation in individual Engineering Design Journals.

Explanation

The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- Why does failure have an important role in engineering design?
- How does failure contribute to the engineering design process?
- How are testing and evaluation connected to failure?
- How do controls within a system prevent failure?
- How does a system change based on the controls that are in place?
- Students describe the role of failure in engineering design in individual Engineering Design Journals.

Extension

Using a variety of materials, students will develop a system to complete a series of tasks, with controlled outcomes.
• Engineering Design Teams will develop a system that allows three different tasks to be performed with limited human intervention.
• Before building the system, designs must be approved by the instructor, including sketches in Engineering Design Journals.
• Construction of the system will be limited to the objects provided in the classroom, with one additional component provided by each team member.
• At least one of the actions performed within the system has to be adjustable by the Engineering Design Team.
• Tape, glue, and fasteners of any kind are unlimited in the construction of this system.

**Enrichment**

Engineering Design Teams connect their creations from the Extension activity into a larger machine, select, and prepare a location for public display of the functional object.

**Evaluation**

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
### Assessment Instrument –
**Teacher Resource 4.3.1.: Class Participation Rubric**

Name:___________________________________________________________________

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments: 

Grade:
Unit 4: Maintaining Technological Systems

Lesson 3: System Testing & Evaluation
Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work, which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations, which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and building supply companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Engineering Design Journals or blank paper
4. Safety glasses, 1 pair per student
5. 12” Rulers, 1 per student
6. Standard Mousetraps, 1 per student
7. Coping saws, 5 per class with replacement blades
8. Toy Pull back cars, 15 per class
9. Clothespins, 24 pack, 5 per class
10. Foam paintbrushes, 1 per student
11. Gift wrap tape, 1-2 rolls per group
12. Masking tape, 1”, 1 roll per group
13. School glue, 4 oz, 2 per group
14. Hot melt glue guns, 10 per class
15. Hot melt glue sticks, 50 pack
16. Paper fasteners (brads) 1 box per class
17. Balsa Wood Economy pack, 3 per class
18. Construction Paper, multi-colored pack
19. Duck brand tape, 20 yd roll, 3 per class
20. Straight plastic straws, 50 pack, 3 per class
21. Kite string 400 ft rolls, 10 per class
22. Electrical Tape, 1 roll per group
23. Scissors, 1 pair per student
24. X-Acto knives, 1 per student, with replacement blades
25. 18” X 24” self-healing cutting mats, 10 per class
26. Used File folders, 1 per student
27. Bamboo skewers, 50 pack, 3 per class
28. Marbles, bag of 40, 5 per class
29. Practice Ping pong balls, pack of 144, 1 per class
30. Toothpicks, box of 100, 5 per class
31. Balloons, pack of 50, 1 per class
32. Cyanoacrylic glue, .07 oz, 8 per class
33. Carpenter’s wood glue, 4 oz, 2 per group
34. Assorted sandpaper
35. Balsa wood easy cutters, 3 per class
36. Corrugated cardboard, Approximately 8” X 10”, 1 per student
37. Used CDs/DVDs, 2 per student
38. Optional: Lumber in length and scraps, as appropriate to the available tools and equipment

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
• Teacher Resource 4.3.1: Class Participation Rubric
• Teacher Resource 4.3.2: Graphing System Performance Answer Key
• Teacher Resource 4.3.3: End of Unit Quiz Answer Key

Student Resources
• Student Resource 4.3.1: Lesson Glossary
• Student Resource 4.3.2: Engineering Design Journal Guidelines
• Student Resource 4.3.3: Graphing System Performance
• Student Resource 4.3.4: Testing and Evaluating Everyday Objects
• Student Resource 4.3.5: Design Brief: Constructing a Controlled System
• Student Resource 4.3.6: End of Unit Quiz

Assessment Resources
• Assessment Resource 4.3.1: Engineering Design Journal Rubric
• Assessment Resource 4.3.2: Testing and Evaluating Everyday Objects Rubric
• Assessment Resource 4.3.3: Constructing a Controlled System Rubric
• Assessment Resource 4.3.4: Engineering Design Team Rubric
# Lesson 3: System Testing & Evaluation

## Teacher Resource 4.3.1.: Class Participation Rubric

Name:_________________________________________

<table>
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</tbody>
</table>

Comments:_____________________________________________________________________

Grade:  
Unit 4: Maintaining Technological Systems

Lesson 3: System Testing & Evaluation

Student Resource 4.3.6.: End of Unit Quiz

Name: ____________________________________________

Multiple Choice: Select the best response(s) from the list provided.

1. **Something that is detailed or complicated, something with many components or steps could be described as____________.**
   a. sculpture b. intricate c. origami d. accuracy

2. **An object that is designed to be _______________ has a specific use or purpose.**
   a. non-functional b. useful c. sculptural d. functional

3. **The correctness or precision of an object is referred to as ______________.**
   a. accuracy b. clarity c. preciseness d. measurement

4. **Two or three dimensional objects created by casting, welding, molding or carving material are known as___________.**
   a. origami b. assemblies c. functional objects d. sculptures

5. **An object that is intended to be visually pleasing rather than for a specific purpose is ______________.**
   a. non-functional b. useful c. sculptural d. functional

6. **Putting together components into a completed product is called ______________.**
   a. sculpture b. building c. assembly d. function

7. **A simplified drawing or sketch showing the relevant or important components is called a ______________.**
   a. diagram b. chart c. flow chart d. thumbnail sketch

8. **Keeping a system or object in good working condition is called___________.**
   a. troubleshooting b. instructions c. maintenance d. repair
9. ________ describes a gradual, detailed process, explaining a procedure that takes place in small increments.
   a. precise  b. clarity  c. intricate  d. step-by-step

10. An object that is unable to perform the function for which it is intended is ________.
    a. sculptural  b. useful  c. non-functional  d. functional

Reflective Response: Using correct grammar, punctuation and complete sentences, write a paragraph to respond to each item below.

1. In your own words, describe the role of failure in engineering design.

2. Thinking back to the projects in this unit, describe a process used by your Engineering Design Team to test and evaluate a system or component.

3. How did graphing system performance contribute to your knowledge of how the system was performing?

4. Why is testing and evaluation important?
Unit 4: Maintaining Technological Systems

Lesson 3: System Testing & Evaluation

Assessment Resource 4.3.1.: Engineering Design Journal Rubric

Name______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

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</tr>
<tr>
<td>Engage - impact of failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explore - object sketches</td>
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<td>Explain - role of failure</td>
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<td>Extend – sketches and notes for planning</td>
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<td>Extend - sign off before building</td>
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<tr>
<td>Activity 4- Sketches of diagram/demonstration</td>
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<td>Improvement in drawing skills over time</td>
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<tr>
<td>Includes notes and comments</td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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<tr>
<td>Bonus: Additional materials</td>
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<tr>
<td>Comments:</td>
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</table>

Grade:
**Unit 4: Maintaining Technological Systems**

**Lesson 3: System Testing & Evaluation**

**Assessment Resource 4.3.2.: Testing and Evaluating Everyday Objects Rubric**

Name:__________________________________________________________________

<table>
<thead>
<tr>
<th></th>
<th>List the name of the object and describe its purpose.</th>
<th>What materials make up this object?</th>
<th>Describe how this object functions – <strong>not</strong> the purpose.</th>
<th>After repeated use, how does the performance change?</th>
<th>What changes could improve the performance this object?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object #1</strong></td>
<td>Materials were listed specifically, i.e. metal spring</td>
<td>The function was described as action, not as purpose</td>
<td>Changes were described accurately</td>
<td>Improvements were suggested</td>
<td></td>
</tr>
<tr>
<td>Descriptions</td>
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<td>Complete</td>
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<td>□ Specific</td>
<td>□ Specific</td>
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<td>□ Object Name</td>
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<td>□ Specific</td>
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</tbody>
</table>

| **Object #2**        | Materials were listed specifically, i.e. metal spring | The function was described as action, not as purpose | Changes were described accurately | Improvements were suggested |
| Descriptions         | Complete                                             | Complete                           | Complete                                                 | Complete                                               |
| included:            | Accurate                                             | Accurate                           | Accurate                                                 | Specific                                               |
| □ Complete           | □ Accurate                                           | □ Specific                          | □ Specific                                              | □ Specific                                             |
| □ Purpose            |                                                      |                                    | □ Specific                                              | □ Specific                                             |
| □ Object Name        |                                                      |                                    |                                                         | □ Specific                                             |

| **Object #3**        | Materials were listed specifically, i.e. metal spring | The function was described as action, not as purpose | Changes were described accurately | Improvements were suggested |
| Descriptions         | Complete                                             | Complete                           | Complete                                                 | Complete                                               |
| included:            | Accurate                                             | Accurate                           | Accurate                                                 | Specific                                               |
| □ Complete           | □ Accurate                                           | □ Specific                          | □ Specific                                              | □ Specific                                             |
| □ Purpose            |                                                      |                                    | □ Specific                                              | □ Specific                                             |
| □ Object Name        |                                                      |                                    |                                                         | □ Specific                                             |

**Comments:**

**Grade:**
Lesson 3: System Testing & Evaluation

Assessment Resource 4.3.3.: Constructing a Controlled System

Rubric

<table>
<thead>
<tr>
<th>Task</th>
<th>4 Complete, all areas addressed</th>
<th>3 Most areas well done</th>
<th>2 Some areas well done</th>
<th>1 Minimal Effort</th>
<th>0 Not attempted, missing</th>
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<tbody>
<tr>
<td>Task 1: Lifting</td>
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<td>Task 2: Pulling</td>
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<td>Task 3: Changing Direction</td>
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<tr>
<td>Repeatability of tasks</td>
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<tr>
<td>Use of materials</td>
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<tr>
<td>Team Member materials contributions</td>
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<tr>
<td>Approval of sketches</td>
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<td>Size requirements</td>
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<td>Creativity</td>
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<tr>
<td>Teamwork</td>
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</table>

Comments:

Grade:
### Lesson 3: System Testing & Evaluation

**Assessment Resource 4.3.4.: Engineering Design Team Rubric**

<table>
<thead>
<tr>
<th>Student Name: ____________________________</th>
</tr>
</thead>
</table>

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
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<tbody>
<tr>
<td>Overall Participation</td>
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<td>Contributions to the group</td>
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<td>Focus on project</td>
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<td>Teamwork</td>
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<td>Strengths and weaknesses</td>
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<td>Special Contributions</td>
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<td>Comments</td>
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<tr>
<td>Overall Grade</td>
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</table>
Based on the descriptions provided, sketch what each of the following function’s graphs might look like:

1. A linear function that is increasing and passes through the points (-2, 0) and (0, 3)

2. A function that is nonlinear and is increasing to the left of the vertical axis, and decreasing to the right.
3. A function that is decreasing and linear, passing through the origin
4. A function that is decreasing and nonlinear. The function approaches but never crosses or intersects the vertical axis as the horizontal value approaches 0. Further, the function approaches but does not cross the horizontal axis as the horizontal value increases.
Based on the following graphs, provide a qualitative description of the function’s behavior.

5. A function that is nonlinear and is decreasing to the left of the vertical axis and increasing to the right of the vertical axis
6. A non-linear increasing function that passes through the origin

7. A linear function that is decreasing
8. A non-linear function that is increasing
Lesson 3: System Testing & Evaluation

Teacher Resource 4.3.3.: End of Unit Quiz Answer Key

Name:___________________________________________________________________

Multiple Choice: Select the best response(s) from the list provided.

1. Something that is detailed or complicated, something with many components or steps could be described as____________.
   a. sculpture  b. intricate  c. origami  d. accuracy

2. An object that is designed to be _________________ has a specific use or purpose.
   a. non-functional  b. useful  c. sculptural  d. functional

3. The correctness or precision of an object is referred to as ________________.
   a. accuracy  b. clarity  c. preciseness  d. measurement

4. Two or three dimensional objects created by casting, welding, molding or carving material are known as__________.
   a. origami  b. assemblies  c. functional objects  d. sculptures

5. An object that is intended to be visually pleasing rather than for a specific purpose is ________________.
   a. non-functional  b. useful  c. sculptural  d. functional

6. Putting together components into a completed product is called ________________.
   a. sculpture  b. building  c. assembly  d. function

7. A simplified drawing or sketch showing the relevant or important components is called a ________________.
   a. diagram  b. chart  c. flow chart  d. thumbnail sketch
8. Keeping a system or object in good working condition is called___________.
   a. troubleshooting   b. instructions   c. maintenance   d. repair

9. _______________ describes a gradual, detailed process, explaining a procedure that takes place in small increments.
   a. precise  b. clarity  c. intricate  d. step-by-step

10. An object that is unable to perform the function for which it is intended is _________________.
    a. sculptural  b. useful  c. non-functional  d. functional

Reflective Response: Using correct grammar, punctuation and complete sentences, write a paragraph to respond to each item below.

11. In your own words, describe the role of failure in engineering design.

   Student responses will vary, but should include failure as part of the testing and evaluation process, to determine strengths and weaknesses, suitability of materials and components, etc.

12. Thinking back to the projects in this unit, describe a process used by your Engineering Design Team to test and evaluate a system or component.

   Student responses will vary but should include a specific process completed with their Engineering Design Team.

13. How did graphing system performance contribute to your knowledge of how the system was performing?

   Student responses will vary but should describe a record of system performance over time as well as specific information such as temperature, RPMs, etc.

14. Why is testing and evaluation important?

   Student responses will vary but should describe the role of determining goodness of fit, responsibility of designer for safety of public, suitability of materials and components, etc.
Unit 4: Maintaining Technological Systems

Lesson 3: System Testing & Evaluation

Student Resource 4.3.1.: Lesson Glossary

Control To provide restraint, conditions, direction over the performance of the component or system

Control System A specific device or procedure intended to govern the performance of a component or system

Electrical Control A specific type of control or control system that governs the sending and receiving of electricity or electrical signals

Electronic Control A specific type of control or control system that determines the flow of electrons through a system, such as through controlling heat

Evaluation To determine the performance and value of a specific component or system

Feedback Mechanism A component within a system that provides information about the performance of the system, allowing controls to function and govern the system

Failure the inability of an object to perform as it was intended due to faults in design, materials, individual components or assembly

Graph A specific type of diagram measuring the connections between two variables or quantities within the same context or object

Mechanical Control A specific type of control or control system that addresses performance through the means of switches, pulleys, governors, or other physical devices

Model A two or three dimensional representation of a system and how it performs

Performance Ability of an object to achieve a given standard rate of work under the provided constraints

Testing Experimenting with the performance of materials, components and suitability of a design for the intended purpose
Unit 4: Maintaining Technological Systems

Lesson 3: System Testing & Evaluation

Student Resource 4.3.2.: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Based on the descriptions provided, sketch what each of the following function’s graphs might look like:

1. A linear function that is increasing and passes through the points (-2, 0) and (0, 3)
2. A function that is nonlinear and is increasing to the left of the vertical axis, and decreasing to the right.

3. A function that is decreasing and linear, passing through the origin
4. A function that is decreasing and nonlinear. The function approaches but never crosses or intersects the vertical axis as the horizontal value approaches 0. Further, the function approaches but does not cross the horizontal axis as the horizontal value increases.

Based on the following graphs, provide a qualitative description of the function’s behavior.

5. A function that is nonlinear and is decreasing to the left of the vertical axis and increasing to the right of the vertical axis
6. A non-linear increasing function that passes through the origin

7. A linear function that is decreasing
8. A non-linear function that is increasing
## Lesson 3: System Testing & Evaluation

### Student Resource 4.3.4.: Testing and Evaluating Everyday Objects

Name: ____________________________________________________________

Using the objects provided, describe their specific qualities in the chart below. Sketch each object in your Engineering Design Journal.

<table>
<thead>
<tr>
<th>List the name of the object and describe its purpose.</th>
<th>What materials make up this object?</th>
<th>Describe how this object functions – <strong>not</strong> the purpose.</th>
<th>After repeated use, how does the performance of this object change?</th>
<th>What changes could improve the performance or prolong the life of this object?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object #1:</strong></td>
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<tr>
<td><strong>Object #2:</strong></td>
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<tr>
<td><strong>Object #3</strong></td>
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</tbody>
</table>
Lesson 3: System Testing & Evaluation

Student Resource 4.3.5.: Design Brief: Constructing a Controlled System

The Problem: Your Engineering Design Team has gotten a contract to build a system that has three specific tasks to complete. Using only the materials provided by your instructor, with the addition of one object from each Team Member, your goal is to build the system and make it functional in the allotted time.

Design Constraints:
Only the specified materials are used in the construction of the object. The system must fit any size requirements provided by the instructor.

Before beginning construction, your design sketches must have instructor approval.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

What kinds of objects will be most helpful to add to the materials list? Each Team Member will need to supply one other object not already on this list.

Human values and limitations will impact the success of your design. How will your Engineering Design Team work to address these issues?

Always use appropriate safety equipment.

Materials: Each Team will receive the following:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>file folders</td>
</tr>
<tr>
<td>2</td>
<td>8X10 sheets construction paper</td>
</tr>
<tr>
<td>6</td>
<td>bamboo skewers</td>
</tr>
<tr>
<td>6</td>
<td>marbles</td>
</tr>
<tr>
<td>2</td>
<td>ping pong balls</td>
</tr>
<tr>
<td>24</td>
<td>plastic straws</td>
</tr>
<tr>
<td>16</td>
<td>toothpicks</td>
</tr>
<tr>
<td>5</td>
<td>clothespins</td>
</tr>
<tr>
<td>3</td>
<td>balloons</td>
</tr>
<tr>
<td>1</td>
<td>18X24” piece of corrugated cardboard</td>
</tr>
<tr>
<td>1</td>
<td>roll of kite string</td>
</tr>
<tr>
<td>2</td>
<td>CDs (or other wheels as provided)</td>
</tr>
</tbody>
</table>

Tape, glue or other fasteners are limited at the discretion of the instructor.

Each Team Member will need to supply one other object not already on this list.

System Goals:
The object must perform these three tasks: lifting, pulling and changing direction in order to be successful. How these tasks are accomplished is up to your Engineering Design Team.

Assessment: The completed system is assessed on the successful completion of the three specified tasks, the ability to repeat those tasks and the creativity of the design.
Unit 4: Maintaining Technological Systems

Lesson 3: System Testing & Evaluation

Student Resource 4.3.6.: End of Unit Quiz

Name:__________________________________

Multiple Choice: Select the best response(s) from the list provided.

15. Something that is detailed or complicated, something with many components or steps could be described as___________.
   a. sculpture     b. intricate     c. origami     d. accuracy

16. An object that is designed to be ____________ has a specific use or purpose.
   a. non-functional  b. useful  c. sculptural  d. functional

17. The correctness or precision of an object is referred to as _____________.
   a. accuracy       b. clarity    c. preciseness  d. measurement

18. Two or three dimensional objects created by casting, welding, molding or carving material are known as___________.
   a. origami     b. assemblies  c. functional objects  d. sculptures

19. An object that is intended to be visually pleasing rather than for a specific purpose is _________________.
   a. non-functional  b. useful  c. sculptural  d. functional

20. Putting together components into a completed product is called _____________.
   a. sculpture     b. building     c. assembly  d. function

21. A simplified drawing or sketch showing the relevant or important components is called a _____________.
   a. diagram       b. chart        c. flow chart  d. thumbnail sketch

22. Keeping a system or object in good working condition is called___________.

23. ______________ describes a gradual, detailed process, explaining a procedure that takes place in small increments.

a. precise  b. clarity  c. intricate  d. step-by-step

24. An object that is unable to perform the function for which it is intended is ____________.

a. sculptural  b. useful  c. non-functional  d. functional

Reflective Response: Using correct grammar, punctuation and complete sentences, write a paragraph to respond to each item below.

25. In your own words, describe the role of failure in engineering design.

26. Thinking back to the projects in this unit, describe a process used by your Engineering Design Team to test and evaluate a system or component.

27. How did graphing system performance contribute to your knowledge of how the system was performing?

28. Why is testing and evaluation important?
Lesson 3: System Testing & Evaluation

Assessment Resource 4.3.1.: Engineering Design Journal Rubric

Name_____________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

4. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

5. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

6. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
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<td>Most areas well done</td>
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<td>Engage - impact of failure</td>
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<td>Extend - sign off before building</td>
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<td>Activity 4- Sketches of diagram/demonstration</td>
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<td>Improvement in drawing skills over time</td>
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<td>Includes notes and comments</td>
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<td>Ability to understand and interpret images, notes and sketches</td>
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<td>Bonus: Additional materials</td>
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Grade:
### Unit 4: Maintaining Technological Systems

**Lesson 3: System Testing & Evaluation**

**Assessment Resource 4.3.2.: Testing and Evaluating Everyday Objects Rubric**

Name: ___________________________________________

<table>
<thead>
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<th>Object #1 Descriptions were/included:</th>
<th>Object #2 Descriptions were/included:</th>
<th>Object #3 Descriptions were/included:</th>
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</table>

<table>
<thead>
<tr>
<th>List the name of the object and describe its purpose.</th>
<th>What materials make up this object?</th>
<th>Describe how this object functions – <strong>not</strong> the purpose.</th>
<th>After repeated use, how does the performance change?</th>
<th>What changes could improve the performance this object?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials were listed specifically, i.e. metal spring</td>
<td>The function was described as action, not as purpose</td>
<td>Changes were described accurately</td>
<td>Improvements were suggested</td>
<td></td>
</tr>
<tr>
<td>☐ Complete</td>
<td>☐ Complete</td>
<td>☐ Complete</td>
<td>☐ Complete</td>
<td></td>
</tr>
<tr>
<td>☐ Accurate</td>
<td>☐ Accurate</td>
<td>☐ Accurate</td>
<td>☐ Accurate</td>
<td></td>
</tr>
<tr>
<td>☐ Specific</td>
<td>☐ Specific</td>
<td>☐ Specific</td>
<td>☐ Specific</td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**

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## Lesson 3: System Testing & Evaluation

**Assessment Resource 4.3.3.: Constructing a Controlled System Rubric**

<table>
<thead>
<tr>
<th></th>
<th>Complete, all areas addressed</th>
<th>Most areas well done</th>
<th>Some areas well done</th>
<th>Minimal Effort</th>
<th>Not attempted, missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1: Lifting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 2: Pulling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 3: Changing Direction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeatability of tasks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team Member materials contributions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approval of sketches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creativity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Grade:
### Assessment Resource 4.3.4.: Engineering Design Team Rubric

**Student Name: _________________________________**

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributions to the group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus on project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengths and weaknesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Contributions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unit #5: Technological Systems in the Designed World

Overview

This course will investigate technological systems through their function, design, development, interaction and maintenance. Systems included in this exploration include communications, construction, manufacturing, bio-medical and power energy.

Big Idea
A variety of different technological tools, processes and materials can be integrated to form systems.

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

Purpose of the Unit

Unit 5 prepares students to address specific challenges within different types of technical systems. Systems included in this exploration include communications, construction, manufacturing, bio-medical and power energy.
## Standards/Benchmarks


<table>
<thead>
<tr>
<th>STL 14I</th>
<th>The vaccines developed for use in immunization require specialized technologies to support environments in which sufficient amounts of vaccines are produced.</th>
</tr>
</thead>
<tbody>
<tr>
<td>14J</td>
<td>Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.</td>
</tr>
<tr>
<td>15G</td>
<td>A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.</td>
</tr>
<tr>
<td>16F</td>
<td>Energy can be used to do work, using many processes.</td>
</tr>
<tr>
<td>16H</td>
<td>Power systems are used to drive and provide propulsion to other technological products and systems.</td>
</tr>
<tr>
<td>17H</td>
<td>Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.</td>
</tr>
<tr>
<td>17I</td>
<td>Communication systems are made up of a source, encoder, transmitter, receiver, decoder and destination.</td>
</tr>
<tr>
<td>19H</td>
<td>The manufacturing process includes the designing, development, making and servicing of products and systems.</td>
</tr>
<tr>
<td>20G</td>
<td>Structures rest on a foundation.</td>
</tr>
<tr>
<td>20H</td>
<td>Some structures are temporary, while others are permanent.</td>
</tr>
<tr>
<td>20I</td>
<td>Buildings generally contain a variety of subsystems.</td>
</tr>
</tbody>
</table>

### Mathematics: Common Core Standards for Mathematics (CCSM, 2011)

#### The Number System Standard (Grade 7)

| 7.NS | Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers. |

#### Statistics and Probability Standard (Grade 8)

| 8.SP | Investigate patterns of association in bivariate data.                                                                           |

#### Geometry Standard (Grade 6)

### English Language Arts: Common Core Standards for English Language Arts (CCSELA, 2011)

#### Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)

- **RST.6-8.1.** Cite specific textual evidence to support analysis of science and technical texts.
- **RST.6-8.3.** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

#### Integration of Knowledge and Ideas (Literacy in Science and Technical Subjects, Grades 6-12)

- **RST.6-8.7.** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- **RST.6-8.8.** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
- **RST.6-8.9.** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

### Science: Benchmarks for Science Literacy (AAAS, 1993/2009)

#### The Human Organism

- **6A/M6** Technologies having to do with food production, sanitation, and health care have dramatically changed how people live and work and have resulted in rapid increases in the human population.

#### The Nature of Science

- **1C/M1** Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.

#### The Designed World

- **8A/M2** People control some characteristics of plants and animals they raise by selective breeding and by preserving varieties of seeds (old and new) to use if growing conditions change.

#### The Physical Setting

- **4E/M4** Energy appears in different forms and can be transformed within a system. Motion energy is associated with the speed of an object. Thermal energy is associated with the temperature of an object. Gravitational energy is associated with the height of an object above a reference point. Elastic energy is associated with the stretching or compressing of an elastic object. Chemical energy is associated with the composition of a substance. Electrical energy is associated with an electric current in a circuit. Light energy is associated with the frequency of electromagnetic waves.

#### The Designed World

- **8B/M2** Manufacturing usually involves a series of steps, such as designing a product, obtaining and preparing raw materials, processing the materials mechanically or chemically, and assembling the product. All steps may occur at a single location or may occur at different locations.

#### Common Themes

- **11A/M3** Any system is usually connected to other systems, both internally and externally.

---

1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Thus a system may be thought of as containing subsystems and as being a sub-system of a larger system.

Unit Objectives

Lesson 1: Power and Energy Systems
Students learn to:
- Understand work, energy, and related terms
- Identify examples of energy used to do work
- Evaluate systems with the specific purpose of driving or propelling

Student Assessment
- Engineering Design Journal
- Presentation
- Survey research project
- Performance Rubrics
- End of unit quiz

Lesson 2: Communication Systems
Students learn to:
- Apply and demonstrate the transfer of information through different communication systems
- Differentiate between human to human, human to machine and machine to human communication
- Identify the components of a communication system including: source, encoder, transmitter, receiver, decoder and destination
- Develop a simple communication system with all necessary components

Student Assessment
- Engineering Design Journal
- Constructed Response items
- Research project
- End of lesson quiz
- End of unit quiz

Lesson 3: Constructing Specialized Manufacturing Environments
Students learn to:
- Identify a structure and its subsystems
- Design a structure and its subsystems
- Differentiate between temporary and permanent structures
- Design a structure resting on a foundation
- Apply the manufacturing process, including: design, development, production and service
- Distinguish between processes and materials used in different manufacturing processes
- Understand practices used to improve production of food, fuel, fiber, in the care of animals and in other products.
- Understand and explain specific requirements for production environments
- Identify the processes involved in the production of vaccines
• Identify basic genetic structure and how it deviates in genetically engineered gene combinations

**Student Assessment**
- Engineering Design Journal
- Constructed Response items
- Performance Rubrics
- End of unit quiz
Lesson 1: Power and Energy Systems

Lesson Snapshot

**Overview**

**Big Idea:** Energy is needed to do work of any kind, by human, machine, system or other means.

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

*Teacher’s Suggestion:* For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

**Purpose of Lesson:** This lesson enables students to learn that Energy is the ability to do work, and work is the application of force over a distance.

**Lesson Duration:** 5 hours, plus 2 enrichment hours.

**Activity Highlights**

**Engagement**

Using everyday objects and online resources, students will locate examples of each type of simple machine and describe how they use energy to do work.

**Exploration**

Using multi-media and print resources, students will research a variety of flying vehicles to determine a brief history and the suitability of each to the Extension Challenge.

**Explanation**

Using prior knowledge of simple machines, students will develop a survey to administer to other students on their knowledge of simple machines and propulsion, and present results.

**Extension**

Working in Engineering Design Teams, students will build and test three different types of flying vehicles to determine the efficiency of different propulsion systems and materials.

**Enrichment**

Using knowledge gained through previous activities, students will develop a propulsion system for a vehicle that is capable of both flight and surface transportation.

**Evaluation**

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Presentations, Survey research project, Performance Rubrics, and an End of unit quiz.

**Lesson 1: Power and Energy Systems**

Students learn to:

- Understand work, energy, and related terms
- Identify examples of energy used to do work
- Evaluate systems with the specific purpose of driving or propelling
Lesson 1: Power and Energy Systems

Lesson Overview

Lesson Duration
5 hours, plus 2 enrichment hours.

Standards/Benchmarks

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

<table>
<thead>
<tr>
<th>STL 16F</th>
<th>Energy can be used to do work, using many processes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16H</td>
<td>Power systems are used to drive and provide propulsion to other technological products and systems.</td>
</tr>
</tbody>
</table>

**Mathematics:** Common Core Standards for Mathematics *(CCSM, 2011)*

**Statistics and Probability Standard (Grade 8)**

- 8.SP Investigate patterns of association in bivariate data.

**English Language Arts:** Common Core Standards for English Language Arts *(CCSELA, 2011)*

**Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)**

- RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

**Science:** Benchmarks for Science Literacy *(AAAS, 1993/2009)*

**The Physical Setting**

- 4E/M4 Energy appears in different forms and can be transformed within a system. Motion energy is associated with the speed of an object. Thermal energy is associated with the temperature of an object. Gravitational energy is associated with the height of an object above a reference point. Elastic energy is associated with the stretching or compressing of an elastic object. Chemical energy is associated with the composition of a substance. Electrical energy is associated with an electric current in a circuit. Light energy is associated with the frequency of electromagnetic waves.

---

1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Learning Objectives
Students learn to:
1. Understand work, energy, and related terms.
2. Identify examples of energy used to do work.
3. Evaluate systems with the specific purpose of driving or propelling.
4. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
5. Work safely and accurately with a variety of tools, machines, and materials.
6. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials

Print Materials

Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. Propulsion
   b. Propulsion systems for kids
   c. Drive systems
   d. Pulley Systems
   e. Gear ratios
   f. Classes of levers
3. NWUAV, Northwest Unmanned Aerial Vehicles Propulsion Systems, Retrieved on 04/30/12 from http://www.nwuav.com/index.html (permission to link requested)
4. Squidoo, Rocket Science for Kids, Retrieved on 04/30/12 from http://www.squidoo.com/RocketScience4Kids (permission to link requested)
7. Society of Women Engineers, Mechanical Engineering - Pulleys, Retrieved on 04/30/12 from http://www.swe.org/lac/lp/pulley_03.html (permission to link requested)
8. Integrated Publishing, Classes of Levers, Retrieved on 04/30/12 from http://www.tpub.com/machines/1a.htm (permission to link requested)

**Required Knowledge and/or Skills**

Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. They should be able to enter information into a spreadsheet application and produce a graph using bivariate data.
Lesson 1: Power and Energy Systems

5-E Lesson Plan

Teacher’s Note: Locate an appropriate space for the flight-testing day of the extension activity, keeping safety and weather concerns in mind. Provide worksheets and materials to students prior to beginning projects to ensure understanding of learning goals.

Engagement

Using everyday objects and online resources, students will locate examples of each type of simple machine and describe how they use energy to do work.

- With the lesson glossary as a resource, students work in Engineering Design Teams to locate examples of each type of simple machine.
- Using Student Resource 5.1.3, students will locate an image of the simple machine in use and explain how energy is used to do work in that machine.
- Completion of the documentation may take place through electronic images or video, printed images, or by sketching in Engineering Design Journals.
- If a computer lab is unavailable, students may complete the project using everyday objects rather than online resources.

Exploration

Using multi-media and print resources, students will research a variety of flying vehicles to determine a brief history and the suitability of each to the Extension Challenge.

- With the Extension project rubric Assessment Resource 5.1.5 as a reference, Engineering Design Teams research historic flying vehicles to select three for use in the Extension project.
- Notes, references and sketches for each are completed in individual Engineering Design Journals.

Explanation

The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- Working in Engineering Design Teams, using prior knowledge of simple machines, students will develop a survey to administer to other students on their knowledge of simple machines and propulsion.
- Results are documented in a spreadsheet and graph format.
- Results are presented in class, documenting the survey instrument, the procedure and results in verbal and graphic formats.

Extension

Working in Engineering Design Teams, students will build and test three different types of flying vehicles to determine the efficiency of different propulsion systems and materials.
• Using the information collected in the Exploration activity, Engineering design teams will build functional models of three different flying machines
• Each machine may have a different type of propulsion and include a variety of materials
• Notes, sketches and materials are documented in the Engineering Design Journal
• A flight day will provide all students the opportunity to observe and evaluate the propulsion systems, materials and models selected.

**Enrichment**

Using knowledge gained through previous activities, students will develop a propulsion system for a vehicle that is capable of both flight and surface transportation.

**Evaluation**

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Presentations, Survey research projects, Performance Rubrics, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
### Teacher Resource 5.1.1: Class Participation Rubric

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

Comments:

Grade:
Assessment Resource 5.1.1: Engineering Design Journal Rubric

Name______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

Assessment:

<table>
<thead>
<tr>
<th>Assessment</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete All areas addressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most areas well done</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some areas well done</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Minimal effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not attempted, missing</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Engage - documentation of simple machine research

Explore- flying vehicles research notes and sketches

Extend – evidence of planning for 3 models

Extend - evidence of testing of 3 models

Improvement in drawing skills over time

Includes notes and comments

Ability to understand and interpret images, notes and sketches

Bonus: Additional materials

Total

Comments:

Grade:
## Assessment Resource 5.1.2: Flying Vehicles Research Project Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussed materials needed to build working model</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Accurately described the propulsion system of the selected vehicle</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Researched a variety of vehicles before selecting models to build</td>
<td>Minimally addressed vehicle types and chose first located</td>
<td>Some evidence of research on a variety of vehicles</td>
<td>Evidence of thorough research on a variety of vehicles</td>
</tr>
<tr>
<td>Thorough documentation of research with visual and textual information</td>
<td>Minimally addressed, missing major information or visuals needed to construct models</td>
<td>Somewhat addressed, missing some information or visuals needed to construct models</td>
<td>Thoroughly addressed, provides text and visual information needed to build all selected models</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td>Ability to apply information gained in class to prior knowledge</td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
## Assessment Resource 5.1.3: Survey Research Project Rubric

**Engineering Design Team Members**

<table>
<thead>
<tr>
<th>Assessment Criteria</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete All areas addressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey instrument was appropriate for planned administration</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Survey instrument was easy to read, legible</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Student completed the assigned number of surveys</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Purpose of the survey was explained on the survey form</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A participant list was collected for all survey participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Items were as short as possible, addressed only one idea, used clear wording</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>The scale was appropriate to the items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey had 10 or fewer items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
<td></td>
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<tr>
<td>Addressed all relevant information</td>
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<tr>
<td>Personalized presentation through individualized information</td>
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<tr>
<td>Participation – active in the presentation, not just reading</td>
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<tr>
<td>Total</td>
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<tr>
<td>Comments:</td>
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</tbody>
</table>

Grade:
### Assessment Resource 5.1.4: Engineering Design Team Rubric

**Student Name: ________________________________**

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall Participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Contributions to the group</td>
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<tr>
<td></td>
<td>Focus on project</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Teamwork</td>
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<td></td>
<td>Strengths and weaknesses</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Special Contributions</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Comments</td>
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<tr>
<td></td>
<td>Overall Grade</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
**Unit 5: Technological Systems in the Designed World**

**Lesson 1: Power and Energy Systems**

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall Participation</td>
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<tr>
<td></td>
<td>Contributions to the group</td>
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<tr>
<td></td>
<td>Focus on project</td>
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<td>Teamwork</td>
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<td>Strengths and weaknesses</td>
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<td></td>
<td>Special Contributions</td>
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<td>Comments</td>
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<td></td>
<td>Overall Grade</td>
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</tr>
</tbody>
</table>
## Assessment Resource 5.1.5: Materials and Propulsion Systems for Flight Rubric

**Names:** ____________________________________________________________

<table>
<thead>
<tr>
<th>Describe the object and its history</th>
<th>The propulsion system was described, and included any changes</th>
<th>A Bill of Materials was provided</th>
<th>Vehicle was able to be tested</th>
<th>Design Constraints were followed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle #1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Complete</td>
<td>□ Complete</td>
<td>□ Complete</td>
<td>□ Complete</td>
<td>□ Materials</td>
</tr>
<tr>
<td>□ Accurate</td>
<td>□ Accurate</td>
<td>□ Accurate</td>
<td>□ Accurate</td>
<td>□ Time</td>
</tr>
<tr>
<td>□ Purpose</td>
<td>□ Specific</td>
<td>□ Specific</td>
<td>□ Able to fly</td>
<td>□ Size</td>
</tr>
<tr>
<td>□ Object Name</td>
<td></td>
<td>□ Prior to building</td>
<td></td>
<td>□ Propulsion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>□ Other</td>
</tr>
</tbody>
</table>

| **Vehicle #2**                     |                                                             |                                 |                                |                                 |
| □ Complete                         | □ Complete                                                  | □ Complete                      | □ Complete                     | □ Materials                     |
| □ Accurate                         | □ Accurate                                                  | □ Accurate                      | □ Accurate                     | □ Time                          |
| □ Purpose                          | □ Specific                                                  | □ Specific                      | □ Able to fly                   | □ Size                          |
| □ Object Name                      |                                                             | □ Prior to building             |                                | □ Propulsion                     |
|                                   |                                                             |                                 |                                | □ Other                          |

| **Vehicle #3**                     |                                                             |                                 |                                |                                 |
| □ Complete                         | □ Complete                                                  | □ Complete                      | □ Complete                     | □ Materials                     |
| □ Accurate                         | □ Accurate                                                  | □ Accurate                      | □ Accurate                     | □ Time                          |
| □ Purpose                          | □ Specific                                                  | □ Specific                      | □ Able to fly                   | □ Size                          |
| □ Object Name                      |                                                             | □ Prior to building             |                                | □ Propulsion                     |
|                                   |                                                             |                                 |                                | □ Other                          |

**Comments:**

**Grade:**
Lesson 1: Power and Energy Systems

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work, which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations, which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and building supply companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Spreadsheet software
4. Access to library resources
5. Engineering Design Journals or blank paper
6. Safety glasses, 1 pair per student
7. 12” Rulers, 1 per student
8. Scissors, 1 pair per student
9. Tissue paper, pack of 20 sheets, 5 per class
10. Twine, 100 yd roll, 1 per class
11. Assorted sandpaper
12. Balsa Wood Easy cutters, 3 per class
13. Rubber bands, bag of 100 assorted, 2 per class
14. Used file folders, 2 per student
15. Construction paper, multi-colored pack
16. Corrugated cardboard, Approx. 8” X 10”, 2 per student
17. Foam insulation, ½” X 24” X 48”, 5 sheets per class
18. Plastic grocery bags, 1 per student
19. Balsa wood Economy Bag, 5 per class
20. Gift wrap tape, 1-2 rolls per group
21. Masking tape, 1”, 1 roll per group
22. School Glue, 4 oz, 2 per group
23. X-Acto knives, 1 per student and replacement blades
24. 18” X 24” Self-healing cutting matts, 10 per class
25. Hot melt glue guns, 10 per class
26. Hot melt glue sticks, 50 pack, 1 per class
27. Paper fasteners (brads) 1 box per class
28. Duck brand tape, 2 yd roll, 3 per class
29. Electrical Tape, 1 roll per group
30. Cyanoacrylic glue, .07 oz, 8 per class
31. Carpenter’s wood glue, 4 oz, 10 per class
32. Empty plastic containers, 1 per student
33. Coping saws, 5 per class, with replacement blades
34. Electric Styrofoam cutters, 2 per class
35. Foam core board, 18” X 24”, 100 per class
36. Monofilament, 6lb test, 900 yds, 1 per class
37. Balloons, 9” latex, pack of 50, 1 per class
38. CO₂ cartridges, 30 per class
39. Optional: Styrofoam sheets or packaging
40. Optional: Rocket launchers for water rockets, 3 per class

Enrichment Activity Materials
1. Safety glasses, 1 pair per student
2. GT-RX Wheels, 100 pack, 1 per class
3. Bamboo skewers, 50 pack, 3 per class
4. Latex hose, 10 ft sections, 2 per class
5. Assorted sandpaper
6. Lumber scraps appropriate to equipment, 25+
7. Corrugated cardboard, Approx. 8” X 10”, 2 per student
8. Used file folders, 1 per student

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
• Teacher Resource 5.1.1: Class Participation Rubric
• Teacher Resource 5.1.2: Simple Machines in Everyday Objects Answer Key

Student Resources
• Student Resource 5.1.1: Unit PowerPoint
• Student Resource 5.1.2: Lesson Glossary
• Student Resource 5.1.3: Engineering Design Journal Guidelines
• Student Resource 5.1.4: Simple Machines in Everyday Objects
• Student Resource 5.1.5: Flying Vehicles Research Project
• Student Resource 5.1.6: Survey Research Project
• Student Resource 5.1.7: Survey Research Project Guidelines
• Student Resource 5.1.8: Design Brief: Materials and Propulsion Systems for Flight
Assessment Resources

- Assessment Resource 5.1.1: Engineering Design Journal Rubric
- Assessment Resource 5.1.2: Flying Vehicles Research Project Rubric
- Assessment Resource 5.1.3: Survey Research Project Rubric
- Assessment Resource 5.1.4: Engineering Design Team Rubric
- Assessment Resource 5.1.5: Materials and Propulsion Systems for Flight Rubric
### Unit 5: Technological Systems in the Designed World

**Lesson 1: Power and Energy Systems**

**Teacher Resource 5.1.1: Class Participation Rubric**

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
**Unit 5: Technological Systems in the Designed World**

**Lesson 1: Power and Energy Systems**

**Teacher Resource 5.1.2: Simple Machines in Everyday Objects Answer Key**

Using print or online resources, locate 3 different real-life examples with images of each of the six simple machines. Copy and paste the images or sketch them in your Engineering Design Journal. Explain how each simple machine works. Cite the web address or print location of each of your findings. Each section should include at least 1 picture or sketch, an explanation of each machine and a citation of the location of the image.

<table>
<thead>
<tr>
<th>1. Pulley</th>
<th>2. Lever</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulley</strong> a type of simple machine that incorporates a rimmed wheel which holds a line and can turn within a frame to change the direction of a force</td>
<td><strong>Lever</strong> A simple machine comprised of a bar with a pivot around a point. At point A, a force is applied, using the pivot at B to provide force at point C.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Wheel and Axle</th>
<th>4. Inclined Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wheel and Axle</strong> A wheel with a central rod or axle that turns, allowing the wheel to turn</td>
<td><strong>Inclined Plane</strong> A type of simple machine used to change the height of an object by rolling or sliding, as in a ramp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Wedge</th>
<th>6. Screw</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wedge</strong> A simple machine similar to the inclined plane, but intended to push objects apart</td>
<td><strong>Screw</strong> A simple machine that incorporates an inclined plane wrapped around a central pole</td>
</tr>
</tbody>
</table>

**Bonus: Airfoil**

<table>
<thead>
<tr>
<th>Bonus: Airfoil</th>
<th>Bonus: Describe the 3 lever types</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Foil</strong> A surface designed to contribute to the control of an object in flight</td>
<td><strong>First class lever</strong> A lever with a pivot point (fulcrum) in the middle, between the input and output forces</td>
</tr>
<tr>
<td></td>
<td><strong>Second Class Lever</strong> A lever that has the output force or load between the fulcrum and input force</td>
</tr>
<tr>
<td></td>
<td><strong>Third class lever</strong> A lever that has the input force between the output force and the fulcrum.</td>
</tr>
</tbody>
</table>
Unit 5: Technological Systems in the Designed World

Lesson 1: Power and Energy Systems

Student Resource 5.1.2: Lesson Glossary

Air Foil A surface designed to contribute to the control of an object in flight

Application Putting an object, system or procedure into use or practice

Chemical energy is associated with the composition of a substance.

Distance a measurement between two objects or points, in any direction, including three-dimensional space

Driving a force that pushes or propels an object, component or system

Elastic energy is associated with the stretching or compressing of an elastic object.

Electrical energy is associated with an electric current in a circuit.

Energy the ability to do work

First class lever A lever with a pivot point (fulcrum) in the middle, between the input and output forces

Force A type of exertion on an object or system due to the interaction with another object, system or human

Fulcrum the pivot point of a lever

Gravitational energy is associated with the height of an object above a reference point.

Inclined Plane A type of simple machine used to change the height of an object by rolling or sliding, as in a ramp

Lever A simple machine comprised of a bar with a pivot around a point. At point A, a force is applied, using the pivot at B to provide force at point C.

Light energy is associated with the frequency of electromagnetic waves.

Motion energy is associated with the speed of an object.

Power Systems A system of components used to complete a specific rate of work in a given time

Power The rate of work done over time, \( P = \frac{W}{t} \) with \( P \) = power, \( W \) = work and \( t \) = time. An example of power is mph - miles per hour, the amount of power needed to travel a certain number of miles in an hour.

Propulsion a force that moves an object forward
**Pulley** a type of simple machine that incorporates a rimmed wheel which holds a line and can turn within a frame to change the direction of a force

**Rate** A speed or pace, as compared to the overall total

**Screw** A simple machine that incorporates an inclined plane wrapped around a central pole

**Second Class Lever** A lever that has the output force or load between the fulcrum and input force

**Thermal energy** is associated with the temperature of an object.

**Third class lever** A lever that has the input force between the output force and the fulcrum.

**Wedge** A simple machine similar to the inclined plane, but intended to push objects apart

**Wheel and Axle** A wheel with a central rod or axle that turns, allowing the wheel to turn

**Work** Activity completed in order to achieve a specific purpose or result
Unit 5: Technological Systems in the Designed World

Lesson 1: Power and Energy Systems

Student Resource 5.1.3: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
### Student Resource 5.1.4: Simple Machines in Everyday Objects

**Name:**

Using print or online resources, locate 3 different real-life examples with images of each of the six simple machines. Copy and paste the images or sketch them in your Engineering Design Journal. Explain how each simple machine works. Cite the web address or print location of each of your findings.

<table>
<thead>
<tr>
<th>Simple Machine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pulley</td>
<td></td>
</tr>
<tr>
<td>2. Lever</td>
<td></td>
</tr>
<tr>
<td>3. Wheel and Axle</td>
<td></td>
</tr>
<tr>
<td>4. Inclined Plane</td>
<td></td>
</tr>
<tr>
<td>5. Wedge</td>
<td></td>
</tr>
<tr>
<td>6. Screw</td>
<td></td>
</tr>
<tr>
<td>Bonus: Airfoil</td>
<td></td>
</tr>
<tr>
<td>Bonus: Describe the 3 lever types</td>
<td></td>
</tr>
</tbody>
</table>
Historically, there have been many different attempts at manned flight, some of them successful, some needing a few more trips to the drawing board.

For your assignment, your Engineering Design Team will research a variety of vehicles, propulsion systems and materials in order to select three vehicles.

For your three selected vehicles, you will need enough information to build a working model, which is capable of some kind of air travel.

**Considerations:** Due to time, space and size constraints, you will not be able to build a full-sized working model of a human-powered vehicle. If you choose this type of vehicle, you will have to generate another propulsion system.

**How does the propulsion system operate?** Is there enough information to be able to build your model accurately?

**What types of materials are available?** While it is highly unlikely that you will have access to a facility that builds aircraft, there are other materials that can simulate the weight ratio or appearance of the materials that would have been used to build the original vehicle, and certainly improvements over materials used in the early days of flight.

**What kinds of vehicles can you build?** Think beyond standard airplanes and gliders. What about helicopters, rockets, and space shuttles, or lighter-than-air vehicles such as hot air balloons and blimps?

**Document your research:** In your Engineering Design Journal, document the vehicles that you study and look for as much information as possible to help you modify and build them.
Unit 5: Technological Systems in the Designed World

Lesson 1: Power and Energy Systems

Student Resource 5.1.6: Survey Research Project

In order to develop an understanding of general knowledge about simple machines and propulsion, your Engineering Design Team will develop and conduct a survey. (See Student Resource 5.1.6: Survey Research Project Guidelines for help in writing the items and conducting the survey.)

What to ask: The survey that you design should measure the following kinds of information:

What do your participants know about simple machines?

Can your participants name them, and describe how they work?

Do your participants know what propulsion is?

Can your participants recognize propulsion in a system?

These items are examples, but should give you some idea about the kinds of questions to ask.

Sharing your results: When you have collected your survey information, you will be recording the information and your team will present it to the class.

In your presentation, you will need to describe your population (the entire group that could be asked to complete the survey, i.e. all 8th grade students), how participants from the population were selected, and how the survey was given (paper and pencil, interview, online, etc.)

The results collected will be entered on a chart and displayed for the class to determine how participants within your population compare to each other on their responses.
Student Resource 5.1.7: Survey Research Project Guidelines

Purpose: The purpose of the research project is to complete a survey to better understand how your friends and families will react to the positive and negative ads that were created by your Engineering Design Team.

With your teacher, as a class, you will decide if you are trying to reach a specific population, such as 8th graders in your school, people who live in your community or just people that you know. The class will also need to decide the number of surveys that each student will need to complete.

Consent: Professional researchers need to obtain permission from each person who is participating in a research study to use their responses prior to beginning the study. Since you will not be trying to publish your results in a journal or magazine, you do not have to formally obtain this permission, but it is a good idea to explain the purpose of the survey to your participants prior to asking them any questions.

Format: As a class, you will need to decide if you are going to use an interview style survey, where you will read the items to participants and record their answers, or if they will fill out a paper form of some kind. You may also have the option of administering the survey through e-mail or other social media, depending on availability.

Generating Items: Here are a few guidelines on generating survey items:

- They should be as short as possible.
- Make sure that you are only asking about one thing in each item.
- They should use clear wording, avoiding special terminology.
- They should be simple to complete.

Scale: The scale is the way that the participants can respond and how those responses are recorded or categorized. Will you use a two-point scale, such as yes or no, a three point scale, such as yes, no and don't know? It is recommended that you select the same type of scale for all questions, or break different scale types into sections.

Other considerations: In addition to the explanation about the survey, you should tell your participants how the data is being used.

The length of the completed survey instrument should be 10 or fewer items in order to maximize the response rate.

Names of respondents can be listed to ensure that the same person is not completing the survey multiple times, but the names should not be listed on the completed survey forms to protect the identity of the person completing the survey.

Remember to thank your participants for their time.
Unit 5: Technological Systems in the Designed World

Lesson 1: Power and Energy Systems

Student Resource 5.1.8: Design Brief: Materials and Propulsion Systems for Flight

The Problem: In previous activities in this lesson, your Engineering Design Team researched a variety of vehicles for manned flight, gathering visual and textual information on multiple vehicles. Using the information that you gained through your research, you will construct working models of a total of three different flying vehicles.

Design Constraints: The instructor, as needed, will determine size, time and other design constraints, such as a limit on materials.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

Human values and limitations will impact the success of your design. How will your Engineering Design Team work to address these issues?

Always use appropriate safety equipment.

Available Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, tissue paper, twine, assorted sandpaper, Balsa Wood Easy Cutter, rubber bands, construction paper, foam insulation, plastic grocery bags, duck brand tape, electrical tape, cyanoacrylic glue, carpenter’s wood glue, empty plastic containers, electric Styrofoam cutters, foam core board, monofilament, balloons, CO2 cartridges, Rocket launchers for water rockets, hot melt glue guns and sticks, X-Acto knives, coping saws, scissors, rulers, corrugated cardboard, file folders, Styrofoam or packing materials, and Balsa Wood. Other materials may be used - consult your teacher.

Once your team has selected the three vehicles to construct, consult your instructor prior to building, with a general Bill of Materials.

Documentation: Document construction and testing of each model, as well as changes from original designs and adaptations of propulsion systems.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation.

Final Testing and Demonstration: A final flight day will allow each engineering Design Team to demonstrate their models and explain the motivation, history, material selection and propulsion for each.

Assessment: Each member of the Team will complete the Engineering Design Team rubric, documenting the performance of each member of the team.
Lesson 1: Power and Energy Systems

Assessment Resource 5.1.1: Engineering Design Journal Rubric

Name____________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

4. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

5. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

6. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage - documentation of simple machine research</td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Explore- flying vehicles research notes and sketches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extend – evidence of planning for 3 models</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extend - evidence of testing of 3 models</td>
<td></td>
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</tr>
<tr>
<td>Improvement in drawing skills over time</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Includes notes and comments</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Bonus: Additional materials</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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</tr>
</tbody>
</table>

Comments:

Grade:
## Lesson 1: Power and Energy Systems

### Assessment Resource 5.1.2: Flying Vehicles Research Project Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussed materials needed to build working model</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Accurately described the propulsion system of the selected vehicle</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Researched a variety of vehicles before selecting models to build</td>
<td>Minimally addressed vehicle types and chose first located</td>
<td>Some evidence of research on a variety of vehicles</td>
<td>Evidence of thorough research on a variety of vehicles</td>
</tr>
<tr>
<td>Thorough documentation of research with visual and textual information</td>
<td>Minimally addressed, missing major information or visuals needed to construct models</td>
<td>Somewhat addressed, missing some information or visuals needed to construct models</td>
<td>Thoroughly addressed, provides text and visual information needed to build all selected models</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td>Ability to apply information gained in class to prior knowledge</td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
### Assessment Resource 5.1.3: Survey Research Project Rubric

#### Engineering Design Team Members

<table>
<thead>
<tr>
<th>Assessment Criteria</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey instrument was appropriate for planned administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey instrument was easy to read, legible</td>
<td></td>
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</tr>
<tr>
<td>Student completed the assigned number of surveys</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Purpose of the survey was explained on the survey form</td>
<td></td>
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</tr>
<tr>
<td>A participant list was collected for all survey participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Items were as short as possible, addressed only one idea, used clear wording</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>The scale was appropriate to the items</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Survey had 10 or fewer items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocal presentation - clear, relevant, answered questions</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Addressed all relevant information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personalized presentation through individualized information</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Participation – active in the presentation, not just reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Grade:
**Unit 5: Technological Systems in the Designed World**

**Lesson 1: Power and Energy Systems**

**Assessment Resource 5.1.4: Engineering Design Team Rubric**

Student Name: ____________________________________________

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
</tr>
</thead>
<tbody>
<tr>
<td>______</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Overall Participation

Contributions to the group

Focus on project

Teamwork

Strengths and weaknesses

Special Contributions

Comments

Overall Grade
### Lesson 1: Power and Energy Systems

#### Assessment Resource 5.1.5: Materials and Propulsion Systems for Flight Rubric

**Names:** ____________________________________________________________

<table>
<thead>
<tr>
<th>Describe the object and its history</th>
<th>The propulsion system was described, and included any changes</th>
<th>A Bill of Materials was provided</th>
<th>Vehicle was able to be tested</th>
<th>Design Constraints were followed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle #1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Complete</td>
<td>☐ Complete</td>
<td>☐ Complete</td>
<td>☐ Complete</td>
<td>☐ Materials</td>
</tr>
<tr>
<td>☐ Accurate</td>
<td>☐ Accurate</td>
<td>☐ Accurate</td>
<td>☐ Accurate</td>
<td>☐ Time</td>
</tr>
<tr>
<td>☐ Purpose</td>
<td>☐ Specific</td>
<td>☐ Specific</td>
<td>☐ Able to fly</td>
<td>☐ Size</td>
</tr>
<tr>
<td>☐ Object Name</td>
<td>☐ Prior to building</td>
<td></td>
<td></td>
<td>☐ Propulsion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>☐ Other</td>
</tr>
</tbody>
</table>

| **Vehicle #1**                     |                                                               |                                 |                              |                                  |
| ☐ Complete                          | ☐ Complete                                                    | ☐ Complete                      | ☐ Complete                   | ☐ Materials                      |
| ☐ Accurate                          | ☐ Accurate                                                    | ☐ Accurate                      | ☐ Accurate                   | ☐ Time                           |
| ☐ Purpose                           | ☐ Specific                                                    | ☐ Specific                      | ☐ Able to fly                | ☐ Size                           |
| ☐ Object Name                       | ☐ Prior to building                                          |                                 |                              | ☐ Propulsion                     |
|                                   |                                                               |                                 |                              | ☐ Other                          |

| **Vehicle #1**                     |                                                               |                                 |                              |                                  |
| ☐ Complete                          | ☐ Complete                                                    | ☐ Complete                      | ☐ Complete                   | ☐ Materials                      |
| ☐ Accurate                          | ☐ Accurate                                                    | ☐ Accurate                      | ☐ Accurate                   | ☐ Time                           |
| ☐ Purpose                           | ☐ Specific                                                    | ☐ Specific                      | ☐ Able to fly                | ☐ Size                           |
| ☐ Object Name                       | ☐ Prior to building                                          |                                 |                              | ☐ Propulsion                     |
|                                   |                                                               |                                 |                              | ☐ Other                          |

**Comments:**

**Grade:**
Overview

Big Idea: The process of communication can take place between humans, machines, and humans and machines.

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

Teacher’s Suggestion: For deeper understanding, have students write the Big Idea in their own Engineering Design Journal (EDJ), using their own words, if they choose.

Purpose of Lesson: This lesson enables students to learn that the transfer of information takes place through different communication systems. These systems are human to human, human to machine and machine to human communication. Students learn to identify the components of a communication system including: source, encoder, transmitter, receiver, decoder and destination and develop a simple communication system with all necessary components.

Lesson Duration: 5 hours, plus 1 enrichment hour.

Activity Highlights

Engagement
Working in Engineering Design Teams, students will play a game, which demonstrates the components of the communication system.

Exploration
Using a variety of materials, and print and electronic sources, students explore different ways of producing sound, and how they could form a communication system.

Explanation
The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject.

Extension
Working in Engineering Design Teams, students will develop a system that can produce three different sounds.

Enrichment
Engineering Design Teams will adjust and repair their sound systems to tune them to different frequencies.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Research projects, an End of lesson quiz, and an End of unit quiz.
Lesson 2: Communication Systems

Lesson Overview

Lesson Duration
5 hours, plus 1 enrichment hour.

Standards/Benchmarks

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>STL 17H</td>
</tr>
<tr>
<td>STL 17I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>English Language Arts: Common Core Standards for English Language Arts (CCSELA, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)</td>
</tr>
<tr>
<td>RST.6-8.3.</td>
</tr>
<tr>
<td>Integration of Knowledge and Ideas (Literacy in Science and Technical Subjects, Grades 6-12)</td>
</tr>
<tr>
<td>RST.6-8.7.</td>
</tr>
<tr>
<td>RST.6-8.9.</td>
</tr>
</tbody>
</table>
Learning Objectives
Students learn to:
1. Apply and demonstrate the transfer of information through different communication systems
2. Differentiate between human to human, human to machine and machine to human communication
3. Identify the components of a communication system including: source, encoder, transmitter, receiver, decoder and destination
4. Develop a simple communication system with all necessary components
5. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
6. Work safely and accurately with a variety of tools, machines, and materials.
7. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials

Print Materials

Internet Search Terms and Suggested Sites
6. Internet Search Items:
   a. Historical musical instruments
   b. How sound travels to the human brain
   c. The communication loop
   d. Building musical instruments, kids
12. Communication theory.org, Communication loop/The process of communication, retrieved on 06/03/12 from http://communicationtheory.org/communication-loop-the-process-of-communication/ (permission to link requested).

**Required Knowledge and/or Skills**
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. The focus of the lesson is on music and sound, such that students who are hearing impaired may need additional materials, equipment and support in completing this lesson.
Unit 5: Technological Systems in the Designed World

Lesson 2: Communication Systems

5-E Lesson Plan

Teacher’s Note: Encourage students who study music to share their experience and instruments with the class, if possible.

Engagement

Working in Engineering Design Teams, students will play a game, which demonstrates the components of the communication system.

- The teacher describes the components of a communication system, through whole class discussion, locating the components of the communication loop in everyday situations, such as sending an e-mail, making a phone call and talking to a friend.
- Once students understand the role of each component, Engineering Design Teams will attempt to communicate a message to all members of the team in a chain reaction, using verbal communication.
- After completing the verbal communication exercise, students will attempt to communicate a message to their Engineering Design Team using only sketching, with no verbal communication or written text.
- In Engineering Design Journals, students will describe the communication process in their own words, developing a personal version of the communication loop and describing potential communication problems.

Exploration

Using a variety of materials, and print and electronic sources, students explore different ways of producing sound, and how they could form a communication system.

- As a class, students will view the YouTube videos on instrument building (See Multimedia Resources)
- Using a variety of materials, students will experiment with generating a variety of sounds, documenting materials and sounds in their Engineering Design Journals

Explanation

The teacher, involving students in the following discussions as they contribute their experiences from the Engagement and Exploration activities along with any prior knowledge they may have about the subject:

- Discussions will include how humans interpret sounds, how sound is generated through musical instruments and how tones and pitches are changed
- If time permits, instructor plays a variety of sounds, with students describing how they feel when hearing that sound in their Engineering Design Journals
- Notes from the discussion are recorded in Engineering Design Journals

Extension
Working in Engineering Design Teams, students will develop a system that can produce three different types of sound.

- Using knowledge of sound and instruments gained in previous activities, students will work in Teams to develop a series of instruments (or one larger instrument to be played by multiple people) that produce at least three distinctly different sounds.
- Documentation of planning and development will take place in Engineering Design Journals.
- Instruments will be shared with the class, and "played", demonstrating sound qualities.
- If time permits, Engineering Design Teams will adjust and repair their sound systems to tune them to different frequencies.

**Enrichment**

Students will research methods of communicating sound signals to people who are hearing impaired, with examples and modifications.

**Evaluation**

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Research projects, an End of lesson quiz, and an End of unit quiz.

*The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.

**Assessment Instrument**
Unit 5: Technological Systems in the Designed World

Lesson 2: Communication Systems

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work, which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations, which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

This lesson is likely to produce more noise from your classroom than usual, be prepared to address this in your specific facility.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, and building companies, musicians, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment
1. Computer w/Internet access
2. Presentation projector
3. Safety glasses, 1 pair per student
4. Twine, 100 yd roll, 1 per class
5. Brass wire, 26 gauge, 30 yds, 5 per class
6. An electronic tuner, or instrument tuning application, 1 per class
7. Corrugated cardboard, approx. 8” X 10”, 30 per class
8. Duck brand tape, 20 yd roll, 3 rolls per class
9. Electrical tape, 1 roll per group
10. Cyanoacrylic all-purpose glue, .07 oz, 8 per class
11. Carpenter’s wood glue, 4 oz, 10 per class
12. Rubber bands, pack of 100 assorted, 2 per class
13. Straight plastic straws, 50 pack, 3 per class
14. Hand sanitizer for mouthpieces, 1 per class
15. School glue, 4 oz, 2 per group
16. Hot melt glue guns, 10 per class
17. Hot melt glue sticks, 50 pack, 1 per class
18. Paper fasteners (brads), 1 box per class
19. Gift wrap tape, 1-2 rolls per group
20. Masking tape 1”, 1 roll per group
21. Assorted Sandpaper
22. Plastic tubing, a variety of lengths and diameters
23. Coping saws, 5 per class, with replacement blades
24. X-Acto knives, 1 per student, with replacement blades
25. 18” X 24” Self-healing cutting matts, 10 per class
26. Balloons, 9” latex, pack of 50, 1 per class
27. Cardboard Mailing tubes, 2” X 6”, case of 50, 1 per class
28. Coffee cans or other empty tin cans, 15 per class
29. Empty plastic bottles, 15 per class
30. Empty glass bottles, 15 per class
31. Metal tubing in various lengths and diameters
32. 3X5” notecards, pack of 100, 1 per class
33. Stop watch, 1 per class
34. Optional: Lumber scraps, appropriate to equipment

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
- Teacher Resource 5.2.1: Class Participation Rubric
- Teacher Resource 5.2.2: Communication Loops and Human Interpretation Teacher Guide
- Teacher Resource 5.2.3: End of Lesson Quiz Answer Key

Student Resources
- Student Resource 5.2.1: Lesson Glossary
- Student Resource 5.2.2: Communication Loops and Interaction Types
- Student Resource 5.2.3: Engineering Design Journal Guidelines
- Student Resource 5.2.4: Sounds and Types of Musical Instruments Research
- Student Resource 5.2.5: Reflective Writing- Sound and Human Communication
- Student Resource 5.2.6: Lesson Design Brief
- Student Resource 5.2.7: End of Lesson Quiz

Assessment Resources
- Assessment Resource 5.2.1: Engineering Design Journal Rubric
- Assessment Resource 5.2.2: Sounds and Types of Musical Instruments Rubric
- Assessment Resource 5.2.3: Reflective Writing Rubric
- Assessment Resource 5.2.4: Engineering Design Team Rubric
### Lesson 2: Communication Systems

**Teacher Resource 5.2.1: Class Participation Rubric**

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
Unit 5: Technological Systems in the Designed World

Lesson 2: Communication Systems

Teacher Resource 5.2.2: Communication Loops and Human Interpretation Teacher Guide

Teacher’s Note: This is an interactive game, which will require that students be able to move about the room, or rearrange their seating to accommodate game play. Preparation is limited, but if you will be teaching this lesson to multiple classes at the same time, it may help to encourage students to limit talking about the activity outside of class until all classes have completed the activity.

Part One: Communication Loops:

Using Student Resource 5.2.2, class discussion and a dry erase or chalkboard, work with students to develop understanding of all components of the communication loop.

Help students with locating the components of the communication loop in everyday situations, such as sending an e-mail, making a phone call and talking to a friend.

Part Two: Verbal Communication:

Once students understand the role of each component, Engineering Design Teams will attempt to communicate a message to all members of the team in a chain reaction, using verbal communication.

- Assign Students specific roles within the communication loop, placing them accordingly in a row. Students should be able to sit close together in order to whisper to each other without being overheard by member of their own team. Ideally, this would take place in teams of six, but if necessary, teams can be larger or smaller. This is less effective in teams with less than four students.
- Provide the “source”(the first person in the row of a team) with a notecard containing a phrase, and instruct the “source” to read the card carefully and then whisper the phrase from the card to the next person in the row from his or her team, without letting anyone else see what is written on the card.
- Subsequent members of the team will whisper the message to the next person in the row as he or she heard it, ending with the last person on the team, the “destination”.
- The “destination” will report the message back to the group, as it was received, checking the original message on the card for accuracy.
- Complete this process 3-6 times per team, as time allows.

Part Three: Visual Communication:

Similar to the verbal communication section, the instructor will provide a word or phrase to the Engineering Design Team, with the “source” being the only person to see the original message.

- Each student will have a turn serving as the “source” for the communication loop. The “source” will receive the word or phrase on a card and attempt to communicate the idea to the team of “destinations” by sketching or drawing.
• Remind players that words, symbols or other text elements are not allowed.
• The “destinations” will report the message back to the group, as it was received, checking the original message on the card for accuracy.

Conclusion:
In Engineering Design Journals, students will describe the communication process in their own words, developing a personal version of the communication loop and describing potential communication problems.

Variations:
• Students may also communicate their ideas via acting, modeling in clay or any other medium.
• Students can develop their own words or phrases for game play.
• Students may be assigned to provide “feedback” or “interference” in the communication process, making the message more difficult to interpret.
Unit 5: Technological Systems in the Designed World

Lesson 2: Communication Systems

Teacher Resource 5.2.3: End of Lesson Quiz Answer Key

1. **String** In this case, string is referring to a type of musical instrument, where sound is produced by plucking, strumming, or using a pick or bow. The piano is considered either a string instrument or a percussion instrument.

2. **Pitch** The frequency of repetition of the sound waves of a note, determining how high or low a note sounds.

3. **Encoder** The medium for translating a message into a format that can be sent by the sender and decoded by the receiver.

4. **Source** The sender or originator of a message in the communication loop.

5. **Human-to-Machine Communication** The process of a human sending a message to a machine, i.e. use of an ATM machine.

6. **Transmitter** Once the source of a message has determined what the message will be, encoded it into a format that can be sent, it is transmitted through a media which will allow the receiver to get and interpret the message.

7. **Destination** The person or place that the sender intended to receive the message.

8. **Tune** A rhythmic succession of notes, or the process of ensuring that the notes produced by an instrument are correct.

9. **Woodwind** A type of musical instrument that incorporates either a single or double reed which vibrate with the force of air blown into the instrument.

10. **Sound** Vibrations of waves that travel through air or water that can be heard when they reach the ear of a person or other animal.

11. **Receiver** The person who gets and translates the message sent from the sender.
12. **Percussion** A type of musical instrument that is struck, shaken or otherwise impacted to make a sound.

13. **Human-to-Human Communication** The process of one human sending a specific message to another human, through talking or other means.

14. **Decoder** After a message is received in the communication loop, it is translated into something that can be understood by the receiver.

15. **Communication System** A system for communication that incorporates all elements of the communication loop.

16. **Machine-to-Human Communication** The process of a machine sending a message to human, such as medical monitoring equipment.

17. **Communication Loop** A cycle or diagram of the communication process that incorporates source, encoder, transmitter, receiver, decoder and destination.

18. **Brass** In this case, brass is referring to a musical instrument, generally made of brass, but sometimes-other metals.

19. **Miscommunication** A failure, misinterpretation or misunderstanding in the communication process.

20. **Wind** In this case, wind is referring to a type of musical instrument, incorporating both woodwinds and brass instruments, as sound is produced by blowing into the instrument.
Brass In this case, brass is referring to a musical instrument, generally made of brass, but sometimes - other metals.

Communication Loop A cycle or diagram of the communication process that incorporates source, encoder, transmitter, receiver, decoder and destination.

Communication System A system for communication that incorporates all elements of the communication loop.

Decoder After a message is received in the communication loop, it is translated into something that can be understood by the receiver.

Destination The person or place that the sender intended to receive the message.

Encoder The medium for translating a message into a format that can be sent by the sender and decoded by the receiver.

Frequency The number of times a sound wave is repeated over a specific unit of time. Humans can generally hear between 20 Hz and 20,000 Hz.

Human-to-Human Communication The process of one human sending a specific message to another human, through talking or other means.

Human-to-Machine Communication The process of a human sending a message to a machine, i.e. use of an ATM machine.

Instrument In this case, instrument is referring to a musical instrument, which is a device intended to create sound.

Machine-to-Human Communication The process of a machine sending a message to human, such as medical monitoring equipment.

Miscommunication A failure, misinterpretation or misunderstanding in the communication process.

Music The art and science of combining sounds in order to generate a specific emotion, sound or rhythm.

Percussion A type of musical instrument that is struck, shaken or otherwise impacted to make a sound.

Pitch The frequency of repetition of the sound waves of a note, determining how high or low a note sounds.

Receiver The person who gets and translates the message sent from the sender.
Sound  vibrations of waves that travel through air or water that can be heard when they reach the ear of a person or other animal

Sound System  A set of equipment for recording and amplifying sound

Source  The sender or originator of a message in the communication loop

String  In this case, string is referring to a type of musical instrument, where sound is produced by plucking, strumming, or using a pick or bow. The piano is considered either a string instrument or a percussion instrument.

Tone  intonation, pitch and notes of a piece of music

Transmitter  Once the source of a message has determined what the message will be, encoded it into a format that can be sent, it is transmitted through a media which will allow the receiver to get and interpret the message

Tune  A rhythmic succession of notes, or the process of ensuring that the notes produced by an instrument are correct

Wind  In this case, wind is referring to a type of musical instrument, incorporating both woodwinds and brass instruments, as sound is produced by blowing into the instrument.

Woodwind  A type of musical instrument that incorporates either a single or double reed which vibrate with the force of air blown into the instrument.
Unit 5: Technological Systems in the Designed World

Lesson 2: Communication Systems

Student Resource 5.2.2: Communication Loops and Interaction Types

The Communication Loop

![Diagram of the communication loop with labeled nodes: Source, Encoder, Transmitter, Destination, Decoder, Receiver.]

Interaction Types

**Human-to-Human** Any sort of communication between humans - talking, phone calls e-mail, written text, body language, acting, etc.

**Human-to-Machine** Communication beginning with a human, but interacting with a machine, using an ATM, paying a bill with an automated phone system, entering information in a computer

**Machine-to-Human** Communication originating from a machine, with data intended to be interpreted by humans, such as a FAX, auto-dialer or medical equipment monitoring a patient without being used directly by another person
Unit 5: Technological Systems in the Designed World

Lesson 2: Communication Systems

Student Resource 5.2.3: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Many types of human communication focus on sound, from conversations to music to alarms. For this project, we will be focusing on human-controlled sound through musical instruments.

Historically, there have been a variety of traditional instruments, including percussion, wind and string instruments, with many variations, including electric ones over time.

Later in this lesson, you will be building a communication system or instrument with your Engineering Design Team that can make three distinctly different sounds.

In preparation for building your instrument, you will use a variety of materials, as well as print and electronic sources, to explore different ways of producing sound, and how the sounds could form a communication system.

**Research Part One: Multi-media and print resources:** Using the computer lab and library resources, Engineering Design Teams will locate information on historical, uncommon and handmade instruments, in preparation for building their own.

Consider all instrument families: Woodwinds, Brass, Strings and Percussion

Did you find others?

How would your Engineering Design Team classify a piano?

Include notes and sketches of what you find in your Engineering Design Journal.

**Research Part Two: Experimenting with Materials:** Using the variety of materials provided by your instructor, experiment with ways of producing and altering sounds.

How do these materials vary from those that you found in your research?

How could these materials be used in the traditional instrument families?

What can you do to the materials to produce different notes?

Include notes and sketches of what you find in your Engineering Design Journal.
Unit 5: Technological Systems in the Designed World

Lesson 2: Communication Systems
Student Resource 5.2.5: Reflective Writing- Sound and Human Communication

Name: _______________________________________________________

Using complete sentences, with correct grammar and punctuation, write a paragraph in response to each item below.

1. How has your perception of human communication changed since learning about the communications loop? Give examples.

2. Much of human communication from music, to speech to warning signals focuses on sound. If you became hearing impaired, how would you adapt to this environment?

3. Describe a situation where a miscommunication has resulted in a problem or misunderstanding in your life.

4. Human communication with machines has become part of our everyday life. Describe three examples of human communication with machines.

5. Many different sounds evoke a specific kind of emotion in the person hearing them. Describe a situation where a sound has influenced your feelings.
The Problem: Sound is a primary method of communication in many settings. How can different sounds communicate different meanings? Working in Engineering Design Teams, students will develop a system that can produce three different types of sound.

Design Constraints: Your completed system will need to make 3 distinctly different sounds. Documentation of planning and development will take place in Engineering Design Journals.

Your Engineering Design Team will have limited time and materials to complete this process, as described by your teacher. Use your time and materials wisely.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

What kind of sound do you want to produce with your system?

Working as a system, will you create three separate instruments, or one instrument that can make three very different sounds?

Is your instrument(s) intended to be played by one person at a time, or many?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, hot melt glue guns and sticks, X-Acto knives, coping saws, scissors, rulers, corrugated cardboard, Twine, 100 yd roll, Brass wire, 26 gauge, 30 yds, An electronic tuner, or instrument tuning application, Duck brand tape, 20 yd roll, Electrical tape, Cyanoacrylic all-purpose glue, .07 oz, Carpenter's wood glue, 4 oz, Rubber bands, pack of 100 assorted, Straight plastic straws, 50 pack, Hand sanitizer for mouthpieces, Paper fasteners (brads), Assorted Sandpaper, Plastic tubing, Balloons, 9” latex, pack of 50, Cardboard Mailing tubes, 2” X 6”, case of 50, Coffee cans or other empty tin cans, Empty plastic bottles, Empty glass bottles, Metal tubing, 3X5” notecards, Stopwatch, and optional: Lumber scraps, appropriate to equipment. Other materials may be used - consult your teacher.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation.

The Presentation: Instruments will be shared with the class, and “played”, demonstrating sound qualities.

If time permits, Engineering Design Teams will adjust and repair their sound systems to tune them to different frequencies.
Write the best response in the blank provided.

1. In this case, string is referring to a type of musical instrument, where sound is produced by plucking, strumming, or using a pick or bow. The piano is considered either a string instrument or a percussion instrument.

2. The frequency of repetition of the sound waves of a note, determining how high or low a note sounds

3. The medium for translating a message into a format that can be sent by the sender and decoded by the receiver

4. The sender or originator of a message in the communication loop

5. The process of a human sending a message to a machine, i.e. use of an ATM machine

6. Once the source of a message has determined what the message will be, encoded it into a format that can be sent, it is transmitted through a media which will allow the receiver to get and interpret the message

7. The person or place that the sender intended to receive the message

8. A rhythmic succession of notes, or the process of ensuring that the notes produced by an instrument are correct
9. A type of musical instrument that incorporates either a single or double reed which vibrate with the force of air blown into the instrument.

10. Vibrations of waves that travel through air or water that can be heard when they reach the ear of a person or other animal.

11. The person who gets and translates the message sent from the sender.

12. A type of musical instrument that is struck, shaken or otherwise impacted to make a sound.

13. The process of one human sending a specific message to another human, through talking or other means.

14. After a message is received in the communication loop, it is translated into something that can be understood by the receiver.

15. A system for communication that incorporates all elements of the communication loop.

16. The process of a machine sending a message to human, such as medical monitoring equipment.

17. A cycle or diagram of the communication process that incorporates source, encoder, transmitter, receiver, decoder and destination.

18. In this case, brass is referring to a musical instrument, generally made of brass, but sometimes other metals.

19. A failure, misinterpretation or misunderstanding in the communication process.

20. In this case, wind is referring to a type of musical instrument, incorporating both woodwinds and brass instruments, as sound is produced by blowing into the instrument.
The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>Complete All areas addressed</td>
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<tr>
<td>Most areas well done</td>
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<td>Some areas well done</td>
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<td>Minimal effort</td>
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<td>Not attempted, missing</td>
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<tr>
<td>Engage – Sketching, personal definitions and notes</td>
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<tr>
<td>Explore - documentation of sounds, types and instruments</td>
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<tr>
<td>Explain – discussion notes, feelings from sound</td>
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<td>Extend – evidence of planning</td>
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<tr>
<td>Extend - sketches for instrument construction</td>
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<td>Improvement in drawing skills over time</td>
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<td>Includes notes and comments</td>
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<td>Ability to understand and interpret images, notes and sketches</td>
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<td>Bonus: Additional materials</td>
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Comments:

Grade:
### Assessment Resource 5.2.2: Sounds and Types of Musical Instruments Rubric

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<tr>
<th>Assessment:</th>
<th>4 Complete All areas addressed</th>
<th>3 Most areas well done</th>
<th>3 Some areas well done</th>
<th>1 Minimal effort</th>
<th>0 Not attempted, missing</th>
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<td>Research- evidence of all instrument families</td>
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<td>Research- use of a variety of sources</td>
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<td>Research - Notes and Sketches of found information</td>
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<td>Materials- evidence of all instrument families</td>
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<td>Materials - evidence of efforts to change sounds produced</td>
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<td>Materials - comparisons</td>
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<tr>
<td>Materials - Notes and Sketches of found information</td>
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<td>Ability to understand and interpret images, notes and sketches</td>
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<td>Bonus: Additional materials</td>
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Comments:                                                                   

Grade:
**Unit 5: Technological Systems in the Designed World**

**Lesson 2: Communication Systems**

**Assessment Resource 5.2.3: Reflective Writing Rubric**

Name: ____________________________________________

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td>Ability to apply information gained in class to prior knowledge</td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

Comments:__________________________________________

Grade:____________________________________________
Assessment Resource 5.2.4: Engineering Design Team Rubric

Name: ____________________________________________

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
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<tr>
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<td>Overall Participation</td>
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<td>Contributions to the group</td>
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<td>Focus on project</td>
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<td>Teamwork</td>
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<td>Strengths and weaknesses</td>
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<td></td>
<td>Special Contributions</td>
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<td>Comments</td>
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<td></td>
<td>Overall Grade</td>
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Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Lesson Snapshot

Big Idea: Production and manufacturing environments for biological and medical equipment and materials must align to standards that ensure the quality of the material produced.

Purpose of Lesson: This lesson enables students to learn that there are specific requirements for production environments where biological and medical materials are produced. Basic genetic structure and how it deviates in genetically engineered gene combinations as well as the processes involved in the production of vaccines are introduced.

Students learn to distinguish between processes and materials used in different manufacturing processes and understand practices used to improve production of food, fuel, fiber, in the care of animals and in other products. The manufacturing process includes: design, development, production and service and can be used to improve production of a variety of materials. Students learn that building structures are also systems and may contain subsystems. Some structures are temporary while others are permanent, and some rest on a foundation.

Lesson Duration: 8 hours, plus 5 enrichment hours.

Activity Highlights

Engagement
Working in Engineering Design Teams, students will complete a short research project, presenting information on a residential system or component to their class.

Exploration
Using an assembly-line manufacturing system, students will design and build models of animal shelters, including appropriate systems and construction types.

Explanation
Using a variety of print, online and hands-on materials, students are introduced to the concept of genetic engineering, and specialized production environments for vaccines.

Extension
Engineering Design Teams will use their knowledge of construction, manufacturing and production systems to design and build a system for a specialized production environment.

Enrichment
Using the models as a guide, students will build animal shelters for use and distribute them through a local veterinary clinic or animal shelter.

Evaluation
The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, and an End of unit quiz.
Lesson 3: Constructing Specialized Manufacturing Environments

Lesson Overview

Lesson Duration
8 hours, plus 5 enrichment hours.

Standards/Benchmarks

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

<table>
<thead>
<tr>
<th>STL 14I</th>
<th>The vaccines developed for use in immunization require specialized technologies to support environments in which sufficient amounts of vaccines are produced.</th>
</tr>
</thead>
<tbody>
<tr>
<td>14J Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.</td>
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<tr>
<td>15G A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.</td>
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</tr>
<tr>
<td>19H The manufacturing process includes the designing, development, making and servicing of products and systems.</td>
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<tr>
<td>20G Some structures are temporary, while others are permanent.</td>
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<tr>
<td>20H Buildings generally contain a variety of subsystems.</td>
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</tr>
</tbody>
</table>

**Mathematics:** Common Core Standards for Mathematics (CCSM, 2011)

**Geometry Standard (Grade 6)**


**The Number System Standard (Grade 7)**

| 7.NS | Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers |

**English Language Arts:** Common Core Standards for English Language Arts (CCSELA, 2011)

**Key Ideas and Details (Literacy in Science and Technical Subjects, Grades 6-12)**

| RST.6-8.1 | Cite specific textual evidence to support analysis of science and technical texts. |
| RST.6-8.3 | Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. |

**Integration of Knowledge and Ideas (Literacy in Science and Technical Subjects, Grades 6-12)**

| RST.6-8.7 | Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). |
| RST.6-8.8 | Distinguish among facts, reasoned judgment based on research findings, |
and speculation in a text.

**RST.6-8.9.** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

---

<table>
<thead>
<tr>
<th><strong>Science:</strong> Benchmarks for Science Literacy (AAAS, 1993/2009)¹</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Common Themes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>11A/M3            Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a sub-system of a larger system.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>The Human Organism</strong></th>
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<tbody>
<tr>
<td>6A/M6 Technologies having to do with food production, sanitation, and health care have dramatically changed how people live and work and have resulted in rapid increases in the human population.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>The Nature of Science</strong></th>
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</thead>
<tbody>
<tr>
<td>1C/M1 Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>The Designed World</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>8A/M2 People control some characteristics of plants and animals they raise by selective breeding and by preserving varieties of seeds (old and new) to use if growing conditions change.</td>
</tr>
</tbody>
</table>

| 8B/M2 Manufacturing usually involves a series of steps, such as designing a product, obtaining and preparing raw materials, processing the materials mechanically or chemically, and assembling the product. All steps may occur at a single location or may occur at different locations. |

---

¹ Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Learning Objectives
Students learn to:
1. Identify a structure and its subsystems.
2. Design a structure and its subsystems.
3. Differentiate between temporary and permanent structures.
4. Design a structure resting on a foundation.
5. Apply the manufacturing process, including: design, development, production and service
6. Distinguish between processes and materials used in different manufacturing processes
7. Understand practices used to improve production of food, fuel, fiber, in the care of animals and in other products.
8. Understand and explain specific requirements for production environments
9. Identify the processes involved in the production of vaccines
10. Identify basic genetic structure and how it deviates in genetically engineered gene combinations
11. Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
12. Work safely and accurately with a variety of tools, machines, and materials.
13. Actively participate in group discussions, ideation exercises, and debates.

Resource Materials
Audiovisual Materials
   (permission to link requested)
   (permission to link requested)
   (permission to link requested)
   (permission to link requested)
   (permission to link requested)
   (permission to link requested)
Print Materials

Internet Search Terms and Suggested Sites
15. Internet Search Items:
   a. Cleanroom Technologies
   b. Basics of Human Production
   c. Vaccine Production
   d. Cleanroom suits
   e. Genetic engineering
   f. Plumbing systems
   g. HVAC systems- residential
   h. Electrical Systems – residential
   i. Manufacturing processes
   j. Building a Greenhouse
   k. Building a doghouse

16. The Nebraska Medical Center, *Biologics Production Facility* Retrieved on 04/30/12 from [http://www.youtube.com/watch?v=oJ_ggqTMQoE](http://www.youtube.com/watch?v=oJ_ggqTMQoE) (permission to link requested)
20. BBC Hardtalk, Sir John Sulston 'No need to rush genetic engineering', Retrieved on 04/30/12 from [http://news.bbc.co.uk/2/hi/programmes/hardtalk/9717378.stm](http://news.bbc.co.uk/2/hi/programmes/hardtalk/9717378.stm) (permission to link requested)
21. University of Utah, *Genetic Science Learning Center*, [http://learn.genetics.utah.edu/content/begin/tour/](http://learn.genetics.utah.edu/content/begin/tour/) (permission to link requested)


27. BuildEazy, *How to Build a Doghouse*, Retrieved on 05/30/12 from http://www.buildeazy.com/doghouse_imp.html (permission to link requested)

**Required Knowledge and/or Skills**

Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. They should be able to work independently and in a team environment.
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

5-E Lesson Plan

Teacher’s Note: This is an extended lesson and will require additional time for preparation and completion. Review and enforce tool safety with students as appropriate to your classroom environment. If a laboratory facility is available with appropriate equipment, consider building full size rather than as models.

Engagement

Working in Engineering Design Teams, students will complete a short research project, presenting information on a residential system or component to their class.

- Working in a short time frame, Engineering Design Teams will research and report back to the class with as much information as possible on their assigned topic within construction.
- Topics to be included are: HVAC, Plumbing, Roofing, Framing, Electrical Systems, Foundations, Permanent Structures, Temporary Structures, Insulation and other areas as selected by the instructor.

Exploration

Using a just-in-time manufacturing system, students will build models of animal shelters, including appropriate systems and construction types.

- Using Student Resource 5.3.5, Engineering Design Teams will be responsible for specific components or systems as assigned, following the provided plan.
- The model will include a variety of materials and follow scaled construction standards, such as placing studs at 16” on center.
- Included components and systems include a door, a window, a foundation, framing, and insulation.
- The number of students per team or course will determine the amount of specificity in assigned tasks.
- Students will reflect on the manufacturing process and changes that they would make in the future.

Explanation

Using a variety of print, online and hands-on materials, students are introduced to the concept of genetic engineering, and specialized production environments for vaccines.

- Discussing the principles of vaccines, students are introduced to the concept that man looks to improve production of a variety of materials to improve quality of life, food, fuel, shelter, etc.
- In attempting to make these improvements, genetic and genetic engineering have been studied to attempt to change or control the way that characteristics of plants and animals are displayed.
• Predictive genetics are presented through Punnett Square diagrams
• Specialized manufacturing environments and facilities ensure the quality and purity of the vaccines and other sensitive materials produced.

Extension

Engineering Design Teams will use their knowledge of construction, manufacturing and production systems to design and build a system for a specialized production environment.
• The specific production environment to be addressed is for the controlled pollination of plants to produce novel genetic combinations, or to fight plant diseases.
• The production environment must be able to isolate the necessary components, such as pollen and produce adequate conditions for plant growth, including ventilation and access to water and sunlight.
• Limitations on size and materials used are determined by the instructor.

Enrichment

Using the models as a guide, students will build animal shelters for use and distribute them through a local veterinary clinic or animal shelter.

Evaluation

The student’s knowledge, skills and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, and an End of unit quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
Assessment Instrument –
Teacher Resource 5.3.1: Class Participation Rubric

Name: _________________________________________________________________

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
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</tr>
</tbody>
</table>

Comments:

Grade:
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work, which will require writing and drawing space, prototyping systems, which will require building materials and tools and presentations, which may use word processing, presentation and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

Students will be working with plant materials that may potentially cause allergic reactions. It is recommended that a parent letter or permission slip be sent home prior to exposing students to plant materials.

When completing the full-sized animal shelters or greenhouses, additional equipment such as table saws and air compressors may be used, if appropriate to the setting. Hand tools are also appropriate for use.

Teacher Suggestion
Business and Industry partnerships appropriate for this lesson may include manufacturing companies, engineering firms, local greenhouses and building supply companies, as well as post-secondary programs and your program advisory committee. These partnerships could include guest speakers, presentation judges, and sources for supplies, such as scrap materials for prototype construction or field trip locations, as appropriate.

Tools/Materials/Equipment

1. Computer w/Internet access
2. Presentation projector
3. Engineering Design Journals or blank paper
4. Safety glasses, 1 pair per student
5. Graph paper, 80 sheet pack, 1 per class
6. 12” Rulers, 1 per student
7. Scissors, 1 pair per student
8. Mitre box and saw for Balsa and Bass Wood, 3 per class
9. Balsa Wood Easy Cutter, 3 per class
10. Balsa Wood Economy Bags, 7 per class
11. Gift wrap tape, 1-2 rolls per group
12. Masking tape, 1”, 1 roll per group
13. School glue, 4 oz, 2 per group
14. Hot melt glue guns, 10 per class
15. Hot melt glue sticks, 50 pack, per class
16. Cyanoacrylic all-purpose glue, .07 oz, 10 per class
17. Corrugated cardboard, approx. 8” X 10”, 30 per class
18. Tyvek mailing envelopes, 7.5” X 10.5 “, pack of 100, 1 per class
19. Straight plastic Straws, 50 pack, 3 per class
20. Transparencies, or other plastic, 2 per student
21. Used file folders, 2 per student
22. Polyester or acrylic quilt batting, 48” X 60” roll, 3 per class
23. Foam core board, 18” X 24” sheets, 20 per class
24. Binder clips, assorted sizes pack of 60, 1 per class
25. Plants or seeds as selected for the greenhouse environment, 15 + per class
26. Lawn and leaf bags, 39 gallon, 10 pack, 1 per class
27. Aquarium tubing, 25 ft, 5 per class
28. Assorted sandpaper
29. 10’X 100’ 2 mil clear plastic sheeting, 2 rolls per class
30. Optional: For Full-sized greenhouse: 2”X 2” lumber, as needed
31. Coping saws, 5 per class, with replacement blades
32. Electric Styrofoam cutters, 2 per class
33. X-Acto knives, 1 per student and replacement blades
34. 18” X 24” Self-healing cutting mats, 10 per class

Enrichment Activity Materials
1. Safety glasses, 1 pair per student
2. 3/8” plywood sheets, 5 per class
3. Foam insulation1/2”X 24” X 48”, 10 per class
4. 2” X 2” X 4’ pressure-treated lumber, 50 per class
5. 1” X 6” X 10’ kiln dried lumber, 8 per class
6. Felt roof deck protection, 216 sq ft, 1 per class
7. #11, 1 ½” galvanized Roofing nails, 5 lb, 1 per class
8. Framing nails, 3”, 2M round head, box of 2000, 1 per class
9. #13 2” 6D Finishing nails, 1 lb, 2 per class
10. Exterior paint, 32 oz flat, light base, 5 per class
11. 3 tab shingles, bundle covering 33.3 ft2, 3 per class
12. 10’ tape measure, 12 per class
13. 8 oz claw hammers, 12 per class
14. 14” crosscut hand saws, 6 per class
15. 2” polyester paintbrushes, 6 per class

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

**Teacher Resources**
- Teacher Resource 5.3.1: Class Participation Rubric
- Teacher Resource 5.3.2: Math for Engineering Design and Production Answer Key
- Teacher Resource 5.3.3: End of Unit Quiz Answer Key

**Student Resources**
- Student Resource 5.3.1: Lesson Glossary
- Student Resource 5.3.2: An Introduction to Genetics and Genetic Engineering
- Student Resource 5.3.3: Engineering Design Journal Guidelines
- Student Resource 5.3.4: Math for Engineering Design and Production
- Student Resource 5.3.5: Manufacturing Systems and Model Production
- Student Resource 5.3.6: Construction Systems Research
- Student Resource 5.3.7: Reflective Writing - Production Environments
- Student Resource 5.3.8: Lesson Design Brief
- Student Resource 5.3.9: End of Unit Quiz

**Assessment Resources**
- Assessment Resource 5.3.1: Engineering Design Journal Rubric
- Assessment Resource 5.3.2: Manufacturing Systems and Model Production Rubric
- Assessment Resource 5.3.3: Reflective Writing Rubric
- Assessment Resource 5.3.4: Engineering Design Team Rubric
Lesson 3: Constructing Specialized Manufacturing Environments

Teacher Resource 5.3.1: Class Participation Rubric

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</table>

Comments:

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Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Teacher Resource 5.3.2: Math for Engineering Design and Production Answer Key

1. Compute the area \( \text{area}_{\text{Rectangle}} = \text{length} \times \text{width} \) of a rectangle with the following lengths and widths:

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 cm</td>
<td>13 cm</td>
<td>52 cm²</td>
</tr>
<tr>
<td>18.5 m</td>
<td>13.2 m</td>
<td>244.2 m²</td>
</tr>
<tr>
<td>1.4 ft</td>
<td>2.3 ft</td>
<td>3.22 ft²</td>
</tr>
<tr>
<td>1.25 m</td>
<td>3.75 m</td>
<td>4.6875 m²</td>
</tr>
</tbody>
</table>

2. Compute the area \( \text{area}_{\text{Triangle}} = \frac{1}{2} \times \text{base} \times \text{height} \) of a triangle with the following bases and heights:

<table>
<thead>
<tr>
<th>Base</th>
<th>Height</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 cm</td>
<td>5 cm</td>
<td>25 cm²</td>
</tr>
<tr>
<td>8.2 in</td>
<td>6.4 in</td>
<td>26.24 in²</td>
</tr>
<tr>
<td>3.7 m</td>
<td>2.5 m</td>
<td>4.625 m²</td>
</tr>
<tr>
<td>2.33 ft</td>
<td>3.67 ft</td>
<td>4.27555 ft²</td>
</tr>
</tbody>
</table>

3. Compute the area \( \text{area}_{\text{Circle}} = \pi r^2 \) of a circle with the following radii. Use the value 3.14 for \( \pi \):

<table>
<thead>
<tr>
<th>Radius</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 cm</td>
<td>4.5216 cm²</td>
</tr>
<tr>
<td>3.8 in</td>
<td>45.3416 in²</td>
</tr>
<tr>
<td>9.1 m</td>
<td>260.0234 m²</td>
</tr>
<tr>
<td>4.25 ft</td>
<td>56.71625 ft²</td>
</tr>
</tbody>
</table>

4. Compute the surface area (sum of the areas of each side) of the following solids:

<table>
<thead>
<tr>
<th>Solid</th>
<th>Surface Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cube with 1.2 m side length</td>
<td>8.64 m²</td>
</tr>
<tr>
<td>Rectangular prism with a length of 5 and a square base with each side measuring 2.1 in.</td>
<td>50.82 in²</td>
</tr>
<tr>
<td>Rectangular prism with a length of 5 and a triangular base with each side measuring 2.1 in (triangle base = 2.1, height = 1.82)</td>
<td>35.322 in²</td>
</tr>
<tr>
<td>Sphere of radius 2.3 cm (surface area of sphere = 4 ( \pi r^2 ))</td>
<td>66.4424 cm²</td>
</tr>
</tbody>
</table>

5. Consider a model built to \( \frac{1}{4} \) scale of a small shed. The model is represented by a rectangular prism that is 4 ft wide, 3.5 ft in length and 2.1 ft in height. What is the surface area of the shed based on the dimensions of the scale model?
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Teacher Resource 5.3.3: End of Unit Quiz Answer Key

Draw a diagram and explain the difference between each of the following:

1. First Class Lever

**First class lever** A lever with a pivot point (fulcrum) in the middle, between the input and output forces

2. Second Class Lever

**Second Class Lever** A lever that has the output force or load between the fulcrum and input force

3. Third Class Lever

**Third class lever** A lever that has the input force between the output force and the fulcrum.

4. Describe 3 different simple machines and their purpose.

**Pulley** a type of simple machine that incorporates a rimmed wheel which holds a line and can turn within a frame to change the direction of a force

**Wheel and Axle** A wheel with a central rod or axle that turns, allowing the wheel to turn

**Wedge** A simple machine similar to the inclined plane, but intended to push objects apart

**Inclined Plane** A type of simple machine used to change the height of an object by rolling or sliding, as in a ramp

**Screw** A simple machine that incorporates an inclined plane wrapped around a central pole

**Lever** A simple machine comprised of a bar with a pivot around a point. At point A, a force is applied, using the pivot at B to provide force at point C.

5. Complete the following Punnet Square diagrams:
Dimples (Dimples, D are dominant)

<table>
<thead>
<tr>
<th>Mother DD</th>
<th>Child 1 Dd</th>
<th>Child 2 Dd</th>
<th>Father dd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 3 Dd</td>
<td>Child 4 Dd</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How many children will have dimples?
None

Nearsightedness (Nearsightedness, N is dominant)

<table>
<thead>
<tr>
<th>Mother nN</th>
<th>Child 1 nn</th>
<th>Child 2 NN</th>
<th>Father nN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 3 nN</td>
<td>Child 4 NN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How many children will be nearsighted?
2, 50%, 1/2

Hitchhiker’s Thumb (Hitchhiker's Thumb, h is recessive)

<table>
<thead>
<tr>
<th>Mother hh</th>
<th>Child 1 hH</th>
<th>Child 2 hH</th>
<th>Father Hh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 3 hh</td>
<td>Child 4 hh</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How many children will have Hitchhiker’s Thumb?
2, 50%, 1/2

6. Draw a diagram of the communication loop, labeling the components.

[Communication loop diagram]
Define the following terms:

7. **Sound** vibrations of waves that travel through air or water that can be heard when they reach the ear of a person or other animal

8. **Miscommunication** A failure, misinterpretation or misunderstanding in the communication process

9. **Foundation** The lowest, load-bearing part of a building, as a base for construction, often composed of concrete

10. **Framing** A rough construction that designates the basic form of interior and exterior walls, doors and windows of a structure

11. **Genetic Engineering** The planned and controlled manipulation of genetic material in a living organism that alters the genetic make-up of that organism

12. **Genetics** The study of hereditary traits and characteristics in organisms

13. **Manufacturing Process** The steps taken to move a raw material through production to the final product

14. **Materials** Any resources or supplies used in the production of goods and services

15. **Permanent Structure** A structure that is intended to stand in the current location for an indefinite but extended period of time.

16. **Pollination** The transfer of pollen from an anther of a plant to the stigma of a plant, but not necessarily the same plant

17. **Production Environment** A specialized environment that allows specific conditions to be met, ensuring a specific level of a controllable situation, such as air quality
18. Temporary Structure A structure that is intended to be moved frequently, although it may serve as the primary residence for one or more people

19. Vaccine A preparation used to stimulate the production of antibodies to develop immunity to a specific disease

20. What is the correct spacing of wooden wall studs in standard residential construction?
   16” on center
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.1: Lesson Glossary

Chromosomes A linear strand of DNA found in most living cells

Design The planning and visual representation of an object or structure before it is built

Development The growth and progress of a design in preparation for building and production

DNA Deoxyribonucleic acid, the main component of chromosomes, the genetic material of virtually all life on Earth

Electrical System A system intended to provide light or heat to a structure

Foundation The lowest, load-bearing part of a building, as a base for construction, often composed of concrete

Framing A rough construction that designates the basic form of interior and exterior walls, doors and windows of a structure

Genetic Engineering The planned and controlled manipulation of genetic material in a living organism that alters the genetic make-up of that organism

Genetically Modified Organism (GMO) An organism or food with components that have been genetically modified to improve production, reduce disease or develop other positive traits

Genetics The study of hereditary traits and characteristics in organisms

HVAC System Heating, Ventilation and Air-conditioning, used to provide these utilities to structures

Insulation A material intended to reduce temperature fluctuation by heat gain or loss in a structure

Just-in-Time Manufacturing A manufacturing process and inventory control system that limits the amount of material or in-progress products that a company has on hand by only ordering the materials needed to produce the next batch.

Manufacturing Process The steps taken to move a raw material through production to the final product

Materials Any resources or supplies used in the production of goods and services

Permanent Structure A structure that is intended to stand in the current location for an indefinite but extended period of time.
Plumbing System A system within a structure that is intended to distribute water and dispose of sewage

Pollination The transfer of pollen from an anther of a plant to the stigma of a plant, but not necessarily the same plant

Practice A set exercise or repetition of a specific process

Predictive Genetics A specific branch of the study of genetic material intended to predict the risks of particular disease or characteristics

Process The changing or transformation of a raw material through electrical, chemical or physical means

Production The act of manufacturing products from materials

Production Environment A specialized environment that allows specific conditions to be met, ensuring a specific level of a controllable situation, such as air quality

Punnett Square A specific type of diagram used to predict the outcome of a genetic combination

RNA Ribonucleic acid, a long chain of genetic material connected to the transmission of genetic information

Roofing A specific type of material intended to be impervious to extreme weather conditions, applied in a specific pattern depending on the type to direct water flow down and off of the structure

Service The maintenance and repair of components or systems

Structure Any constructed building, permanent or temporary intended for any purpose

Temporary Structure A structure that is intended to be moved frequently, although it may serve as the primary residence for one or more people

Tyvek A synthetic non-woven plastic material that is frequently used in building construction as a moisture barrier between the framing and the outermost layer of material

Vaccine A preparation used to stimulate the production of antibodies to develop immunity to a specific disease
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.2: An Introduction to Genetics and Genetic Engineering

Genetics is the study of heredity and characteristics in living organisms.

In order to determine the basic heredity of a certain characteristic, a Punnett Square diagram can be completed.

For example: Left-handedness is a recessive characteristic. In a family where one parent is left-handed and one of two children is left-handed, we can predict the genetic combinations of the parents, and the potential combinations in children. Capital letters are used to distinguish dominant traits, and lower case letters are used to mark recessive traits.

Mother - Left-handed II

<table>
<thead>
<tr>
<th>Child 1</th>
<th>Child 2</th>
<th>Father - Right-handed RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>lR</td>
<td>IR</td>
<td></td>
</tr>
<tr>
<td>Child 3</td>
<td>Child 4</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>II</td>
<td></td>
</tr>
</tbody>
</table>

Being left-handed, the mother would have to have inherited the recessive left-handed gene from both of her parents. In order to produce a left-handed child, the father would have to have inherited one left-handed gene from one of his parents.

In this combination, ½ or 50% of the children in this family are predicted to be left-handed.

Simple predictions like this have helped scientists all over the world to determine the probability that a specific trait will be inherited and expressed in a specific way.

Homework: Using your family or a friend’s, try to predict the genetic combinations for the following traits, completing the Punnett Squares in your Engineering Notebook:

1. Handedness (Right is dominant, Left is recessive)
2. Eye Color (Green or Brown are dominant, Blue or Gray are recessive)
3. Freckles (Freckles are dominant, No Freckles is recessive)
4. Earlobes (Unattached is dominant, Attached is recessive)
5. Tongue Rolling (Ability to roll the sides of the tongue inward is dominant, inability is recessive)

What else did you observe in looking for these traits?
What about genes that create combination traits through incomplete dominance?

For example: Consider another family with two children. The mother has straight hair and the father has curly hair. One of the children has straight hair and one has curly hair, what is the probability of another child being born with wavy hair – a combination of straight and curly?

<table>
<thead>
<tr>
<th>Mother - straight hair ss</th>
<th>Father – Curly hair sC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 1: ss</td>
<td>Child 2: ss</td>
</tr>
<tr>
<td>Child 3: sC</td>
<td>Child 4: sC</td>
</tr>
</tbody>
</table>

In this case, we know that the maternal grandparents both have straight hair, and as straight hair is a recessive trait, the mother can only have the ss combination. The paternal grandparents include one parent with straight and one parent with curly hair. Knowing that straight hair is recessive, we can predict that the parent with straight hair also had the ss combination.

In this case, ½ or 50% of the children are predicted to have a hair type other than straight, but we cannot predict the likelihood of whether the children receiving the C gene will curly or wavy hair because of the incomplete dominance of the gene.

In plants, incomplete dominance is easier to see.
Plants can be combined into new genetic combinations, just like humans. When a white flower is crossed (mated) with a red flower, incomplete dominance will produce a pink flower.

<table>
<thead>
<tr>
<th>White Parent Flower Ww</th>
<th>Red Parent Flower Rr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower 1: WR = Red</td>
<td>Flower 2: wR = pink</td>
</tr>
<tr>
<td>Flower 3: Wr = pink</td>
<td>Flower 4: wr = white</td>
</tr>
</tbody>
</table>

When the dominant red gene R is combined with the dominant white gene W, the red gene will be displayed in a red flower. When one gene is dominant and one is recessive, the resulting flower will have incomplete dominance shown through a pink color. When both genes are recessive, the white color will be displayed.

Codominance is another way in which combinations can create new patterns. For example, in the example of the flowers, if the color gene were codominant, instead of producing pink flowers, the Wr flower would be white with red spots and the wR flower would be red with white spots, expressing both colors as dominant.

Genetic Engineering is the careful manipulation of genetic material to create an improved organism.

When an inherited trait is not so positive, like a propensity for illness or disease, careful control of genetic material can help to prevent the passing on of the genetic material that causes the problem.
In plants, genetic combinations are easy to control through specialized production environments. **For your final project in this lesson, your team will design and build an indoor environment for the genetic engineering of plants.**

**For example:**

In a field of corn, the pollen generally travels through the air to pollinate any of the plants growing within that field. The pollen may travel further, but it is very unlikely to pollinate any other type of plant within that area. If the entire field is planted with the same variety of corn, this is generally not a problem, but what if you wanted to produce a variety that was resistant to a particular disease? How could you be sure that the pollinated ears were pollinated with the very same plant, or another plant that you selected?

**Did you know that a single grain of pollen pollinates a single silk within an ear to produce one kernel of corn?**

In attempting to develop a disease-resistant strain, many different varieties are planted in the same field. In order to know which combination produced a particular genetic combination, plants are pollinated by hand.

**The process:**

1. When a corn stalk has reached a level of maturity where the tassel (anther) of the plant is developing pollen and the ears have formed, a sharp knife is used to cut off the top of the ear, exposing the silk.

2. The exposed silk is quickly covered with a plastic bag and allowed to grow out for at least 24 hours.

3. The tassel is carefully covered with a paper bag, labeled and stapled shut to collect the pollen.

4. When the silk is sufficiently grown out, the plant scientist carefully taps the bag against his or her hand, releasing the pollen from the tassel into the paper bag.

5. The paper bag is carefully removed to keep the pollen inside the bag, limiting exposure to other airborne materials.

6. With the paper bag of pollen poised close to the ear, the plastic bag is removed, and the paper bag takes its place, carefully stapled around the stalk.

Now that you know the procedure, your team will select a plant type, design, develop and construct an environment to allow this procedure to take place indoors.
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.3: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.4: Math for Engineering Design and Production

Name:____________________________________________________________________

1. Compute the area ($\text{area}_{\text{Rectangle}} = \text{length} \times \text{width}$) of a rectangle with the following lengths and widths:

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 cm</td>
<td>13 cm</td>
<td>52 cm²</td>
</tr>
<tr>
<td>18.5 m</td>
<td>13.2 m</td>
<td>244.2 m²</td>
</tr>
<tr>
<td>1.4 ft</td>
<td>2.3 ft</td>
<td>3.26 ft²</td>
</tr>
<tr>
<td>1.25 m</td>
<td>3.75 m</td>
<td>4.75 m²</td>
</tr>
</tbody>
</table>

2. Compute the area ($\text{area}_{\text{Triangle}} = \frac{1}{2} \times \text{base} \times \text{height}$) of a triangle with the following bases and heights:

<table>
<thead>
<tr>
<th>Base</th>
<th>Height</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 cm</td>
<td>5 cm</td>
<td>25 cm²</td>
</tr>
<tr>
<td>8.2 in</td>
<td>6.4 in</td>
<td>26.88 in²</td>
</tr>
<tr>
<td>3.7 m</td>
<td>2.5 m</td>
<td>9.625 m²</td>
</tr>
<tr>
<td>2.33 ft</td>
<td>3.67 ft</td>
<td>4.53 ft²</td>
</tr>
</tbody>
</table>

3. Compute the area ($\text{area}_{\text{Circle}} = \pi r^2$) of a circle with the following radii. Use the value 3.14 for $\pi$:

<table>
<thead>
<tr>
<th>Radius</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 cm</td>
<td>1.35 cm²</td>
</tr>
<tr>
<td>3.8 in</td>
<td>18.09 in²</td>
</tr>
<tr>
<td>9.1 m</td>
<td>253.1 m²</td>
</tr>
<tr>
<td>4.25 ft</td>
<td>56.5 ft²</td>
</tr>
</tbody>
</table>

4. Compute the surface area (sum of the areas of each side) of the following solids:

<table>
<thead>
<tr>
<th>Solid</th>
<th>Surface Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cube with 1.2 m side length</td>
<td></td>
</tr>
<tr>
<td>Rectangular prism with a length of 5 and a square base with each side measuring 2.1 in.</td>
<td></td>
</tr>
<tr>
<td>Rectangular prism with a length of 5 and a triangular base with each side measuring 2.1 in (triangle base = 2.1, height = 1.82)</td>
<td></td>
</tr>
<tr>
<td>Sphere of radius 2.3 cm (surface area of sphere = 4 $\pi r^2$)</td>
<td></td>
</tr>
</tbody>
</table>

5. Consider a model built to $\frac{1}{4}$ scale of a small shed. The model is represented by a rectangular prism that is 4ft wide, 3.5 ft in length and 2.1 ft in height. What is the surface area of the shed based on the dimensions of the scale model?
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.5: Manufacturing Systems and Model Production

The Challenge: To develop and use a manufacturing system to build scale models of animal shelters, demonstrating correct building procedures, with suitable materials.

Systems and Materials: The completed shelter must include a door, a window, a foundation, framing, and insulation.

Building Guidelines and Constraints: As this is a model, your completed structure will be ¹⁄₄ the size of the planned structure. Materials will be simulated, but will still be accurate in scale.

Wall framing studs are placed at 16” on center, and materials are assumed to be finished wood.

The outer covering will be plywood, with a shingled roof and a floor simulating a foundation.

The building plan:

The completed shelter will be 48” X 32”, standing 34” high, built at ¹⁄₄ scale.

The height from the floor to the top plate will be 18”, with the remaining 16” building the gable of the roof.

The door will be 12”X16”, centered in the front wall.
The window will be centered in the left wall, assuming a 6”X8” window.

Front Elevation

Side Elevation
Bill of Materials:

Determine the amount that you will need of each material and have your teacher check off the materials prior to beginning construction.

<table>
<thead>
<tr>
<th>Component</th>
<th>Material Type</th>
<th>Size/ # of unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framing studs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall cladding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Window</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing underlayment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shingles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sketch the layout of your studs here:

Using the measurements provided, determine the slope or angle of the roof.

Once your plan has been approved, you can start construction.
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.6: Construction Systems Research

Names: ____________________________________________

Purpose: To gain as much information as possible in a short amount of time, to exchange with the other teams in your class.

Scenario: You have been looking for a summer job, and a construction company has called you back. You need to learn as much as possible about construction materials and systems before your interview tomorrow.

Challenge: You will have 25 minutes to research products online to learn as much as possible about your assigned system or material.

Your assigned topic:

1. Describe the product/system.

2. How does it work?

3. How much does it cost?

4. Durability, how long will it last?

5. Advantages

6. Disadvantages, i.e. special equipment, toxicity, etc.

7. How does this product or system impact the people using the structure?
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.7: Reflective Writing – Construction and Production Environments

Name:___________________________________________________________________

Using complete sentences with correct grammar and punctuation, write a paragraph in response to each of the items below.

1. Select a product to be manufactured and describe conditions that could be important to that production environment.

2. Describe a way in which specialized equipment and practices have been used to improve the production of food, fiber, fuel, other useful products or in the care of animals.

3. Explain the components of a general manufacturing process.

4. Describe a situation where it could be beneficial to have a temporary rather than a permanent structure.

5. If you were living in a remote location and had to choose only one system to include in your residential structure, which system would you choose and why?
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.8: Lesson Design Brief
Part One: Exploration: Construction of Model Animal Shelters

The Problem: There are many systems, materials and codes necessary to build a safe environment for housing animals. Using a just-in-time manufacturing system, students will build models of animal shelters, including appropriate systems and construction types.

Design Constraints: As a just-in-time system, as little inventory (in this case, completed components) as possible should be stored before adding them to the model.

Each team will complete a series of components or specific parts to be integrated with each of the models.

The model will include a variety of materials and follow scaled construction standards, such as placing studs at 16” on center.

Incorporated components and systems include a door, a window, a foundation, framing, and insulation. Material is selected to represent specific materials in building construction.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

How will your team assign work to maintain the just-in-time inventory rule?

The building plan is generated from your Student Resource 5.3.5. Is yours correct and legible?

What can your Engineering Design Team do to ensure that your components are constructed to the correct scale?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, graph paper, mitre box and saw for Balsa and basswood, Balsa wood easy cutter, cyanacrylic all-purpose glue, tyvek mailing envelopes, straight plastic straws, transparencies, quilt batting, foam core board, binder clips, lawn and leaf bags, aquarium tubing, assorted sandpaper, hot melt glue guns and sticks, X-Acto knives, coping saws, scissors, rulers, corrugated cardboard, file folders, Balsa Wood. Other materials may be used - consult your teacher.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation.
The Assessment: Craftsmanship in construction of the model, as well as individual components will be analyzed as a group. In their Engineering Design Journals, students will reflect on the manufacturing process and changes that they would make in the future.

Part Two: Extension: Design and Build a Specialized Production Environment

The Problem: Many production environments have specialized controls such as clean rooms, temperature and moisture controls. Engineering Design Teams will use their knowledge of construction, manufacturing and production systems to design and build a system for a specialized production environment.

Design Constraints: Your teacher will determine the finished size of your greenhouse. It may be a tabletop model or a full-sized walk-in greenhouse, depending on time, materials and facility constraints.

The specific production environment to be addressed is for the controlled pollination of plants to produce novel genetic combinations, or to fight plant diseases.

The production environment must be able to isolate the necessary components, such as pollen and produce adequate conditions for plant growth, including ventilation and access to water and sunlight.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

Does your classroom have windows? How can you address sunlight without windows?

What kind of plants will you grow? How does this affect your design?

How will pollination be controlled in this greenhouse?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, gift-wrap tape, masking tape, school glue, graph paper, mitre box and saw for Balsa and basswood, Balsa wood easy cutter, cyanoacrylic all-purpose glue, tyvek mailing envelopes, straight plastic straws, foam core board, binder clips, plants for greenhouse, lawn and leaf bags, aquarium tubing, assorted sandpaper, 2 mil clear plastic sheeting, hot melt glue guns and sticks, X-Acto knives, coping saws, scissors, rulers, claw hammers, Balsa Wood and optional: For Full-sized greenhouse: 2”X 2” lumber, as needed. Other materials may be used - consult your teacher.

The Prototype: The prototype built by your Engineering Design Team should demonstrate the proof of concept, meaning that it shows that your design will do what you intend for it to do. Use care in building the prototype and test it prior to your presentation.

Part Three: Enrichment: Construction of Full-sized Animal Shelters

The Problem: Construction of full-sized shelters for animals requires a series of specific processes. Using the models as a guide, students will work in Engineering Design Teams to build animal shelters for use and distribute them through a local veterinary clinic or animal shelter.

Design Constraints: Always follow directions from your teacher in using hand or power tools. Listed materials include hand tools as needed.

The listed materials are for a specific sized shelter. Consult your teacher before making any changes.

Follow the design and model to complete your shelter, considering any issues that you had with those activities before beginning construction.

Things to Consider: All members of the Engineering Design Team bring different strengths to the group. What can you do to make the most of these strengths?

If your classroom is not set up to build something this large, where else might you work on this project?

What weather and climate considerations in your local area might impact the design of your shelter? Does it snow heavily or often? Is it humid? Is it hot or cold?

What can your team do to limit wasting of materials in constructing your shelter?

Always use appropriate safety equipment.

Materials: Engineering Design Journals, 3/8” plywood sheets, Foam insulation 1/2” X 24” X 48”, 2” X 2” X 4’ pressure-treated lumber, 1” X 6” X 10’ kiln dried lumber, Felt roof deck protection, 216 sq ft, #11, 1 ½” galvanized Roofing nails, 5 lb, Framing nails, 3”, 2M round head, box of 2000, #13 2” 6D Finishing nails, 1 lb, Exterior paint, 32 oz flat, light base, 2” polyester paintbrushes, 3 tab shingles, bundle covering 33.3 ft2, 10’ tape measure, 8 oz tubular steel claw hammers, and 14” crosscut hand saws. Other materials may be used - consult your teacher.

The Construction: Build this shelter as if you were building it for your own pet, or a friend’s pet. Use care in building the shelter and test it prior to your presentation.

The Presentation: Discuss your finished shelters as a class. What worked well? What would you change next time? Document your discussion in your Engineering Design Journal, prior to distributing houses to a local veterinary hospital or animal shelter.
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Student Resource 5.3.9: End of Unit Quiz

Name: ____________________________________________________________

Draw a diagram and explain the difference between each of the following:

1. First Class Lever

2. Second Class Lever

3. Third Class Lever

4. Describe 3 different simple machines and their purpose.
5. Complete the following Punnet Square diagrams:

Dimples (Dimples, D are dominant)

Mother DD

<table>
<thead>
<tr>
<th>Child 1</th>
<th>Child 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Father dd

How many children will have dimples?

Nearsightedness (Nearsightedness, N is dominant)

Mother nN

<table>
<thead>
<tr>
<th>Child 1</th>
<th>Child 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Father nN

How many children will be nearsighted?

Hitchhiker’s Thumb (Hitchhiker's Thumb, h is recessive)

Mother hh

<table>
<thead>
<tr>
<th>Child 1</th>
<th>Child 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Father Hh

How many children will have Hitchhiker’s Thumb?

6. Draw a diagram of the communication loop, labeling the components.
Define the following terms:

21. Sound

22. Miscommunication

23. Foundation

24. Framing

25. Genetic Engineering

26. Genetics

27. Manufacturing Process

28. Materials

29. Permanent Structure

30. Pollination

31. Production Environment

32. Temporary Structure

33. Vaccine

34. What is the correct spacing of wooden wall studs in standard residential construction?
Unit 5: Technological Systems in the Designed World

Lesson 3: Constructing Specialized Manufacturing Environments

Assessment Resource 5.3.1: Engineering Design Journal Rubric

Name______________________________

The purpose of the Engineering Design Journal is to serve as a documentation of the process. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration - reflection on manufacturing process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanation - notes and diagrams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension - notes and sketches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension - evidence of planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension - materials and construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension - design constraints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improvement in drawing skills over time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Includes notes and comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonus: Additional materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Grade:
### Assessment Resource 5.3.2: Manufacturing Systems and Model Production Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understood and selected appropriate materials to build model</strong></td>
<td>Materials were selected haphazardly, without consideration of use</td>
<td>Most materials address use</td>
<td>Materials were carefully selected to address design constraints</td>
</tr>
<tr>
<td><strong>Accurately described and completed the construction of the model</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Followed design constraints</strong></td>
<td>Minimally addressed constraints, kept mistakes</td>
<td>Addressed most constraints, made effort to repair any mistakes</td>
<td>Evidence of thoroughly following constraints</td>
</tr>
<tr>
<td><strong>Completed sketched and Bill of Materials</strong></td>
<td>Minimally addressed, missing major information or visuals needed to construct models</td>
<td>Somewhat addressed, missing some information or visuals needed to construct models</td>
<td>Thoroughly addressed, provides text and visual information needed to build all selected models</td>
</tr>
<tr>
<td><strong>Use of Related Information in determining size and materials</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td><strong>Ability to apply information gained in class with math and spatial concepts</strong></td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**
**Unit 5: Technological Systems in the Designed World**

**Lesson 3: Constructing Specialized Manufacturing Environments**

**Assessment Resource 5.3.3: Reflective Writing Rubric**

Name: ________________________________________________

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td>Ability to apply information gained in class to prior knowledge</td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect.</td>
<td>Some connections to prior knowledge or experience, some correct application to different context.</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**

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### Lesson 3: Constructing Specialized Manufacturing Environments

**Assessment Resource 5.3.4: Engineering Design Team Rubric**

Student Name: ____________________________

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
</tr>
</thead>
<tbody>
<tr>
<td>_____</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributions to the group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus on project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengths and weaknesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Contributions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Grade</td>
<td></td>
<td></td>
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</tbody>
</table>
Unit #6: The Refocus of NASA

Overview

NASA’s Space Shuttle Program, officially called Space Transportation System (STS), was the United States government’s manned launch vehicle program from 1981 to 2011. The termination of this 30 year long program was the culmination of influencing factors that arose from political, economical, and societal decisions.

This course will investigate space transportation systems in terms of systems, subsystems, innovations, effectiveness, and positive and negative consequences of technological development.

Big Idea
Space transportation systems, although highly sophisticated and technologically advanced, employ the basic subsystems found in conventional transportation systems.

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

Purpose of the Unit
Unit 6 challenges students to explore the new focus of NASA’s space program and analyze and evaluate future spacecraft from the perspective of systems and subsystems.
### Technology: Standards and Benchmarks for Technological Literacy (STL) *(ITEA/ITEEA, 2000/2002/2007)*

**STL8** Students will develop an understanding of the attributes of design.

8E Design is a creative planning process that leads to useful products and systems.

**STL12** Students will develop the abilities to use and maintain technological products and systems.

12J Use computers and calculators in various applications.

**STL13** Students will develop the abilities to assess the impact of products and systems.

13F Design and use instruments to gather data.

13G Use data collected to analyze and interpret trends in order to identify the positive and negative effects of a technology.

13H Identify trends and monitor potential consequences of technological development.

13I Interpret and evaluate the accuracy of the information obtained and determine if it is useful.

**STL18** Students will develop an understanding of and be able to select and use transportation technologies.

18G 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.

18I 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.

### Science: Benchmarks for Science Literacy *(AAAS, 1993/2009)*

**Scientific Enterprise (AAAS–1C)**

1C/M6 Computers have become invaluable in science, mathematics, and technology because they speed up and extend people’s ability to collect, store, compile, and analyze data; prepare research reports; and share data and ideas with investigators all over the world.

**Technology and Science (AAAS –3A)**

3A/M2 Technology is essential to science for such purposes as access to outer space and other remote locations, sample collections and treatment, measurement, data collection and storage, computation and communication of information.

3A/M3 Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. They also have to take human values and limitations into account.

**Design and Systems (AAAS-3B)**

3B/M1 Design usually requires taking into account not only physical and biological constraints, but also economic, political, social, and aesthetic ones.

3B/M2a All technologies have effects other than those intended by the design, some of which may have been predictable and some not.

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1 Material reprinted from *Benchmarks for Science Literacy* (AAAS, 1993, 2009) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, DC.
Common Core Standards - Mathematics (CCSM, 2011)

The Number System (CCSM, Grade 7)
7NS 1-d Apply properties of operations as strategies to add and subtract rational numbers.

Expressions and Equations (CCSM, Grade 7)
7EE 3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

Geometry (CCSM, Grade 7)
7G 1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

Common Core Standards - English Language Arts - Science and Technical Subjects (CCELA, 2011)

Key Ideas and Details (CCELA, Grade 7)
RST.6-8.3. Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure (CCELA, Grade 7)
RST.6-8.5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.

Integration of Knowledge and Ideas (CCELA, Grade 7)
RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Pre/Post Test

1. T F Propagation is a subsystem of transportation.
2. T F Processes, such as receiving, loading, and evaluating are necessary for the entire transportation system to operate efficiently.
3. T F Data collected from research can be used to identify positive and negative effects of a transportation system.
4. T F Design is a creative planning process that can lead to useful products and systems.
5. T F Collecting data and using instruments can help evaluate the accuracy of the information obtained and determine if it is useful.

Pre/Post Test KEY

1. F
2. T
3. T
4. T
5. T
Unit Objectives

**Lesson 1: Celebrating the Space Shuttle**
Students learn to:
- Use data collected from research to identify the positive and negative effects of Space Shuttle Missions.
- Interpret and evaluate information to determine if it is useful.
- Understand that space transportation involves people and goods and a combination of individuals and vehicles.
- Calculate speed and distance traveled by an asteroid in space.

**Student Assessment**
- Multiple Choice Response Items
- Presentation Rubric
- Written Report Rubric
- Performance Rubric
- Quiz

**Lesson 2: The Future of the Space Program**
Students learn to:
1. Understand NASA’s vision for the future of space exploration.
2. Explain that transportation systems move people and goods.
3. Explain that transportation systems are made up of subsystems that work together.
4. Explain that useful products and systems are the result of a creative planning process.

**Student Assessment**
- Engineering Design Journal
- Constructed Response items
- Performance Rubrics
- End of lesson quiz
- End of unit quiz
Unit 6: The Refocus of NASA

Lesson 1: Celebrating the Space Shuttle

Lesson Snapshot

Overview

Big Idea: The analysis of current technologies is essential to future technological change and innovation.

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


1. The journal can be a notebook that is dedicated specifically for the use of documenting design notes or as simple as several papers stapled together.
2. A journal is a place to record ideas, inspirations, discoveries, sketches, and notes. Students will use their journal to record thoughts and ideas as they work through their design projects. Some general guidelines students should follow are:
   a. Leave a few pages blank at the beginning to create a table of contents
   b. Date and sign each page
   c. Number each page
   d. Never remove pages
   e. Use an ink pen; do not erase

For deeper understanding, have students write the Big Idea in their EDJ, using their own words, if they choose.

Purpose of Lesson: This lesson enables students to understand the rationale behind the cancellation of the space shuttle program and to evaluate the effectiveness and accomplishments of the missions.

Lesson Duration: 3.5 - 4 hours.

Activity Highlights

Engagement
Students watch a video of the last Space Shuttle flight and engage in discussion about the reasons for the cancellation of the Space Shuttle Program.

Exploration
Students research and collect information about why the Space Shuttle Program was terminated then report their findings in class discussion.

Explanation
The teacher explains that technological change is constant, inevitable, and rapid. The teacher continues the discussion with a brief history of the Space Shuttle Program and highlights of the Shuttle missions. The explanation concludes with students sharing positive and negative effects /accomplishments of the Space Shuttle Program in a graphic organizer.
Extension
Working in a team, students are assigned a “Shuttle” and will become an expert on the history, accomplishments, and failures (positives and negatives) of that Shuttle’s missions. Teams will develop a presentation using their findings and share with the class.

Enrichment
Students will form teams and debate whether or not the Space Shuttle Program was a success or a waste of money.

Evaluation
The students’ knowledge, skills, and attitudes are assessed using Brief Constructed Response Items, Presentation Project, Performance Rubrics, and a Unit Quiz.
Lesson 1: Celebrating the Space Shuttle Program

Lesson Overview

Lesson Duration
4 hours.

Standards/Benchmarks

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

- **13G** Use data collected to analyze and interpret trends in order to identify the positive and negative effects of a technology.
- **13H** Identify trends and monitor potential consequences of technological development.
- **13I** Interpret and evaluate the accuracy of the information obtained and determine if it is useful.

**Science:** Benchmarks for Science Literacy *(AAAS, 1993/2009)*

- **Scientific Enterprise (AAAS – 1C)**
  - **1C/M6** Computers have become invaluable in science, mathematics, and technology because they speed up and extend people's ability to collect, store, compile, and analyze data; prepare research reports; and share data and ideas with investigators all over the world.

- **Technology and Science (AAAS – 3A)**
  - **3A/M2** Technology is essential to science for such purposes as access to outer space and other remote locations, sample collections and treatment, measurement, data collection and storage, computation and communication of information.

- **Design and Systems (AAAS – 3B)**
  - **3B/M2a** All technologies have effects other than those intended by the design, some of which may have been predictable and some not.

**Mathematics** Common Core Standards for Mathematics *(CCSM, 2011)*

- **Expressions and Equations (CCSM Grade 7)**
  - **7EE 3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

- **Geometry (CCSM, Grade 7)**
  - **7G 1** Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

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Learning Objectives
Students learn to:

- Use data collected from research to identify the positive and negative effects of Space Shuttle Missions.
- Interpret and evaluate information to determine if it is useful.
- Understand that space transportation involves people and goods and a combination of individuals and vehicles.
- Calculate speed and distance traveled by an asteroid in space.

Resource Materials

Audiovisual Materials


Print Materials


Internet Search Terms and Suggested Sites
1. Internet Search Items:
   a. Space Shuttle Program
   b. Terminating the Space Shuttle Program
   c. Shuttle Missions
   d. Positives and Negatives of the Space Shuttle Program
   e. Decision to terminate the Space Shuttle


**Required Knowledge and/or Skills**
Students should be able to search for information on the Internet. They should know how to use word processing and presentation software.
Unit 6: The Refocus of NASA

Lesson 1: Celebrating the Space Shuttle Program

5-E Lesson Plan

Teacher’s Note: Academic language is critical to student success in this lesson. Be sure to allow time for students to learn correct technical terms, as well as academic terms that may be unfamiliar or unclear. For the extension activity, any materials may be used, but uniform building materials such as LEGO}s may be easier for some students to use and interpret in diagrams.

Big Idea: The analysis of current technologies is essential to future technological change and innovation.

For deeper understanding, have students write the Big Idea in their EDJ, using their own words, if they choose.

If teacher has not already done so, teacher will discuss the following:

1. The journal can be a notebook that is dedicated specifically for the use of documenting design notes or as simple as several papers staples together.
2. A journal is a place to record ideas, inspirations, discoveries, sketches, and notes. Students will use their journal to record thoughts and ideas as they work through their design projects. Some general guidelines students should follow are:
   a. Leave a few pages blank at the beginning to create a table of contents
   b. Date and sign each page
   c. Number each page
   d. Never remove pages
   e. Use an ink pen; do not erase

The teacher may introduce the vocabulary at this time or at a time deemed appropriate. (Student Resource 6.1.2: Lesson Vocabulary)

Engagement

1. The teacher begins the lesson by showing the “FROG” video: STS 135- Launch Tribute.
2. After the video, the teacher initiates the conversation by asking for comments about the video.
3. The teacher continues by asking students what they know about the Space Shuttle Program, in terms of people, missions, flights, events, etc.
4. The teacher asks “why” the Space Shuttle Program was terminated, and who made that decision.

Link to video, STS 135- Launch Tribute
**Link to embed video, STS 135- Launch Tribute**
<script type="text/javascript" src="http://cdn-akm.vmixcore.com/vmixcore/js?auto_play=0&cc_default_off=1&player_name=uvp&width=512&height=332&player_id=1aa0b90d7d31305a75d7fa03bc403f5a&t=V0-6oML46ztsYRJ2xWTprTtnvZ16Fklh"></script>

**Exploration**
1. The teacher groups the students in teams of 3-4.
2. The teacher asks the teams to spend the next twenty minutes researching and collecting information about why the Space Shuttle Program was terminated.
3. Student teams share their findings with the class.

**Explanation**
1. The teacher explains that technological change is constant, difficult, and affected by a variety of circumstances. Choosing the technologies that will form the foundation of our future can be tough decisions to make. The criteria and strategies for making these decisions are affected by politics, economics, society, and a number of other influencing factors. Making difficult technological decisions, such as terminating the Space Shuttle Program, requires the decision-makers to give careful thought to the above mentioned entities. Sometimes those decisions are appropriate and sometimes they are not.
2. The Space Shuttle program has a 30-year legacy. The Space Shuttle Program began in 1972. In 2004, President Bush announced the Space Shuttle Program would end in 2010. In 2010, President Obama confirmed Bush’s plans and terminated the program.
3. Critics of the Program dismiss it as a costly failure, but its accomplishments were many.
   a. The logic for start-up of the initial Space Shuttle Program was clear: replace the Apollo-era one-shot rockets with a reusable space vehicle and this in turn would lead to cheap, reliable space-fare. But the shuttle was never reliable as hoped; maintaining the fleet took months instead of weeks, and the shuttle made an average fewer than five flights per year.
   b. Originally it was estimated that the space shuttle would carry payloads into orbit at a cost of $1,500 per kg, however that true cost was 40 times that.
   c. Two tragic accidents forced NASA to ground the shuttles for a combined total of five yeas. The final cost of the program was estimated to be over $200 billion.
   d. The shuttle had many achievements. It carried three of NASA’s great observatories into orbit – the Hubble Space Telescope, the Compton Gamma Ray Observatory and the Chandra X-ray Observatory. Several spacecraft also were carried by the shuttle into orbit; the *Galileo* probe went to Jupiter, *Magellan* mapped Venus and the European Space Agency's *Ulysses* conducted the first survey of the sun’s environment. Additionally, hundreds of small-scale lab experiments were conducted on the space shuttle.
   e. Most importantly, the shuttle did the heavy lifting for the International Space Station (ISS), our orbital space lab.
4. The teacher explains that six shuttles were built. Their names, in the order they were built, are *Enterprise, Columbia, Challenger, Discovery, Atlantis*, and *Endeavour*. The teacher gives a brief overview of each shuttle’s mission. *Atlantis*, the teacher explains, carried the Hubble Telescope; students complete a worksheet that refers to a Hubble discovery.
   a. The *Enterprise* was flown only within Earth’s atmosphere, during shuttle approach and landing tests conducted in 1977.
b. *Columbia* flew the first five Shuttle missions, beginning in April 1981, and was modified to fly extended-duration missions as long as 16 days. *Columbia* and its seven-member crew were lost during reentry on February 1, 2003.

c. *Challenger* was built as a vibration-test vehicle and then upgraded to become the second operational Shuttle. The *Challenger* and its seven-member crew were lost in a launch accident on January 28, 1986.


5. *Atlantis* followed in October 1985. *Atlantis* carried the Hubble Telescope into orbit. Teacher gives students a worksheet to complete. Students may work in groups or individually. (Student Resource 6.1.3: Worksheet - The Speed of an Asteroid), (Teacher Resource 6.1.1: The Speed of an Asteroid Key)
a. *Endeavour*, built to replace *Challenger*, made its debut in May 1992 with a dramatic mission that featured the rescue of a stranded Intelsat 6 commercial communications satellite.

6. The teacher reminds students that the space shuttles were originally designed for space transportation that would be reusable and save money.

7. Teacher assigns students in groups of 2-3 and asks groups to research positive and negative aspects of the Space Shuttle Program.

8. After 10-15 minutes, research stops.

9. The teacher draws a chart on the board and writes two categories; Positives and Negatives.

10. Each group records its findings in the appropriate column.

11. The class discusses the findings.

**Extension**

1. Teacher passes out Student Resource 6.1.4: Research Project and Presentation Guidelines and reviews with class.

2. The teacher groups students into six different teams. Each team is assigned a "shuttle" to explore. Teams will research their assigned shuttle to discover the following information in order to become “experts” on their shuttles:
   a. Date the shuttle was built and date last mission was flown
   b. Three detailed, notorious events of the shuttle
   c. Successes, failures, tragedies
   d. Longest length of time spent in space
   e. Place of the shuttle’s retirement

3. Teams will create a presentation based on their findings via poster, PPT, oral presentation, etc.

4. A written report of the presentation will be submitted also.

5. When presentations are complete all students participate in a discussion to evaluate each space shuttle mission.

6. Class participation is assessed with Assessment Resource 6.1.1: Class Participation Rubric.

7. Presentations are evaluated by rubric (Assessment Resource 6.1.2: Research Project and Presentation Rubric)

8. Written reports are evaluated by rubric (Assessment Resource 6.1.3: Research Project Written Report Rubric)

9. Students will complete a Brief Constructed Response (BCR) item: What did we learn from the Space Shuttle missions that can justify the more than $200 billion-dollar plus price tag for each launch? (Student Resource 6.1.5: BCR, Assessment Resource 6.1.4 - Brief Constructed Response Rubric).


**Enrichment**
1. Students will form debate teams to discuss effects of the Space Shuttle Program.
2. A suggested topic might be: Was the Space Shuttle Program a worthwhile endeavor?
3. Some students will be advocates of NASA and some will be angry politicians or community members.
4. Students will research their parts, whether they are pro or con.
5. Students will practice the debate, then present to teachers, principals, and parents.

**Evaluation**
Student knowledge, skills, and attitudes are assessed using true/false, brief constructed response, and rubrics. 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.

1. Assessment Resource 6.1.1: Class Participation Rubric

<table>
<thead>
<tr>
<th>Class Participation Rubric</th>
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<tbody>
<tr>
<td>Name</td>
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<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
2. Assessment Resource 6.1.2: Research Project and Presentation Rubric

<table>
<thead>
<tr>
<th>Research Project and Presentation Rubric</th>
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<tbody>
<tr>
<td>Presenters</td>
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<td></td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Complete – all areas addressed</td>
</tr>
<tr>
<td>Most areas well done</td>
</tr>
<tr>
<td>Some areas well done</td>
</tr>
<tr>
<td>Minimal effort</td>
</tr>
<tr>
<td>Documented date shuttle was built</td>
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<tr>
<td>and date last mission was flown</td>
</tr>
<tr>
<td>Includes three detailed descriptions</td>
</tr>
<tr>
<td>of notorious events of the shuttle</td>
</tr>
<tr>
<td>Describes in detail: successes,</td>
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<tr>
<td>failures, tragedies</td>
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<tr>
<td>Documented problems, successes,</td>
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<tr>
<td>and failures</td>
</tr>
<tr>
<td>Documented longest length of time</td>
</tr>
<tr>
<td>spent in space</td>
</tr>
<tr>
<td>Described final resting place, date</td>
</tr>
<tr>
<td>A relevant video is included</td>
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<tr>
<td>Documented at least three sources</td>
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<tr>
<td>of information</td>
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<tr>
<td>Was the presentation professional?</td>
</tr>
<tr>
<td>Did not read from slides</td>
</tr>
<tr>
<td>Vocal presentation - clear, relevant</td>
</tr>
<tr>
<td>Was able to answer questions about</td>
</tr>
<tr>
<td>the topic</td>
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<tr>
<td>Total</td>
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<tr>
<td>Comments:</td>
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<tr>
<td>Grade:</td>
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3. Assessment Resource 6.1.3: Research Project Written Report

<table>
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<tr>
<th>Research Project Written Report</th>
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<tbody>
<tr>
<td>Name</td>
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<td></td>
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<tr>
<td>4</td>
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<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Excellent organization</td>
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<tr>
<td>enhances readability and/or</td>
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<tr>
<td>understandability of report.</td>
</tr>
<tr>
<td>Content appropriate to all</td>
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<tr>
<td>section of report.</td>
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<tr>
<td>Some content placed incorrectly</td>
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<td>in report.</td>
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<td>Inappropriate content of</td>
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<td>several sections of report.</td>
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<tr>
<td>Unique format aspects that</td>
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<tr>
<td>enhance report impact.</td>
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<tr>
<td>Followed specified format.</td>
</tr>
<tr>
<td>A few format errors.</td>
</tr>
<tr>
<td>So many format errors as to</td>
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<tr>
<td>make report ineffective.</td>
</tr>
</tbody>
</table>
Spelling | No spelling errors. | 1-2 spelling errors. | 3-4 spelling errors. | Many spelling errors. 
---|---|---|---|---
Grammar and Punctuation | No grammar or punctuation errors. | Minor grammar or punctuation errors. | A few significant grammar and punctuation errors. | Pages or paragraphs with multiple grammar and punctuation errors. 
Content | All required documentation is included. | Most required documentation is included. | Some documentation is included. | Very little documentation is included. 
Total

Comments:

Grade:

4. Assessment Resource 6.1.4: Brief Constructed Response Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
5. Assessment Resource 6.1.5: Engineering Design Journal Rubric

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<td>Most areas well done</td>
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<td>Some areas well done</td>
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<td></td>
<td>Minimal effort</td>
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<td>Not attempted, missing</td>
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<td></td>
<td>Research notes pertaining to Space Shuttle termination</td>
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<tr>
<td></td>
<td>Speed of an Asteroid - math notes, problems 1 and 2</td>
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<td>Research notes pertaining to positive and negative aspects of Space Shuttle Program</td>
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<td>Research notes for Debate Team activity</td>
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<td>Ability to understand and interpret images, notes, and sketches</td>
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<td>Bonus: Additional materials</td>
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</tbody>
</table>
Unit 6: The Refocus of NASA

Lesson 1: Celebrating the Space Shuttle Program

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content. Gather recyclable materials to represent a variety of categories.

Ideally, the classroom setting will provide opportunities for both individual and group work and have resources to show DVDs and presentations.

Tools/Materials/Equipment
- Computer with Internet access
- Presentation projector
- Library resources such as books, magazines, CDs, and manuals
- Poster paper
- Markers
- Rulers
- Scissors

Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson-appropriate tasks
d. Students work as part of a team to contribute to a proposed solution to a problem.

Teacher Resources
- Teacher Resource 6.1.1: The Speed of an Asteroid - Key
- Teacher Resource 6.1.2: End-of-Lesson 1 Quiz - Key

Student Resources
- Student Resource 6.1.1: Engineering Design Journal Guidelines
- Student Resource 6.1.2: Lesson Vocabulary
- Student Resource 6.1.3: Worksheet - The Speed of an Asteroid
- Student Resource 6.1.4: Research Project and Presentation Guidelines
- Student Resource 6.1.5: Brief Constructed Response
- Student Resource 6.1.6: End-of-Lesson 1 Quiz

Assessment Resources
- Assessment Resource 6.1.1: Class Participation Rubric
- Assessment Resource 6.1.2: Research Project and Presentation Rubric
- Assessment Resource 6.1.3: Research Project Written Report Rubric
- Assessment Resource 6.1.4: Brief Constructed Response Rubric
- Assessment Resource 6.1.5: Engineering Design Journal Rubric
Lesson 1: Celebrating the Space Shuttle
Teacher Resource 6.1.1: The Speed of an Asteroid Key

Answer Key - The Speed of an Asteroid

Problem 1 - At the distance of the asteroid, this field would measure about 110,000 kilometers across. How many kilometers did the asteroid travel during the time of the exposure?

Answer: Students will have to convert the length of the streak into kilometers using the scale of the image. Use a millimeter ruler to determine the scale of the image by first measuring the width of the image to get 118 millimeters. This physical length is equal to 110,000 kilometers, so the image scale is just 110,000 km/118 millimeters = 932 km/mm. The length of the asteroid streak is 20 millimeters, so its length is 20 x (932 km/mm) = 18,640 kilometers.

Problem 2 - What was the approximate speed of the asteroid in kilometers/hour from the beginning to the end of the trail?

Answer: The paragraph says that the exposure took 40 minutes, so during that time the asteroid moved the distance indicated in Problem 1. The speed is then 18,640 Kilometers/0.66 hours = 28,200 km/hr.
Name:__________________________________

1. **What does NASA stand for?**  
   a. National and Space Association  
   b. National Aeronautics Space Administration  
   c. National Association of Space Administration  
   **d. National Aeronautics and Space Administration**

2. **The acronym for the orbiting space station used for scientific and space research**  
   a. OSS  
   **b. ISS**  
   c. SIS  
   d. STS

3. **The space shuttles had many assignments. These were called**  
   a. Objectives  
   b. Payloads  
   c. Function  
   **d. Missions**

4. **The precise period of time, ranging from minutes to hours, within which a launch must occur for a rocket or space shuttle to be positioned in the proper orbit is called the**  
   a. Timeframe  
   b. **Launch window**  
   c. Allocated space allowance  
   d. Space bracket

5. **Each launch is assigned a number that begins with the letters**  
   a. **STS**  
   b. TSL  
   c. STL  
   d. TST
6. How many years was the Space Shuttle Program active?
   a. 50
   b. 32
   c. 41
   d. 30

7. Christa McAuliffe was scheduled to be the first teacher to fly in space; she was aboard this shuttle when it exploded.
   a. Challenger
   b. Discovery
   c. Endeavor
   d. Atlantis

8. A space telescope was carried into space in 1990 by which shuttle
   a. Challenger
   b. Discovery
   c. Endeavor
   d. Atlantis

9. The Hubble telescope orbits which object in the solar system?
   a. sun
   b. earth
   c. moon
   d. mars

10. The total complement of equipment carried by a spacecraft for the performance of a particular mission in space is termed
   a. goods
   b. inputs
   c. payload
   d. capital

11. Three of the shuttles were named Discovery, Endeavor, and Enterprise. The remaining three shuttle names are
   a. Columbia, Challenger and Kearsarge
   b. Atlantis, Challenger, and Columbia
   c. Columbus, Extemeter, and Atlantis
   d. Indemnity, Columbia and Challenger

12. Where did the space shuttles commonly land?
   a. Atlantic Ocean
b. Briggs Space Center  

**c. Kennedy Space Center**  

d. White Sands Space Harbor  

13. **Like any other object in low-Earth orbit, a space shuttle must reach speeds**  
of about __________ to remain in orbit.  

a. 53,000 mph  

b. 12,000 mph  

c. 32,000 mph  

**d. 17,500 mph**  

14. **The space shuttle program is officially known as**  

a. the Space Voyager (SV)  

**b. the Space Transportation System (STS)**  

c. Starpath (SPT)  

d. the Gateway to ISS (GISS)  

15. **Liquid hydrogen and liquid oxygen make up most of a shuttle’s fuel; this**  
makes the exhaust of the launch  

a. a mixture of more gas than water  

b. **mostly water vapor**  

c. a flammable mixture of gas vapors  

d. there is no exhaust on a shuttle  

16. **Which shuttle was the first to be built?**  

a. **Columbia**  

b. **Atlantis**  

**c. Enterprise**  

d. None of the above  

17. **Which two shuttles ended in fatal disasters?**  

a. **Atlantis, Columbia**  

b. **Discovery, Challenger**  

c. **Columbia, Endeavor**  

d. **Challenger, Columbia**  

18. **Due to the speed of the shuttles, the crews were able to see a sunset or sunrise every**  
a. 12 hours  

b. **45 minutes**  

c. hour
d. 5 minutes

19. The space shuttle’s Thermal Protection System, or heat shield, contains what approximate number of sand tiles?
   a. 30,000
   b. 50,000
   c. 15,000
   d. 300,000

20. The space shuttle has landed on the moon how many times?
   a. 2 times
   b. 12 times
   c. 5 times
   d. Never
Unit 6: The Refocus of NASA

Lesson 1: Celebrating the Space Shuttle

Student Resource 6.1.1: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures, and references.

1. Using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 6: The Refocus of NASA

Lesson 1: Celebrating the Space Shuttle

Student Resource 6.1.2: Lesson Vocabulary

Accomplishment - something done admirably or creditably.

International Space Station (ISS) - an orbiting space station, construction of which began in 2001 with the cooperation of 16 nations; used for scientific and space research.

Launch - to send forth, catapult, or release; to set going; initiate.

Legacy - the lasting effects an event leaves behind after it's finished.

Mission - an operation designed to carry out the goals of a specific program.

NASA - National Aeronautics and Space Administration.

Orbiter - Also called space shuttle orbiter; the crew and payload-carrying component of the space shuttle; a space probe designed to orbit a planetary body or moon.

Payload - the total complement of equipment carried by a spacecraft for the performance of a particular mission in space.

Space Shuttle - any of several U.S. space vehicles consisting of a reusable manned orbiter that touches down on a landing strip after an orbital mission, two reusable solid rocket boosters that drop off after initial ascent, and an expendable external tank containing liquid propellants.

Space Transportation System (STS) - NASA’s name for the overall Shuttle Program.

Terminate - to bring to an end; put an end to.
This is an image of a star-field in the constellation Centaurus taken by the Hubble Space Telescope in 1994. In addition to the bright stars, the streak of a single asteroid can also be seen (circled in yellow). The Hubble has “accidentally” detected over 100 asteroids as its cameras have been looking at other targets. Many of the asteroids are new discoveries. The curvature of the asteroid’s trail as it moved across the sky was caused by parallax changes as the telescope orbited Earth during the 40-minute exposures. The field is 2.7 arc-minutes on a side, and the distance to the asteroid was estimated to be 140 million kilometers from Earth. Based on the faintness of the asteroid at this distance, it was probably only 2 kilometers across!

**Problem 1** - At the distance of the asteroid, this field would measure about 110,000 kilometers across. How many kilometers did the asteroid travel during the time of the exposure?

**Problem 2** - What was the approximate speed of the asteroid in kilometers/hour from the beginning to the end of the trail?
Lesson 1: Celebrating the Space Shuttle

Student Resource 6.1.4: Research Project and Presentation Guidelines

The purpose of this project is to promote an accurate understanding and awareness of the space shuttle missions.

Each team will research, present, and submit a report on an assigned shuttle. Each team member is expected to participate equally in the effort.

Presenting material requires careful preparation and planning to effectively communicate to your audience.

In completing your research/presentation project:

1. Research the following information:
   a. Date the shuttle was built and date last mission was flown
   b. Three detailed, notorious events of the shuttle
   c. Successes, failures, tragedies
   d. Longest length of time spent in space
   e. Place of the shuttle’s retirement
   f. Include a video, if relevant

2. Choose a format for your presentation, such as poster, oral, PPT, etc.

3. Use both Internet and print resources to document your research.

4. Cite at least three sources in your written report.

5. Remember that spell check finds misspelled words; it does not find incorrect words.

6. Read your report carefully, or have someone else read it before turning it in.

7. Know your information; do not read from the slides.

8. Be prepared to answer questions about your topic.

Citing References:
When citing an electronic document such as a website, blog, or YouTube video, use this format in the References list:

   Author, Title, Retrieved on date from http://

When citing print materials, use this format in the References list:

   Author. (Year of Publication). Title, City of Publisher, State of Publisher: Name of Publishing Company.
Unit 6: The Refocus of NASA

Lesson 1: Celebrating the Space Shuttle

Student Resource 6.1.5: Brief Constructed Response

Reflect on the following statement. Write a one-paragraph answer. Include a strong topic sentence with good supporting details to support your answer.

What did we learn from the Space Shuttle missions that can justify the more than $200 billion-dollar plus price tag for each launch?
Name: __________________________________________

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   a. National and Space Association
   b. National Aeronautics Space Administration
   c. National Association of Space Administration
   d. National Aeronautics and Space Administration

2. The acronym for the orbiting space station used for scientific and space research
   a. OSS
   b. ISS
   c. SIS
   d. STS

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   a. Objectives
   b. Payloads
   c. Function
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   b. TSL
   c. STL
   d. TST

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   a. 50
   b. 32
   c. 41
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   c. Endeavor  
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   b. Discovery  
   c. Endeavor  
   d. Atlantis  

9. The Hubble telescope orbits which object in the solar system?  
   a. sun  
   b. earth  
   c. moon  
   d. mars  

10. The total complement of equipment carried by a spacecraft for the performance of a particular mission in space is termed  
    e. goods  
    f. inputs  
    g. payload  
    h. capital  

11. Three of the shuttles were named Discovery, Endeavor, and Enterprise. The remaining three shuttle names are  
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    b. Atlantis, Challenger, and Columbia  
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    b. Briggs Space Center  
    c. Kennedy Space Center  
    d. White Sands Space Harbor
13. Like any other object in low-Earth orbit, a space shuttle must reach speeds of about _________ to remain in orbit.
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   b. 12,000 mph  
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14. The space shuttle program is officially known as
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   b. the Space Transportation System (STS)  
   c. Starpath (SPT)  
   d. the Gateway to ISS (GISS)

15. Liquid hydrogen and liquid oxygen make up most of a shuttle’s fuel; this makes the exhaust of the launch
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   b. mostly water vapor  
   c. a flammable mixture of gas vapors  
   d. there is no exhaust on a shuttle

16. Which shuttle was the first to be built?
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17. Which two shuttles ended in fatal disasters?
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   b. Discovery, Challenger  
   c. Columbia, Endeavor  
   d. Challenger, Columbia

18. Due to the speed of the shuttles, the crews were able to see a sunset or sunrise every
   a. 12 hours  
   b. 45 minutes  
   c. hour  
   d. 5 minutes

19. The space shuttle's Thermal Protection System, or heat shield, contains what approximate number of sand tiles?
a. 30,000
b. 50,000
c. 15,000
d. 300,000

20. The space shuttle has landed on the moon how many times?
   a. 2 times
   b. 12 times
   c. 5 times
   d. Never
## Lesson 1: Celebrating the Space Shuttle

### Assessment Resource 6.1.1: Class Participation Rubric

<table>
<thead>
<tr>
<th>Name</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:
## Unit 6: The Refocus of NASA

### Lesson 1: Celebrating the Space Shuttle

**Assessment Resource 6.1.2: Research Project and Presentation Rubric**

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<th>Research Project and Presentation Rubric</th>
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<th>3</th>
<th>2</th>
<th>1</th>
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<tr>
<td><strong>Complete. All areas addressed.</strong></td>
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<tr>
<td><strong>Most areas well done.</strong></td>
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<tr>
<td><strong>Some areas well done.</strong></td>
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<tr>
<td><strong>Minimal effort.</strong></td>
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<tr>
<td><strong>Documented date shuttle was built and date last mission was flown</strong></td>
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<tr>
<td><strong>Includes three detailed descriptions of notorious events of the shuttle</strong></td>
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<tr>
<td><strong>Describes in detail: successes, failures, tragedies</strong></td>
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<tr>
<td><strong>Documented problems, successes, and failures</strong></td>
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<tr>
<td><strong>Documented longest length of time spent in space</strong></td>
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<tr>
<td><strong>Described final resting place, date</strong></td>
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<tr>
<td><strong>A relevant video is included</strong></td>
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<tr>
<td><strong>Documented at least three sources of information</strong></td>
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</tr>
<tr>
<td><strong>Was the presentation professional?</strong></td>
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<tr>
<td><strong>Did not read from slides</strong></td>
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<tr>
<td><strong>Vocal presentation - clear, relevant</strong></td>
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<tr>
<td><strong>Was able to answer questions about the topic</strong></td>
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Grade:
### Assessment Resource 6.1.3: Research Project Written Report Rubric

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<th>Research Project Written Report</th>
<th>Name</th>
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</thead>
<tbody>
<tr>
<td><strong>Organization</strong></td>
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</tr>
<tr>
<td>Excellent organization enhances readability and/or understandability of report.</td>
<td>Content appropriate to all sections of report.</td>
</tr>
<tr>
<td><strong>Format</strong></td>
<td>Unique format aspects that enhance report impact.</td>
</tr>
<tr>
<td><strong>Spelling</strong></td>
<td>No spelling errors.</td>
</tr>
<tr>
<td><strong>Grammar and Punctuation</strong></td>
<td>No grammar or punctuation errors.</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>All required documentation is included.</td>
</tr>
</tbody>
</table>

**Total**

**Comments:**

Grade:
Unit 6: The Refocus of NASA

Lesson 1: Celebrating the Space Shuttle

Assessment Resource 6.1.4: Brief Constructed Response Rubric

<table>
<thead>
<tr>
<th>BCR Rubric</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Below Target</td>
</tr>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>
Lesson 1: Celebrating the Space Shuttle

Assessment Resource 6.1.5: Engineering Design Journal Rubric

Name___________________________________________

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help to think about the project. Do not assume that something is insignificant; it may be the key to the finished design.

2. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

3. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

<table>
<thead>
<tr>
<th>Engineering Design Journal Rubric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Assessment:</td>
</tr>
<tr>
<td>Completed all areas addressed</td>
</tr>
<tr>
<td>Most areas well done</td>
</tr>
<tr>
<td>Some areas well done</td>
</tr>
<tr>
<td>Minimal effort</td>
</tr>
<tr>
<td>Not attempted, missing</td>
</tr>
<tr>
<td>Research notes pertaining to Space Shuttle termination</td>
</tr>
<tr>
<td>Speed of an Asteroid - math notes, problems 1 and 2</td>
</tr>
<tr>
<td>Research notes pertaining to positive and negative aspects of Space Shuttle Program</td>
</tr>
<tr>
<td>Research notes for Debate Team activity</td>
</tr>
<tr>
<td>Ability to understand and interpret images, notes, and sketches</td>
</tr>
<tr>
<td>Bonus: Additional materials</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Comments:

Grade:
## Technology Systems: Unit - Lesson 1

### Materials/Supplies List

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Vendor (use key)</th>
<th>Qty. per 25 Students</th>
<th>Approx. price (total)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MATERIALS/SUPPLIES</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Poster paper</td>
<td>DS, OSS</td>
<td>12 sheets</td>
<td>10.00</td>
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<tr>
<td>Markers</td>
<td>DS, OSS</td>
<td>4 sets</td>
<td>12.00</td>
</tr>
<tr>
<td>Library resources such as books, magazines, CDs</td>
<td>free</td>
<td></td>
<td>free</td>
</tr>
<tr>
<td><strong>TOOLS</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>*Strong scissors</td>
<td>BSS, CHS, DS, TEC</td>
<td>8</td>
<td>3.00 ea</td>
</tr>
<tr>
<td>*Rulers</td>
<td>BSS, CHS, DS, TEC</td>
<td>10</td>
<td>1.00 ea</td>
</tr>
<tr>
<td>*Computer w/Internet Access</td>
<td>OSS</td>
<td></td>
<td>At least 1</td>
</tr>
<tr>
<td>*Presentation projector</td>
<td>OSS</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

### Vendor Key

BSS = Building Supply Store (Lowe’s, Home Depot, etc.)
CHS = Craft/Hobby Store (Michael’s, AC Moore, Jo Ann’s Fabric and Crafts, etc.)
DS = Department Store (WalMart, Target, KMart, etc.)
GS = Grocery Store (Super WalMart, Krugers, Giant, Stop & Shop, Safeway, etc.)
TEC = Technology Education Store (Kelvin, Paxton/Patterson, Pitsco, IASCO, etc.)
OSS = Office Supply Store (Office Depot, Staples, PaperMart, etc.)

*indicates a material that is also used in another lesson.
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Lesson Snapshot

Overview

**Big Idea:** Transportation systems are made up of subsystems that work together to function as a whole.

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


1. The journal can be a notebook that is dedicated specifically for the use of documenting design notes or as simple as several papers staples together.
2. A journal is a place to record ideas, inspirations, discoveries, sketches, and notes. Students will use their journals to record thoughts and ideas as they work through their design projects. Some general guidelines students should follow are:
   a. Leave a few pages blank at the beginning to create a table of contents
   b. Date and sign each page
   c. Number each page
   d. Never remove pages
   e. Use an ink pen; do not erase

*For deeper understanding of the Unit, have students write the Big Idea in their EDJs, using their own words, if they choose.*

**Purpose of Lesson:** This lesson highlights NASA’s vision for its future space program. The lesson will familiarize students with future space transportation systems and how they will support human space travel.

**Lesson Duration:** 9-10 hours.

**Activity Highlights**

**Engagement**

Students will explore the new vision and focus of NASA since the retirement of the space shuttle program.

**Exploration**

Students identify specific areas of focus for NASA’s new space program. Students identify the space transportation vehicles NASA proposes and speculate how each must function together as a system to work effectively.

**Explanation**

The teacher explains that transportation systems are used to move people or goods. The teacher expands on NASA’s new vision of the space program, giving a brief description of each area. The teacher briefly explains the relationship between moving people and goods and the future space transportation systems as well as that systems are made up of subsystems.
**Extension**
Students will work in teams to design, develop, and test a space launch subsystem and devise a presentation that explains the connection to a subsystem and describes the evolution of their design solution.

**Enrichment**
Students will design a “future” spacecraft and illustrate and explain its subsystems.

**Evaluation**
The students’ knowledge, skills, and attitudes are assessed using Engineering Design Journals, Constructed Response items, Performance Rubrics, an End-of-Lesson Quiz, and an End-of-Unit Quiz.
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Lesson Overview

Lesson Duration
9-10 hours

Standards/Benchmarks

<table>
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<tbody>
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<td>8E</td>
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<td>18F</td>
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<tr>
<td>18G</td>
</tr>
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<td>18I</td>
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<table>
<thead>
<tr>
<th>Science: Benchmarks for Science Literacy (AAAS, 1993/2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1C/M6</td>
</tr>
<tr>
<td>3A/M2</td>
</tr>
<tr>
<td>3A/M3</td>
</tr>
</tbody>
</table>

| Mathematics | Common Core Standards for Mathematics (CCSM, 2011) |
|---|
| The Number System (CCSM, Grade 7) |
| 7NS 1-d | Apply properties of operations as strategies to add and subtract rational numbers. |
| Expressions and Equations (CCSM, Grade 7) |
| 7EE 3 | Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate |
with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

### Geometry (CCSM, Grade 7)

| 7G 1 | Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. |

### English Language Arts - Science and Technical Subjects

**Common Core Standards-English Language Arts - (CCELA, 2011)**

<table>
<thead>
<tr>
<th>Key Ideas and Details (CCELA, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RST.6-8.3. Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Craft and Structure (CCELA, Grade 7)</th>
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</thead>
<tbody>
<tr>
<td>RST.6-8.5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Integration of Knowledge and Ideas (CCELA, Grade 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).</td>
</tr>
</tbody>
</table>

### Learning Objectives

Students learn to:

1. Understand NASA’s vision for the future of space exploration.
2. Explain that transportation systems move people and goods.
3. Explain that transportation systems are made up of subsystems that work together.
4. Explain that useful products and systems is the result of a creative planning process.

### Resource Materials

**Audiovisual Materials**


**Print Materials**


**Internet Search Terms and Suggested Sites**

1. Internet Search Items:
   a. Future focus of NASA
   b. NASA’s new focus
   c. NASA’s new space program
   d. Human Exploration
   e. International Space Station
f. Science Mission
g. NASA Aeronautics

2. Suggested Sites:

**Required Knowledge and/or Skills**

Students should be able to search for information on the Internet. They should know how to use word processing and presentation software. Students should demonstrate the ability to wear and use safety equipment as appropriate. Students should understand and demonstrate the safe use of appropriate tools and equipment.
Lesson 2: The Future of the Space Program

5-E Lesson Plan

Teacher’s Note: Academic language is critical to student success in this lesson. Be sure to allow time for students to learn correct technical terms, as well as academic terms that may be unfamiliar or unclear. For the extension activity, any materials may be used, but uniform building materials such as LEGO may be easier for some students to use and interpret in diagrams.

Big Idea: Transportation systems are made up of subsystems that work together to function as a whole.

For deeper understanding, have students write the Big Idea in their EDJ, using their own words, if they choose.

If teacher has not already done so, teacher will discuss the following:

1. The journal can be a notebook that is dedicated specifically for the use of documenting design notes or as simple as several papers staples together.
2. A journal is a place to record ideas, inspirations, discoveries, sketches, and notes. Students will use their journals to record thoughts and ideas as they work through their design projects. Some general guidelines students should follow are:
   a. Leave a few pages blank at the beginning to create a table of contents
   b. Date and sign each page
   c. Number each page
   d. Never remove pages
   e. Use an ink pen; do not erase

The teacher may introduce the vocabulary at this time or at a time deemed appropriate.
(Student Resource 6.2.2, Lesson Vocabulary)

Engagement

1. The teacher begins the lesson by showing the “FROG” video Budget Video 2013.
2. The teacher asks all students to jot down important highlights of the video.
3. When the video is over, the teacher guides a discussion about the new vision and the future focus of NASA.
4. The teacher uses the board or overhead to create a list based on student discussion about video. The list should be titled: Future Focus of NASA.
5. The teacher asks students what they remember from the video in terms of NASA’s new focus, since the space shuttle is no longer in operation.
6. As students recall the new focus content, a student volunteer writes the remarks on the board.

To embed Budget Video 2013:
Exploration
1. The class discusses its “new focus” list from the Engagement section.
2. The teacher makes another chart on the board; this list has four columns titled: Human Exploration, International Space Station, Science Missions, and NASA Aeronautics.
3. Students form “Buzz” groups (Buzz groups are simply small groups of two or three students formed in an impromptu fashion to discuss a topic for a short period.) (see Teacher Resource 6.2.1: Buzz Groups)
4. Each group is given one of the four topics; some groups may have the same topic depending on the size of the class.
5. At this point, it may be necessary to view the video again, as the video content is pertinent to the discussion.
6. Groups are given a few minutes to “buzz” about the ideas from the original list and where they fit in the new list.
7. The class comes together as a whole to discuss the new list.
8. Teams work again as “buzz” groups to discuss two topics:
   a. How will the changes in NASA’s focus affect the future of mankind?
   b. How will the future space systems in NASA’s vision function together to accomplish NASA’s goals?
   c. How does the term “subsystem” relate to NASA’s new vision?
9. Groups take 10 minutes to discuss the topic and then all groups share their ideas with the class.

Explanation
1. The teacher confirms the students’ ideas about the new focus of NASA.
2. The teacher states: transportation systems are used to move people or goods and all transportation systems have subsystems.
3. The teacher explains: The end of the space shuttle program does not mean the end of NASA, or even of NASA sending humans into space. NASA has a robust program of exploration, technology development, and scientific research that will last for years to come.
4. The teacher explains that NASA has a vision to develop new ways to transport people and goods within space, not particularly to develop systems that transport people to space. The job of transporting people and goods into space will now be the job of private industry.
5. The teacher states that NASA has identified four main areas as its new focus: Human Exploration, International Space Station, Science Missions, and NASA Aeronautics.
   a. The first three areas relate directly to space exploration (transportation) while the third area relates to aeronautics on earth.
7. The teacher gives a brief explanation of each area.
   a. Human Exploration - NASA is designing and building the capabilities to send humans to explore the solar system, working toward a goal of landing humans on Mars. NASA is currently building the Multi-Purpose Crew Vehicle (MCV), based on the design for the Orion capsule, with a capacity to take four astronauts on 21-day missions. NASA is also moving forward with the development of the Space
Launch System (SLS) - an advanced heavy-lift launch vehicle that will provide an entirely new national capability for human exploration beyond Earth’s orbit.

b. **The International Space Station (ISS)** - The International Space Station is the centerpiece of NASA’s spaceflight activities in low-earth orbit. Part of the U.S. portion of the station has been designated as a national laboratory, and NASA is committed to using this unique resource for scientific research. Commercial companies are well on their way to providing cargo and crew flights to the ISS, which allows NASA to focus its attention on the next steps into our solar system.

c. **Science Missions** - NASA is conducting numerous missions that will seek new knowledge and understanding of Earth, the solar system, and the universe. NASA has observatories in Earth orbit and deep space, spacecraft visiting the moon and other planetary bodies, and robotic landers, rovers, and sample return missions. NASA’s science vision encompasses questions as practical as hurricane formation, as enticing as the prospect of lunar resources, and as profound as the origin of the Universe.

d. **NASA Aeronautics** - NASA is researching ways to design and build aircraft that are safer, more fuel-efficient, quieter, and environmentally responsible. They are also working to create traffic management systems that are safer, more efficient, and more flexible. They are developing technologies that improve routing during flights and enable aircraft to climb to and descend from their cruising altitude without interruption.

8. The teacher states that transportation systems are a major part of NASA’s new focus for space exploration. NASA is proposing that humans will be transported to space by private companies, dock at a space station, then launch from a space vehicle at the space station to travel to another destination.

9. The teacher explains that the new space systems will require the development of revolutionary new advanced transportation designs and concepts.

10. The teacher explains that although the new space vehicles will be very sophisticated, they will still be comprised of subsystems as in typical common everyday transportation systems with which we are familiar.

11. The teacher explains that systems are very important to engineering and design, making the design and production processes much easier. Imagine if you had to design a Boeing 747 airplane, which would be a huge, complicated task. However, it becomes more manageable if the aircraft system is divided into subsystems and then further into components and parts. One team might be assigned to design the landing gear, another to design the wing system, another to design the fuselage, etc. Mechanical systems are made up of subsystems, components, and parts that work together to perform a task or function.

12. The teacher shows the PPT presentation ([Teacher Resource 6.2.3: Systems PPT](#)).

13. The teacher puts students in groups of 3-4 and passes out [Student Resource 6.2.3: Systems and Subsystems Reference Sheet](#). The class reviews the Systems and Subsystems Resource Sheet to ensure understanding.

14. The teacher prepares for the next lesson (see [Teacher Resource 6.2.4: As Simple as a Bicycle - Preparation](#)).

15. Students complete [Student Resource 6.2.4: Bicycle Systems Quiz](#).

16. The teacher passes out [Student Resource 6.2.5: As Simple as a Bicycle - Investigation](#) and reviews with students. Class discusses the findings of the investigations.

**Extension**

1. Students are divided into groups of 3-4.
2. The teacher reminds students to record information in their EDJs.
3. A journal is a place to record ideas, inspirations, discoveries, sketches, and notes. Students will use their journals to record thoughts and ideas as they work through their design projects. Some general guidelines students should follow are:
   a. Leave a few pages blank at the beginning to create a table of contents
   b. Date and sign each page
   c. Number each page
   d. Never remove pages
   e. Do not erase

4. The teacher passes out Student Resource 6.2.6: The Engineering Design Process and explains that using a design process can help you get from thinking about a design to producing a design. The class reviews the Design Process sheet. Groups will use the design process to guide the development of their prototypes.

5. The teacher passes out and reviews Student Resource 6.2.7: Design a Better Paper Clip, Design Brief. This is an individual challenge activity that gives students experience using the Design Process. After students have completed the challenge, students present their solutions and discuss their design processes.

6. The teacher begins this part of the Extension activity by showing this video about private companies that are building transport spacecrafts. It provides an engagement activity as students prepare for the design challenge.
   Video - Teacher Resource 6.2.10: NASA. Taking America to New Heights

7. After the video and a brief discussion, the teacher passes out Student Resource 6.2.8: Vision of a Launch System - Design Brief. Teacher assigns students in teams to design and build a thrust structure (a subsystem) that will be attached to a rocket that will be used to transport humans and goods to the International Space Station.


9. Students test their designs using Student Resource 6.2.12: Test Sheet

**Enrichment**

Students will act as private companies that have been challenged to design a “complete” spacecraft to shuttle people and cargo to the International Space Station. Each subsystem of the space craft should be identified in the final presentation.

Students complete Student Resource 6.2.13: SpaceX Math Problems

**Evaluation**

The students’ knowledge, skills, and attitudes are assessed using Engineering Design Journals, Constructed Response Items, Performance Rubrics, an End-of-Lesson Quiz, and an End-of-Unit Quiz.

The rubrics are presented in advance of the activities to familiarize students with the expectations and performance criteria. They are also 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.

Rubrics are both below and included as separate resources, suitable for distribution to students.
### Class Participation Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Rarely prepared. Minimal effort to participate.</td>
<td>Prepared for class. Attempts to answer teacher-generated questions.</td>
<td>Well prepared for class. Attempts to answer teacher-generated questions and adds additional information to class when relevant.</td>
</tr>
<tr>
<td><strong>Curiosity</strong></td>
<td>Rarely demonstrates curiosity.</td>
<td>Usually demonstrates curiosity.</td>
<td>Consistently demonstrates curiosity.</td>
</tr>
<tr>
<td><strong>Use of Time</strong></td>
<td>Gives up easily. Is not engaged. Has difficulty remaining on task.</td>
<td>Makes good use of class time to work on assignments and projects.</td>
<td>Makes excellent use of class time to work on assignments and projects.</td>
</tr>
</tbody>
</table>

Comments:

Grade:

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### Engineering Design Journal Rubric

<table>
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<tr>
<th>Assessment:</th>
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<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
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</thead>
<tbody>
<tr>
<td>Complete. All areas addressed.</td>
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<tr>
<td>Most areas well done.</td>
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<tr>
<td>Some areas well done.</td>
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<tr>
<td>Minimal effort.</td>
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<tr>
<td>Not attempted, missing.</td>
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<td>Budget Link Video comments</td>
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<tr>
<td>Notes - New focus of NASA</td>
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<tr>
<td>Notes - System PPT</td>
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<tr>
<td>Research findings - As simple as a bicycle</td>
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<tr>
<td>Activity - Design a better paper clip</td>
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<td>Notes</td>
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<td>Sketches</td>
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<tr>
<td>Activity - Vision of a launch system</td>
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<tr>
<td>Notes</td>
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<tr>
<td>Sketches</td>
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<td>Test results</td>
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</table>

**Extension activity - Design a space craft**

**Notes**

**Sketches**

**SpaceX math problems**

**Ability to understand and interpret images, notes, and sketches**

**Bonus: Additional materials**

**Total**

**Comments:**

**Grade:**

3. **Assessment Resource 6.2.3: Brief Constructed Response Rubric**

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<tr>
<th></th>
<th><strong>Below Target</strong></th>
<th><strong>At Target</strong></th>
<th><strong>Above Target</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question.</td>
<td>Response demonstrates an understanding of the text.</td>
<td>Response demonstrates an understanding of the complexities of the text.</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question.</td>
<td>Addresses the demands of the question.</td>
<td>Exceeds the demands of the question.</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning.</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning.</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
</tbody>
</table>

**Comments:**

**Grade:**

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4. Assessment Resource 6.2.4: Reflective Writing Rubric

<table>
<thead>
<tr>
<th>Reflective Writing Rubric</th>
<th>Category</th>
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<td>Name</td>
<td>Understanding</td>
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<tr>
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<td>Below Target</td>
<td>At Target</td>
<td>Above Target</td>
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<tr>
<td></td>
<td></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question</td>
<td>Response demonstrates an understanding of the text</td>
<td>Response demonstrates an understanding of the complexities of the text</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question</td>
<td>Addresses the demands of the question</td>
<td>Exceeds the demands of the question</td>
</tr>
<tr>
<td></td>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning.</td>
</tr>
<tr>
<td></td>
<td>Ability to apply information gained in class to prior knowledge</td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect</td>
<td>Some connections to prior knowledge or experience, some correct application to different context</td>
<td>Shows clear connections to prior knowledge or experience, applies knowledge correctly to different context</td>
</tr>
</tbody>
</table>

Comments:

Grade:
5. Assessment Resource 6.2.5: Engineering Design Team Rubric

<table>
<thead>
<tr>
<th>Engineering Design Team Rubric</th>
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<tbody>
<tr>
<td><strong>Student:</strong></td>
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<tr>
<td>Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:</td>
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<tr>
<td><strong>Lesson #</strong></td>
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<td>_____</td>
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<td>Team Member #3</td>
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<td><strong>Contributions to the group</strong></td>
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<td><strong>Special Contributions</strong></td>
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<td><strong>Comments</strong></td>
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<tr>
<td><strong>Overall Grade</strong></td>
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</table>
Lesson 2: The Future of the Space Program

Laboratory-Classroom Preparation

Teacher Preparation
Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, in particular if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. View all materials prior to sharing them with students to determine appropriate content.

Ideally, the classroom setting will provide opportunities for both individual and group work, and have resources to show DVDs and presentations. Additionally, students will be completing design work, which will require writing and drawing space, assembling and disassembling systems, which will require materials and tools. Students will give presentations, which may use word processing, presentation, and design software. If students are already familiar with CAD, it may be incorporated in this lesson.

Tools/Materials/Equipment
- Computer w/Internet access
- Presentation projector
- Engineering Design Journals or blank paper
- Various styles and sizes of paperclips
- Wire for making a new paperclip, various gauges
- Liter soda bottles
- Corrugated cardboard
- Brass tubing
- 35 mm film canisters
- Craft sticks
- Dowels
- Package sealing tape about 2 inches wide
- 25-50 pounds (11-23 kilograms) of sand
- A sturdy cloth bag to hold the sand
- Glue guns and hot-melt glue
- Several sets of needle nose pliers (for making paperclips)

Tools:
- Safety glasses or goggles
- Glue Gun (low-temperature type is recommended)
- Cardboard Cutter (utility knife or box cutter for cutting 3 1/2 inch [9 centimeter] squares)
- Strong scissors (for cutting sticks or trimming cardboard)
- Rulers
- Yard Stick (or meter stick).
Laboratory-Classroom Safety and Conduct
a. Students use tools and equipment safely, and only as allowed.
b. Students demonstrate respect and courtesy for the ideas expressed by others.
c. Students use computers only for lesson appropriate tasks
d. Students work as part of the Engineering Design Team to contribute to a proposed solution to a problem.

Teacher Resources
- Teacher Resource 6.2.1: Buzz Groups
- Teacher Resource 6.2.3: Systems PPT
- Teacher Resource 6.2.4: As Simple as a Bicycle- Preparation
- Teacher Resource 6.2.5: Bicycle Systems Quiz Key
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- Student Resource 6.2.2: Lesson Vocabulary
- Student Resource 6.2.3: Systems and Subsystems Resource Sheet
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- Student Resource 6.2.8: Vision of a Launch System- Design Brief
- Student Resource 6.2.9: Rocket Basics
- Student Resource 6.2.10: Background on Ares I and Ares V
- Student Resource 6.2.11: Understanding Thrust and Thrust Structures
- Student Resource 6.2.12: Test Sheet
- Student Resource 6.2.13: SpaceX Math Problems
- Student Resource 6.2.14: Reflective End of Lesson Quiz
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Assessment Resources
- Assessment Resource 6.2.1: Class Participation Rubric
- Assessment Resource 6.2.2: Engineering Design Journal Rubric
- Assessment Resource 6.2.3: Brief Constructed Response Rubric
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- Assessment Resource 6.2.5: Engineering Design Team Rubric
Buzz Groups, Pairs, and Triads

Buzz groups are simply small groups of two or three students formed in an impromptu fashion to discuss a topic for a short period. In a pair, it is almost impossible for a student to stay silent and once students have spoken "in private" they are much more likely to speak afterwards "in public" in the larger group. Buzz groups are very useful to get things going. The sound of ten pairs of students "buzzing" is quite energizing compared with one person speaking in a group of 20. Buzzes can also tune students in to your subject matter and wind up their ideas; for example:

"To start off, let's buzz for five minutes on what your initial reactions were to the readings I set for this week's seminar. Off you go."

They are also useful when a difficult topic or some awkwardness has brought a session to a standstill; for example:

"Well that seems to have stopped us in our tracks! Let's try and tackle that in buzz groups for a few minutes and then come back and try again once we've thought it through a bit more."

It does not matter a great deal if students work in twos or threes if you are just using buzz groups to liven things up and get everyone involved. If, however, you are setting a challenging task or a difficult question, pairs tend to be less disciplined and give up more quickly; for example: "I don't really understand this." "No, it's difficult isn't it?" "The disco was brilliant last night wasn't it?"

Triads seem to be able to be more resourceful and rigorous, perhaps because at any given time one of the three is neither speaking nor being directly spoken to, and so can have half an eye on the question or task the group is supposed to be working on. Triads will keep at tasks for longer without drifting off the topic.
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Teacher Resource 6.2.2: Video


http://www.nasa.gov/externalflash/human_space/

Teacher Resource 6.2.3: Systems PPT

Unit 6 PowerPoint file.
Teacher Resource 6.2.4: As Simple as a Bicycle - Preparation

Teacher Instructions for As Simple as a Bicycle Activity

This activity uses the mechanisms of a bicycle to help students think about the systems in a product that must be designed. It offers students a strategy for tackling a complex solution that they might have in mind. It provides practice with breaking big ideas into manageable, designable parts by identifying systems and/or components that need design and engineering. This activity requires teachers and/or to students to bring in bicycles for demonstration and study.

Prior to the lesson:
1. The teacher gathers the bicycles, parts, and other required materials
2. Set up work stations: Organize placement of bikes and parts for hands-on study of systems, components, and parts.
3. Set up workspace for two areas:
   a. Bike systems study - teams of students will study the subsystems on one bike.
   b. Components and parts study - set up “study stations” of components and parts grouped by the subsystems.

Day of the lesson:
1. Group students into teams of 3-4. Students will use their design journals to write notes about their investigations.
2. Teams will rotate throughout the bicycle stations to examine the subsystems, components, parts, and connectors on the bicycles and the bicycle parts.
3. Students will regroup as a class and discuss their findings and discuss the following questions:
   a. What do you know about what bicycles do?
   b. What do you know about bicycle parts?
   c. What do you know about what makes bicycles work?
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Teacher Resource 6.2.5: Bicycle Systems Quiz KEY

Like all transportation systems, a bicycle has six subsystems.

1. Structural
2. Propulsion
3. Guidance
4. Suspension
5. Control
6. Support

In the chart below, the columns are complete for the subsystem “Structural.” Please complete the “Purpose” and “Example Components” columns for the remaining subsystems.

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Purpose</th>
<th>Example Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Structural</td>
<td>To accommodate a vehicle’s cargo and form the basic framework of the vehicle</td>
<td>Chassis, body, fuselage</td>
</tr>
<tr>
<td>2. Propulsion</td>
<td>A force to propel a system from a starting point to a destination</td>
<td>Engine and transmission</td>
</tr>
<tr>
<td>3. Guidance</td>
<td>To provide information concerning control of the vehicle</td>
<td>Maps, GPS, signs</td>
</tr>
<tr>
<td>4. Suspension</td>
<td>Vehicle weight is supported by the suspension systems as it moves down or through a pathway</td>
<td>Springs, wings, etc.</td>
</tr>
<tr>
<td>5. Control</td>
<td>Controls speed and direction of a vehicle’s path</td>
<td>Handlebars, stem, wheels, frame system</td>
</tr>
<tr>
<td>6. Support</td>
<td>To maintain vehicles and other transportation technologies</td>
<td>Garage, gas stations</td>
</tr>
</tbody>
</table>

Using the diagram below, highlight the different systems. Each system should be one color—include a color key.

1. Structural
2. Propulsion
3. Guidance
4. Suspension
5. Control
6. Support
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Teacher Resource 6.2.6: Reflective End-of-Lesson Quiz Key

1. Briefly explain why the space shuttle program ended.

Responses will vary. Budget problems, President Bush passed a law, Shuttle had too many safety issues, shuttle outlived its value

2. Write a brief description or explanation of NASA’s plan for the future of the space program. Be sure to include information about all four areas.

Answers will vary, but should include main topics of Human Exploration, International Space Station, Science Missions, NASA Aeronautics

3. Transportation vehicles are made up of systems, such as structural, propulsion, suspension, guidance, control, and support. Write a definition of what each term means.

a. Structural - the basic framework of a transportation system, body, fuselage
b. Propulsion - the force that propels a system to move, engine, motors, transmission
c. Guidance - provides information concerning control of the vehicle, maps, signs, etc.
d. Control - controls speed and direction, steering, brakes, etc.
e. Support - used to maintain the transportation system, gas stations, garage, etc.

4. Think back through the lesson to transportation systems we talked about. Choose one and identify or explain the subsystems in that transportation system.

Answers will vary

5. Imagine that you are helping a friend do maintenance on his/her bicycle. As you proceed, you realize the frame is bent to a point that the bicycle does not move in a straight line fashion. Which subsystem is malfunctioning?

Structural
Space X Launches the First Commercial Rocket to the ISS

Answer Key

Problem 1 – The Dragon Capsule has the shape shown in the photo above (Courtesy NASA). The diameter of the base just above the curved head shield at its bottom is 3.2 meters. The diameter of the top is 2.2 meters. The capsule is 2.3 meters tall, and it would be 5.2 meters tall to its apex at the top, if it were the shape of an upside-down ice cream cone. From the information provided, what is the volume of the Dragon Capsule in cubic meters?

Answer: Students should first compute the volume of the full “ice cream cone” with a base radius of R = (3.2/2)=1.6 meters and a height h = 5.2 meters, then subtract the cone with a height of h = (5.2-2.3) = 2.9 meters and a base radius of R = (2.2/2)=1.1 meters. The difference is the volume of the capsule.

\[ V = \frac{1}{3} \pi (1.6)^2 (5.4) - \frac{1}{3} \pi (1.1)^2 (2.0) \]

\[ = 14.5 - \frac{3}{7} \]

\[ = 10.8 \text{ cubic meters} \]

Problem 2 - Suppose you had a room in your house with an 8-foot (2.7 meter) ceiling. If the floor area were a perfect square, what would be the dimensions of the floor so that the volume of this room were the same as the volume of the Dragon Capsule A) in meters? B) in feet?

Answer: A) The volume of the room would be \( V = 2.7 \times \text{Area} \), and since \( \text{Area} = \text{L}^2 \) for a square floor, the length would be given by \( 10.8 = 2.7 \times \text{L} \), so \( \text{L} = 2 \text{ meters} \).

B) 1 meter = 3 feet, so the length would be \( \text{L} = 6 \text{ feet} \). The dimensions of the room would be \( 2 \text{m} \times 2 \text{m} \times 2.7 \text{m} \) or \( 6 \text{ feet} \times 6 \text{ feet} \times 8 \text{ feet} \).

Note: Have the students try to imagine five astronauts lying on couches in this volume with computer equipment and spacesuits too!

Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Teacher Resource 6.2.8: Multiple Choice Quiz

Name:__________________________________

Circle the best answer.

1. NASA has a vision to develop new ways to transport people and goods *within* space, not particularly to develop systems that transport people *to* space. The job of transporting people and goods into space will now be the job of
   a. Russia
   b. Private industry
   c. NASA engineers
   d. Great Britain

2. NASA is conducting numerous missions that will seek new knowledge and understanding of Earth, the solar system, and the universe. This will include discovering aspects as practical as hurricane formation, as enticing as the prospect of lunar resources, and as profound as the origin of the universe. This is part of NASA’s new focus area:
   a. Science missions
   b. Human exploration
   c. Aeronautics
   d. International Space Station

3. These are small groups of two or three students formed impromptu to discuss a topic for a short period.
   a. Spuz groups
   b. Bee groups
   c. Team groups
   d. Buzz groups

4. This transportation subsystem controls speed and direction of a vehicles path. Examples: steering, brakes, etc.
   a. steering
   b. guidance
   c. control
   d. frame
5. The smallest piece of a design
   a. spec
   b. part
   c. unit
   d. fraction

6. NASA is designing and building the capabilities to send humans to explore the solar system, working toward a goal of landing humans on Mars. NASA calls this part of its new focus
   a. Human exploration
   b. Aerospace
   c. Science missions
   d. International Space Station

7. A group of related parts that form a whole functioning device is called
   a. System
   b. Task
   c. Part
   d. Subsystem

8. This subsystem accommodates a vehicle's cargo and forms the basic framework of the vehicle
   a. Support
   b. Propulsion
   c. Structure
   d. Guidance

9. This subsystem is used to maintain vehicles and other transportation technologies
   a. Support
   b. Propulsion
   c. Structure
   d. Guidance

10. This is the centerpiece of NASA’s spaceflight activities in low Earth orbit. Part of the U.S. portion of it has been designated as a national laboratory, and NASA is committed to using this unique resource for scientific research.
    a. International Satellite System
    b. International Space Craft
    c. International Space Station
    d. International Space System
11. A vehicle’s weight is supported by this subsystem as it moves down or through a pathway. Examples: springs, wings, etc.
   a. Suspension
   b. Propulsion
   c. Control
   d. Guidance

12. This force propels a system from a starting point to a destination.
   a. Suspension
   b. Support
   c. Propulsion
   d. Guidance

13. This provides information concerning control of the vehicle, like maps, GPS, etc.
   a. Suspension
   b. Support
   c. Propulsion
   d. Guidance

14. Something within a system or subsystem that performs a specific function
   a. Switch
   b. Starter
   c. Support
   d. Component

15. NASA is researching ways to design and build aircraft that are safer, more fuel-efficient, quieter, and environmentally responsible.
   a. NASA Aeronautics
   b. Science missions
   c. Space exploration
   d. Flight exploration

16. A system of components and parts that is part of a larger system
   a. Part
   b. Subsystem
   c. Station
   d. Component

17. A set of steps to follow to develop a solution to a problem
   a. Scientific method
   b. Loop Process
   c. Engineering Design Process
   d. Discovery pathway
18. Crucial components of the Constellation Program, meant to transport humans and cargo to space
   a. ISS
   b. Orion
   c. Ares
   d. Apollo

19. The only spacecraft capable of delivering and returning large payloads and scientific experiments to and from space recently retired.
   a. Ares I
   b. Space shuttle
   c. Orion spacecraft
   d. Constellation

20. The program that was working on new spacecraft (rockets) that would have been capable of traveling to the ISS and one day to the moon.
   a. Ares I
   b. Constellation
   c. Orion spacecraft
   d. Hubble satellite
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Teacher Resource 6.2.9: End-of-Unit Quiz - KEY

Name:__________________________________

1. What does NASA stand for?
   a. National and Space Association
   b. National Aeronautics Space Administration
   c. National Association of Space Administration
   d. National Aeronautics and Space Administration

2. The acronym for the orbiting space station used for scientific and space research
   a. OSS
   b. ISS
   c. SIS
   d. STS

3. The space shuttles had many assignments. These were called
   a. Objectives
   b. Payloads
   c. Function
   d. Missions

4. The precise period of time, ranging from minutes to hours, within which a launch must occur for a rocket or Space Shuttle to be positioned in the proper orbit is called the
   a. Timeframe
   b. Launch window
   c. Allocated space allowance
   d. Space bracket

5. Each launch is assigned a number that begins with the letters
   a. STS
   b. TSL
   c. STL
   d. TST
6. How many years was the Space Shuttle Program active?
   a. 50
   b. 32
   c. 41
   d. 30

7. Christa McAuliffe, was scheduled to be the first teacher to fly in space; she was aboard this shuttle when it exploded.
   a. Challenger
   b. Discovery
   c. Endeavor
   d. Atlantis

8. This space telescope was carried into space in 1990 by which shuttle
   a. Challenger
   b. Discovery
   c. Endeavor
   d. Atlantis

9. The Hubble telescope orbits which object in the solar system?
   a. sun
   b. earth
   c. moon
   d. mars

10. The total complement of equipment carried by a spacecraft for the performance of a particular mission in space is termed
    a. goods
    b. inputs
    c. payload
    d. capital

11. Three of the shuttles were named Discovery, Endeavor, and Enterprise. The remaining three shuttle names are
    a. Columbia, Challenger and Kearsarge
    b. Atlantis, Challenger, and Columbia
    c. Columbus, Extemeter, and Atlantis
    d. Indemnity, Columbia and Challenger

12.
13. Where did the Space Shuttles commonly land?
   a. Atlantic Ocean
   b. Briggs Space Center
   c. Kennedy Space Center
   d. White Sands Space Harbor

14. Like any other object in low-Earth orbit, a Space Shuttle must reach speeds of about _________ to remain in orbit.
   a. 53,000 mph
   b. 12,000 mph
   c. 32,000 mph
   d. 17,500 mph

15. The space shuttle program is officially known as
   a. the Space Voyager (SV)
   b. the Space Transportation System (STS)
   c. Starpath (SPT)
   d. the Gateway to ISS (GISS)

16. Liquid hydrogen and liquid oxygen make up most of a shuttle’s fuel; this makes the exhaust of the launch
   a. a mixture of more gas than water
   b. mostly water vapor
   c. a flammable mixture of gas vapors
   d. there is no exhaust on a shuttle

17. Which shuttle was the first to be built?
   a. Columbia
   b. Atlantis
   c. Enterprise
   d. None of the above

18. Which two shuttles ended in fatal disasters?
   a. Atlantis, Columbia
   b. Discovery, Challenger
   c. Columbia, Endeavor
   d. Challenger, Columbia

19.
20. Due to the speed of the shuttles, the crews were able to see a sunset or sunrise every
   a. 12 hours
   b. 45 minutes
   c. hour
   d. 5 minutes

21. The space shuttle's Thermal Protection System, or heat shield, contains what approximate number of sand tiles?
   a. 30,000
   b. 50,000
   c. 15,000
   d. 300,000

22. The space shuttle has landed on the moon how many times?
   a. 2 times
   b. 12 times
   c. 5 times
   d. Never

21. NASA has a vision to develop new ways to transport people and goods within space, not particularly to develop systems that transport people to space. The job of transporting people and goods into space will now be the job of
   a. Russia
   b. Private industry
   c. NASA engineers
   d. Great Britain

22. NASA is conducting numerous missions that will seek new knowledge and understanding of Earth, the solar system and the universe. This will include discovering aspects as practical as hurricane formation, as enticing as the prospect of lunar resources, and as profound as the origin of the Universe. This is part of NASA’s new focus area:
   a. Science missions
   b. Human exploration
   c. Aeronautics
   d. International Space Station

23. These are small groups of two or three students formed impromptu to discuss a topic for a short period.
   a. Spuz groups
   b. Bee groups
   c. Team groups
   d. Buzz groups
24. This transportation subsystem controls speed and direction of a vehicle’s path. Examples: steering, brakes, etc.
   a. steering
   b. guidance
   c. control
   d. frame

25. The smallest piece of a design
   a. spec
   b. part
   c. unit
   d. fraction

26. NASA is designing and building the capabilities to send humans to explore the solar system, working toward a goal of landing humans on Mars. NASA calls this part of their new focus
   a. Human exploration
   b. Aerospace
   c. Science missions
   d. International Space Station

27. A group of related parts that form a whole functioning device is called a
   a. System
   b. Task
   c. Part
   d. Subsystem

28. This subsystem accommodates a vehicle’s cargo and forms the basic framework of the vehicle
   a. Support
   b. Propulsion
   c. Structure
   d. Guidance

29. This subsystem is used to maintain vehicles and other transportation technologies
   a. Support
   b. Propulsion
   c. Structure
   d. Guidance
30. This is the centerpiece of NASA’s spaceflight activities in low Earth orbit. Part of the U.S. portion has been designated as a national laboratory, and NASA is committed to using this unique resource for scientific research.
   a. International Satellite System
   b. International Space Craft
   c. **International Space Station**
   d. International Space System

31. A vehicle’s weight is supported by this subsystem as it moves down or through a pathway. Examples: springs, wings, etc.
   a. Suspension
   b. Propulsion
   c. Control
   d. Guidance

32. This force propels a system from a starting point to a destination.
   a. Suspension
   b. Support
   c. **Propulsion**
   d. Guidance

33. This provides information concerning control of the vehicle, like maps, GPS, etc.
   a. Suspension
   b. Support
   c. Propulsion
   d. Guidance

34. Something within a system or subsystem that performs a specific function
   a. Switch
   b. Starter
   c. Support
   d. **Component**

35. NASA is researching ways to design and build aircraft that are safer, more fuel-efficient, quieter, and environmentally responsible.
   a. **NASA Aeronautics**
   b. Science missions
   c. Space exploration
   d. Flight exploration
36. A system of components and parts that is part of a larger system  
   a. Part  
   b. Subsystem  
   c. Station  
   d. Component  

37. A set of steps to follow to develop a solution to a problem  
   a. Scientific method  
   b. Loop Process  
   c. Engineering Design Process  
   d. Discovery pathway  

38. Crucial components of the Constellation Program, meant to transport humans and cargo to space  
   a. ISS  
   b. Orion  
   c. Ares  
   d. Apollo  

39. The only spacecraft capable of delivering and returning large payloads and scientific experiments to and from space recently retired.  
   a. Ares I  
   b. Space shuttle  
   c. Orion spacecraft  
   d. Constellation  

40. The program that was working on new spacecraft (rockets) that would have been capable of traveling to the ISS and one day to the moon.  
   a. Ares I  
   b. Constellation  
   c. Orion spacecraft  
   d. Hubble satellite
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Teacher Resource 6.2.10: Video

Teacher Resource 6.2.10 Video-Taking America to New Heights
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.1: Engineering Design Journal Guidelines

The purpose of the Engineering Design Journal is to serve as a documentation of the process of attempting to address a problem. Professional designers are often required to keep their design journals as a legal record of their designs. These generally contain sketches, notes, pictures and references.

1. In using the journal, document all aspects of the process, from formal drawings to pictures that help you to think about the project.

2. Do not assume that something is insignificant; it may be the key to the finished design.

3. Not everyone excels at drawing, but the purpose here is to improve individual skills while visually communicating ideas.

4. Adding other materials to the design journal such as articles and pictures is a common practice, but sources need to be properly documented.

5. Always date your entries and make sure that your name is on your Engineering Design Journal.

6. It is ok to use a variety of materials in your journal. Any writing instrument that is legible (pen, pencil, etc.) will communicate your idea. Be careful of materials that can show through the other side if you are using both sides of the page.

7. Work on your Engineering Design Journal every day to improve your drawing skills.
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.2: Lesson Vocabulary

**Buzz Group** - small groups of two or three students formed impromptu to discuss a topic for a short period.

**Component** - a group of parts that work together to perform a specific function in a system or subsystem.

**Control** - controls speed and direction of a vehicles path. Examples: steering, brakes, etc.

**Guidance** - provides information concerning control of the vehicle. Examples: maps, GPS, signs.

**Part** - the smallest piece of a design.

**Propulsion** - a force to propel a system from a starting point to a destination. Examples: engine and transmission.

**Structural** - Structural systems accommodate a vehicle’s cargo and form the basic framework of the vehicle. Examples: chassis, body, fuselage.

**Subsystem** - A system of components and parts that is part of a larger system.

**Support** - used to maintain vehicles and other transportation technologies. Examples: garage, gas station.

**Suspension** - vehicle weight is supported by the suspension systems as it moves down or through a pathway. Examples: springs, wings, etc.

**Systems** - A group of related parts (subsystems or components) that form a whole functioning device.
Mechanical systems are made up of subsystems or components that form a complete functioning device. A system might be broken down like this:

1. **System** - A group of related parts (subsystems or components) that form a whole functioning device.
2. **Subsystem** - A system of components and parts that is part of a larger system.
3. **Component** - A group of parts that work together that perform a specific function in a system or subsystem.
4. **Part** - the smallest piece of a design.

Transportation systems have specific subsystems:

1. **Structural** - Structural systems accommodate a vehicle’s cargo and form the basic framework of the vehicle. Examples: chassis, body, fuselage.
2. **Propulsion** - A force to propel a system from a starting point to a destination. Examples: engine and transmission.
3. **Guidance** - provide information concerning control of the vehicle. Examples: maps, GPS, signs.
4. **Suspension** - vehicle weight is supported by the suspension systems as it moves down or through a pathway. Examples: springs, wings, etc.
5. **Control** - controls speed and direction of a vehicles path. Examples: steering, brakes, etc.
6. **Support** - used to maintain vehicles and other transportation technologies. Examples: garage, gas station.
Lesson 2: The Future of the Space Program

Student Resource 6.2.4: Bicycle Systems Quiz

Just like every transportation system, a bicycle has six subsystems.

1. Structural
2. Propulsion
3. Guidance
4. Suspension
5. Control
6. Support

In the chart below, the columns are complete for the subsystem ‘Structural.’ Please complete the ‘Purpose’ and ‘Example Components’ columns for the remaining subsystems.

<table>
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<td></td>
<td></td>
</tr>
<tr>
<td>4. Suspension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Support</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Using the diagram below, highlight the different systems. Each system should be one color—including a color key.
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.5: As Simple as a Bicycle - Investigation

Background: We see bicycles everywhere. In fact, they are so familiar, we often take them for granted. We can easily think about the different things a bicycle can do. We can sit comfortably on a seat, make it move forward, make it stop, go faster on flat places, and can make it go up steep hills. It all seems very simple, yet each of the things we expect it to do requires a different system. Each system has subsystems and each subsystem may be made of several parts.

Systems are made up of subsystems, which are made up of components and parts that work together to complete a task. Referring to a bicycle, think about using the pedals to move the bike forward. The pedals are attached to the pedal axle, which is attached to the frame, which has parts that attach to the chain, which has parts connected to the rear wheel, and as the rear wheel rotates, you drive forward.

Your Challenge - Your team will explore, identify, and distinguish the subsystems, components, and parts of a bicycle.

Materials:
1. 2-4 bicycles or tricycles of different kinds, shapes, and sizes (brought in by teacher or students)
2. Various bicycle parts - 1 or 2 examples of each system:
   a. Drive systems: pedals, cranksets (crank and chainwheel), chains, axles, wheels
   b. Steering system: handlebars, front wheel, headset bearings
   c. Brake systems: brake levers, cables, and calipers (attached as a system)
   d. Structural system parts:
      • Frames: without any components attached—any size, style
      • Wheels: different sizes and designs (some missing spokes or out of true is fine)
      • Handlebars: down-swept and straight
      • Seats (or saddles): different shapes and designs
3. Bike repair stands (to raise and support bikes off the floor for study)
4. Old rags or paper towels for wiping grease and dirt off hands and bikes

Tools:
1. Several screwdrivers (Phillips head, straight)
2. Various wrenches
3. Hammers

To Do:
1. Teams will rotate throughout the bicycle stations to examine the subsystems, components, parts, and connectors on the bicycles and the bicycle parts.
2. Write down notes in your design journal about how parts connect and work together in each system. Your notes may be sketches.
3. Answer the questions:
   d. What do you know about what bicycles do?
   e. What do you know about bicycle parts?
   f. What do you know about what makes bicycles work?
4. Regroup as a class and discuss your findings.
Getting from thinking about a design to producing a design

- You will be using a design process to guide the development of your project from an idea to the design of a prototype.
- The steps in the process can be performed in different sequences and repeated as needed.
- Every problem is unique, and engineers and designers may choose to approach the design process in different ways.
- Brainstorming is a group problem-solving process in an open forum without criticism.
- Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

**Define a Problem** - The design process begins with identifying a need. Opportunities to design a new product or redesign an existing one are everywhere. They often come from a problem that has been experienced personally. The goal is to identify many design opportunities and narrow them down.

**Research Ideas/Explore Possibilities** - Gather a lot of information about the nature of the problem in order to help narrow down your choices. Find out if other people experience the same problem and research any existing products or solutions that may currently be used to solve the problem. Choose a design opportunity to address. Write a problem statement.

**Brainstorm Possible Solutions** - Try to come up with as many ideas as you can for solving the problem or addressing the design opportunity. Brainstorming may involve the use of SCAMPER and other techniques. Then, narrow down your solutions and choose one to three to pursue further.

**Develop Written Design Proposal** - Write a design proposal to help outline the problem. A design proposal can also be called a design brief. It includes a problem statement, a description of the user needs, a proposed solution, and often a sketch of the idea or solution. This is a working document that can be changed as new information is discovered.

**Specify Constraints and Identify Criteria** - Criteria and constraints establish the requirements of the design.

**Generate Ideas** - Come up with as many ideas as you can. The more ideas you have, the more creative your ideas become and the options you have for a solution.

**Consider Alternative Solutions** - It is important to continue to consider alternative solutions throughout the process.
Select An Approach - Choose the best approach to begin making your model or prototype. Consider materials, tools, and machinery you will need to use. Devise an outline of steps to follow.

Make Model/Prototype - A prototype is a working model that is used to test a design concept by making actual observations and necessary adjustments.

Test and Evaluate - An engineer must not only design a product that works—s/he must consider many other factors, such as safety, environmental concerns, ethical considerations, and risks and benefits.

Refine/Improve - From your testing and evaluation, you may realize that revisions may be needed to improve your design.
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.7: Design a Better Paper Clip - Design Brief

In this short activity, you will experience using the design process to produce a better paper clip. You will need this experience when you design your spacecraft prototype.

To Begin:
Explore the paper clips and pins given to you. At one time, pins were used to fasten paper together before the paper clip was invented. As you explore, pay close attention to your hands and fingers and notice how you must manipulate them as you fasten pieces of paper together. What do you notice? How do you move your fingers to separate the clip to direct it to the paper? You may notice, your actions are unconscious, and the ease with which you use the clip indicates a successful design.

Next, investigate the properties of the shape and materials of the paperclip designs. What is happening when you use each design? In your journal, make notes about each and refer to your notes as you design your unique paper clip. Notice common characteristics of each design and properties of the materials that allow the designs to function properly.

Your Challenge:
The owners of Office Supplies, Inc. have been experiencing financial difficulties over the last few years. In an attempt to revive their business, they feel a better paper clip design could greatly increase their sales growth, bringing them out of the red and into the black. Being an up and coming designer, the company has chosen you to invent the new design.

To Do:
1. Follow the design process as you work through the challenge (Refer to the Design Process Resource Sheet).
2. Try out all your ideas and make sketches of each design.
3. Record your work in your Design Journal
4. When finished, be prepared to present your design.

Criteria and Constraints:
1. The new design must be unique; it cannot look like any design you have ever seen.
2. It can be no larger than 2”x 2” (5cm x 5cm).
3. It must hold 10 pieces of paper.
4. You can use other materials to enhance your design, but the main material must be wire.
5. There cannot be any sharp ends.
6. Record your work in your design journal.

Materials and Tools:
1. Wire
2. Assortment of bead-types materials (opt)
3. Needle nose pliers for bending the wire
4. Use the square to the right to test the paper clip size.
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.8: Vision of a Launch System - Design Brief

Time: 6-45 minute class periods

Background:
The era of space flight is breaking new ground. Since the retirement of the space shuttle program, NASA has changed its vision for space exploration. NASA plans to focus on larger long-term goals, like sending crews to a nearby asteroid and eventually Mars. This goal requires private companies to build small rocket ships to take astronauts and cargo to the International Space Station (ISS), where future space destinations will be launched. Ferrying astronauts and cargo will save time and money. Once the spaceships are built, NASA plans to hire the private companies to taxi astronauts into space within five years. Until they are ready, NASA is paying Russia about $63 million per astronaut to do the job.

Challenge Statement:
Your company is hoping to be one of the companies NASA hires to transport astronauts and cargo to the ISS. Your engineering design team was chosen to develop the design that will be presented to NASA (teacher and classmates). Your presentations will be submitted as individual subsystems of your final design. Your first presentation to NASA will be a “thrust structure” design.
The thrust structure is the portion (subsystem) of the structure that attaches the engine to the rest of the spacecraft.

- Design and build a thrust structure that will be attached to a rocket that will be used to transport humans and goods to the International Space Station
- You will launch it, record the results, and then make improvements to the design that make it lighter and stronger.
- The model must be very strong, yet as light as possible, as it must be “launched into orbit” three times. The rocket must travel at least 3.3 feet (1 meter) into orbit; this represents low Earth orbit.
- You will get four chances to improve on the design to make it lighter and stronger.
- Launch to orbit = propelling a 1-liter bottle of water to the height of approximately 3 feet (1 meter) into the air.
- Be sure to use your design journal to document your ideas (thoughts and sketches). It will be graded.

Criteria and Constraints:
- Use only the specified materials.
- The thrust structure must be taller than 2 inches (5 centimeters) and must allow space in the center for fuel lines and valves represented by a 35mm-film canister without its lid.

Review the following Resources sheets before beginning the challenge:
Student Resource 6.2.9 Rocket Basics
Student Resources 6.2.10 Background on Ares I and Ares V
Student Resource 6.2.11 Understanding Thrust and Thrust Structures
Materials:
- 1-liter soda bottles
- 2-liter soda bottles
- Corrugated cardboard
- Brass tubing
- 35 mm film canisters
- Craft sticks
- Dowels
- Package sealing tape about 2 inches wide
- 25-50 pounds (11-23 kilograms) of sand
- A sturdy cloth bag to hold the sand
- Poster board
- Markers
- Glue guns and hot-melt glue.

Tools:
- Safety glasses or goggles
- Glue Gun (low-temperature type is recommended)
- Cardboard Cutter (utility knife or box cutter for cutting 3 1/2 inch (9 centimeter) squares)
- Strong scissors (for cutting sticks or trimming cardboard)
- Rulers
- Yard Stick (or meter stick)

To Do:
**Determine the “Engine Thrust”**
Your first task will be to determine the necessary thrust to propel the bottle rocket “to orbit.”

a. Determine a drop height for the sandbag so that the rocket just flies off the ring stand (flying too far would be subjecting the structure to more force than necessary and possibly overshooting “orbit.”)

b. A volunteer will drop the sandbag and another will catch the rocket. (Launch this rocket without a thrust structure.) Measure the height of the drop with a yard stick or measuring tape or punch a small hole in a file card or piece of manila folder and slide it on a ring stand to mark the height. Start out by dropping the weight from a very low height and gradually increase the drop height until the bottle just barely flies off the ring stand.

c. Keep launching your rocket until it consistently launches three times to the desired height.

d. Once you have your optimal drop height, record it and post it in the same place as the challenge. Mark a ring stand at that height with tape or tape the file card onto the ring stand.
Check for Understanding
Discuss the following questions with the class:

1. How much mass are we launching to orbit?

2. Which subsystem is responsible for the movement of the bottle rocket into orbit?

3. What is the source of the force identified in Question 2?

4. What forces are acting on the bag of sand when it is suspended in the air before the drop?

5. What forces are acting on the bag when it is released?

Build Your Design
Your team will design four different thrust systems.

1. Follow the Engineer Design Process as you develop your designs (refer to your Design Process reference sheet).
2. Brainstorm ideas and sketch them in your design journal; jot down notes about each design.
3. Choose your best idea to build.
4. Build your design.
5. Test and record results of each test.
6. Evaluate each design, positives and negatives.
7. Repeat the procedure three more times, reflecting on the positives and negatives of the previous design.
8. Write notes about your testing and results in your design journal.
9. Remember, your goal is to design a thrust structure that very strong, yet as light as possible.

Present Your Solution
Teams will prepare a presentation to NASA on their most successful thrust design.

1. Use your testing information and your design journal information to create a poster presentation to present to NASA (teacher and classmates).
2. Be sure to explain aspects of the thrust system as a subsystem as part of a bigger system.
3. Be sure to explain the development of each prototype, discuss successes and failures, and modifications to your designs.
4. Your poster will "show" the evolution of your design from its initial stage to its final stage.
5. Your team members will "tell" the story of the design process as you worked through to your final solution.
6. Your final statements will include a concise explanation of "what we learned."
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.9: Rocket Basics

Rocket Basics
A rocket is a vehicle that contains everything needed to place a payload into space. A payload can be people, a satellite, or other equipment. A rocket in its simplest form is a tube holding a gas that is packed under pressure. A small opening at one end of the tube allows the gas to escape. When the gas escapes, it gives a thrust, or push, that propels the rocket in the opposite direction. Modern rockets use a propellant. Propellant is a mixture of fuel and a chemical called an "oxidizer" that gives off oxygen. The fuel and oxidizer burn together and produce rocket thrust.

People have been sending rockets into space for more than 50 years, starting with the launch of the Soviet Union's Sputnik I in 1957. The technology of basic rocketry is nearly 2,000 years old. The first device known to use rocket propulsion was built between 428 and 347 B.C.

The concepts are still the same, but rockets have evolved considerably. Innovative technologies, new materials, and improved engineering practices, along with lessons learned from past experience, influence the evolution of rockets.

Apollo Program
The Apollo Program had the ambitious goal of sending humans to land on the moon, then returning them safely to Earth. To achieve this goal, NASA used technology from previous rockets and developed new technology. On July 20, 1969, Apollo 11 was the first spacecraft to meet the goal. Apollo 11 was a spacecraft that flew on top of a Saturn V (5) rocket. Apollo 11 consisted of three parts—the Service Module, the Command Module and the Lunar Module. The Saturn V was a three-stage rocket made of more than three million parts. A staged rocket fires several engines or sets of engines. The first stage lifts the rocket off the pad. That stage then falls away as the second-stage engines ignite to carry the remaining rocket to an even higher altitude.

Space Shuttle Program
Even before Apollo 11 carried humans to the moon, NASA was already planning the space shuttle as a way to allow humans to remain in space. The space shuttle is the only spacecraft capable of delivering and returning large payloads and scientific experiments to and from space. The space shuttle usually orbits around Earth about 200 miles up. It can go higher than that, but it cannot leave Earth orbit, which is necessary to travel to the moon. The shuttle is the world's first reusable spacecraft and consists of three main components: the two white solid rocket boosters, the orange external tank, and the orbiter. The solid rocket boosters are reusable. They are ejected from the shuttle system about two minutes after liftoff. They use a parachute to land in the ocean. A ship retrieves them, and they are prepared to use for another launch. The external tank is ejected from the orbiter about eight minutes after launch. As it falls back to Earth, it burns up in the atmosphere. Each of the space shuttle orbiters—Atlantis, Discovery and Endeavour—was designed for a life of at least 100 missions.
**Constellation Program**

Prior to the last space shuttle launching in 2011, NASA was working on new spacecraft for America's next generation of rockets, called the Constellation Program. Launches were expected to occur no sooner than 2015, Constellation spacecraft were to make trips to the International Space Station and one day go to the moon. Constellation components were:

- *Ares I* (1) rocket
- *Ares V* (5) rockets
- Orion crew exploration vehicle
- Altair lunar lander

*Ares I* and *Orion* were to take crews to the space station. Just as the Apollo spacecraft rode atop the *Saturn V* rocket, *Orion* would have ridden atop the *Ares I*, which was/is also called the crew launch vehicle. Unlike the *Saturn V* rocket used during the Apollo era, the Constellation Program was to use two rockets for a mission to the moon. When astronauts traveled beyond Earth’s orbit, Altair and the necessary cargo were to ride on the huge *Ares V*. After both rockets had been launched, the astronauts in the Orion crew capsule would dock with the part of the *Ares V* called the Earth departure stage and the Altair for the trip to the moon. *Ares I* would have been like a car or SUV that carried the crew to space. *Ares V*, also known as the heavy-lift vehicle, would have been like an 18-wheeler that carried the lunar lander and other equipment.

**New Focus**

Now with the Space Shuttle Program and Constellation program cancelled, NASA has refocused its vision of the space program. NASA plans to focus on larger long-term goals, like sending crews to a nearby asteroid and eventually Mars. This goal requires private companies to build small rocket ships to take astronauts and cargo to the International Space Station, where the future destinations will be launched. Ferrying astronauts and cargo will save time and money. Once the spaceships are built, NASA plans to hire the private companies to taxi astronauts into space within five years. Until they are ready, NASA is paying Russia about $63 million per astronaut to do the job.

Information derived in part from:


http://www.nasa.gov/audience/foreducators/diypodcast/rocket-evolution-index-diy.html
Lesson 2: The Future of the Space Program

Student Resource 6.2.10: Background on Ares I and Ares V

Background on Ares I and Ares V

The Ares I and Ares V rockets were crucial components of the Constellation Program. Ares I and the larger Ares V were named after Ares, the Greek god of war, which is the equivalent to the Roman god Mars.

Before the cancellation of the Space Shuttle and Constellation Programs, NASA had plans for new manned flights to the moon and possibly to Mars and beyond. Unlike its predecessors, the Ares would have used separate launch vehicles to transport cargo and crew. Ares I was to carry humans to space, while Ares V was to transport large-scale hardware such as items needed to establish a lunar base.

NASA Ares I Rocket was to be used primarily to launch the Orion Spacecraft to the International Space Station or to 'park' payloads in Earth orbit for retrieval by other spacecraft bound for the moon or other destinations. The 'I' in Ares I refers to the single Solid Rocket Booster (SRB) in the first stage. The vehicle was to be used to launch the unmanned cargo supply version of the Orion, as well as unmanned satellites weighing at or less than 25 metric tons. Ares-I technology is based on Apollo and Space Shuttle propulsion elements.

Ares V would have launched the Earth Departure Stage and Altair lunar lander had NASA returned to the Moon, which was planned for 2019, but would also have served as the principal launcher for missions beyond the Earth-Moon system, including the program's ultimate goal, a manned mission to Mars after 2030. The unmanned Ares V would complement the smaller and human-rated Ares I rocket for the launching of the 4–6 person Orion spacecraft. Both rockets, deemed safer than the current Space Shuttle, would have utilized technologies developed for the Apollo program, the Shuttle, and the Delta IV EELV programs. However, the Constellation program, including Ares V and Ares I was canceled in October 2010 by the passage of the 2010 NASA authorization bill. In September 2011 NASA detailed the Space Launch System as its new vehicle for human exploration beyond Earth’s orbit.

NASA's scrapped Ares I rocket may see new life as part of a new private launch vehicle to provide commercial flights to space for satellites, cargo – and maybe even people.
Every pound that is carried to space requires fuel to do so, regardless of whether that pound is cargo, crew, fuel, or part of the spacecraft itself. The more the vehicle and fuel weigh, the fewer passengers and smaller payload the vehicle can carry. Designers try to keep all the parts of the vehicle, including the skeleton (or structure), as light as possible.

To design a lightweight structure is very difficult, because it must be strong enough to withstand the tremendous thrust (or force) of the engines during liftoff. Throughout the history of space vehicles, engineers have used various strategies for the structure.

When the Ares spacecraft were id development, NASA engineers worked to design it as light as possible, constructing them of lightweight, strong materials, such as Al-Li 2195, an aluminum-lithium alloy, which is less dense and stiffer than pure aluminum. NASA engineers also designed the structures to use as little material as possible to achieve the strength and rigidity they need. So, for example, they made use of a network of hollow tubular struts (called a truss) rather than use more compact, but heavier solid beams.

The engineering design challenge you will engage in resembles the Ares V thrust structure, which attached the five liquid fuel engines of the Ares V to the body of the spacecraft. The thrust structure is an essential part of the spacecraft, which must be kept lightweight. As they burn, the five RS-68 engines of the Ares V produce about 3,510,275 pounds (1,592 metric tons) of thrust. This means that the thrust structure must bear a load equivalent to 3,510,275 pounds (1,592 metric tons) of weight pushing on it. The thrust structure must not only withstand this terrific force, it must transfer it to the vehicle in a balanced way, without damaging the vehicle.

In class discussion, answer the questions below.

1. Why is it important to make the launch vehicle as lightweight as possible?
2. What are the Ares launch vehicles?
3. What are some ways NASA engineers could make the Ares launch vehicles as lightweight as possible?
4. If it costs $10,000 to lift a pound (half a kilogram) of payload into orbit aboard the International Space Station, calculate the cost of sending yourself into space. How much would it cost to send yourself, your family and your pets into space?
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.12: Test Sheet

Vision of a Launch System - Test Sheet

Names ___________________________ ___________________________
Date __________

Sketch your model below, after testing. Show any failure points.

Record your test results. Describe the results of the testing. Explain which features seemed effective and which weren’t.

Test# _______ Results (success or fail) _______________

1.

2.

3.
Space X Launches the First Commercial Rocket to the ISS

The SpaceX Falcon 9 rocket soared into space from Space Launch Complex-40 on Cape Canaveral Air Force Station in Florida, carrying the Dragon capsule (left) to orbit on May 22, 2012.

During the flight, there were a series of check-out procedures to test and prove Dragon's systems, including rendezvous and berthing with the International Space Station. If the capsule performed as planned, the cargo and experiments it was carrying would be transferred to the station.

Problem 1 – The Dragon Capsule has the shape shown in the photo above (Courtesy NASA). The diameter of the base just above the curved head shield at its bottom is 3.2 meters. The diameter of the top is 2.2 meters. The capsule is 2.3 meters tall, and it would be 5.2 meters tall to its apex at the top, if it were the shape of an upside-down ice cream cone.

The volume of an ice cream cone with a base radius of \( R \) and a height of \( h \) is given by the formula

\[
V = \frac{1}{3} \pi R^2 h
\]

From the information provided, what is the volume of the Dragon Capsule in cubic meters?

Problem 2 - Suppose you had a room in your house with an 8-foot (2.7 meter) ceiling. If the floor area were a perfect square, what would be the dimensions of the floor so that the volume of this room were the same as the volume of the Dragon Capsule A) in meters? B) in feet?
Lesson 2: The Future of the Space Program

Student Resource 6.2.14: Reflective End of Lesson Quiz

Name: ____________________________________________________________

Answer each question with a paragraph, using complete sentences.

1. Briefly explain why the space shuttle program ended.

2. Write a brief description or explanation of NASA’s plan for the future of the space program. Be sure to include information about all four areas.

3. Transportation vehicles are made up of systems, such as structural, propulsion, suspension, guidance, control, and support. Write a definition of what each term means.
   
   f. Structural- 
   g. Propulsion- 
   h. Guidance- 
   i. Control- 
   j. Support-

4. Think back through the lesson to transportation systems we talked about. Choose one and identify or explain the subsystems in that transportation system.

5. Imagine that you are helping a friend do maintenance on his/her bicycle. As you proceed, you realize the frame is bent to a point that the bicycle does not move in a straight line fashion. Which subsystem is malfunctioning?
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.15: End of Lesson 2 Quiz

Name: ____________________________________________

Circle the best answer.

1. NASA has a vision to develop new ways to transport people and goods within space, not particularly to develop systems that transport people to space. The job of transporting people and goods into space will now be the job of
   a. Russia
   b. Private industry
   c. NASA engineers
   d. Great Britain

2. NASA is conducting numerous missions that will seek new knowledge and understanding of Earth, the solar system and the universe. This will include discovering aspects as practical as hurricane formation, as enticing as the prospect of lunar resources, and as profound as the origin of the Universe. This is part of NASA’s new focus area:
   a. Science missions
   b. Human exploration
   c. Aeronautics
   d. International Space Station

3. These are small groups of two or three students formed impromptu to discuss a topic for a short period.
   a. Spuz groups
   b. Bee groups
   c. Team groups
   d. Buzz groups

4. This transportation subsystem controls speed and direction of a vehicle’s path. Examples: steering, brakes, etc.
   a. steering
   b. guidance
   c. control
   d. frame
5. The smallest piece of a design  
   a. spec  
   b. part  
   c. unit  
   d. fraction

6. NASA is designing and building the capabilities to send humans to explore the solar system, working toward a goal of landing humans on Mars. NASA calls this part of their new focus  
   a. Human exploration  
   b. Aerospace  
   c. Science missions  
   d. International Space Station

7. A group of related parts that form a whole functioning device is called a  
   a. System  
   b. Task  
   c. Part  
   d. Subsystem

8. This subsystem accommodates a vehicle's cargo and forms the basic framework of the vehicle  
   a. Support  
   b. Propulsion  
   c. Structure  
   d. Guidance

9. This subsystem is used to maintain vehicles and other transportation technologies  
   a. Support  
   b. Propulsion  
   c. Structure  
   d. Guidance

10. This is the centerpiece of NASA’s spaceflight activities in low Earth orbit. Part of the U.S. portion of it has been designated as a national laboratory, and NASA is committed to using this unique resource for scientific research.  
    a. International Satellite System  
    b. International Space Craft  
    c. International Space Station  
    d. International Space System
11. A vehicle’s weight is supported by this subsystem as it moves down or through a pathway. Examples: springs, wings, etc.
   a. Suspension
   b. Propulsion
   c. Control
   d. Guidance

12. This force propels a system from a starting point to a destination.
   a. Suspension
   b. Support
   c. Propulsion
   d. Guidance

13. This provides information concerning control of the vehicle, like maps, GPS, etc.
   a. Suspension
   b. Support
   c. Propulsion
   d. Guidance

14. Something within a system or subsystem that performs a specific function
   a. Switch
   b. Starter
   c. Support
   d. Component

15. NASA is researching ways to design and build aircraft that are safer, more fuel-efficient, quieter, and environmentally responsible.
   a. NASA Aeronautics
   b. Science missions
   c. Space exploration
   d. Flight exploration

16. A system of components and parts that is part of a larger system
   a. Part
   b. Subsystem
   c. Station
   d. Component

17. A set of steps to follow to develop a solution to a problem
   a. Scientific method
   b. Loop Process
   c. Engineering Design Process
   d. Discovery pathway
18. Crucial components of the Constellation Program, meant to transport humans and cargo to space
   a. ISS
   b. Orion
   c. Ares
   d. Apollo

19. The only spacecraft capable of delivering and returning large payloads and scientific experiments to and from space recently retired.
   a. Ares I
   b. Space shuttle
   c. Orion spacecraft
   d. Constellation

20. The program that was working on new spacecraft (rockets) that would have been capable of traveling to the ISS and one day to the moon.
   a. Ares I
   b. Constellation
   c. Orion spacecraft
   d. Hubble satellite
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Student Resource 6.2.16: End of Unit 6 Quiz

Name:____________________________________

1. What does NASA stand for?
   a. National and Space Association
   b. National Aeronautics Space Administration
   c. National Association of Space Administration
   d. National Aeronautics and Space Administration

2. The acronym for the orbiting space station used for scientific and space research
   a. OSS
   b. ISS
   c. SIS
   d. STS

3. The space shuttles had many assignments. These were called
   a. Payloads
   b. Function
   c. Missions
   d. Objectives

4. The precise period of time, ranging from minutes to hours, within which a launch
   must occur for a rocket or Space Shuttle to be positioned in the proper orbit is called the
   a. Timeframe
   b. Launch window
   c. Allocated space allowance
   d. Space bracket

5. Each launch is assigned a number that begins with the letters
   a. STS
   b. TSL
   c. STL
   d. TST

6. 
How many years was the Space Shuttle Program active?
   a. 50
   b. 32
   c. 41
   d. 30

7. Christa McAuliffe was scheduled to be the first teacher to fly in space; she was aboard this shuttle when it exploded.
   a. Challenger
   b. Discovery
   c. Endeavor
   d. Atlantis

8. This space telescope was carried into space in 1990 by which shuttle
   a. Challenger
   b. Discovery
   c. Endeavor
   d. Atlantis

9. The Hubble telescope orbits which object in the solar system?
   a. sun
   b. earth
   c. moon
   d. mars

10. The total complement of equipment carried by a spacecraft for the performance of a particular mission in space is termed
    a. goods
    b. inputs
    c. payload
    d. capital

11. Three of the shuttles were named Discovery, Endeavor, and Enterprise. The remaining three shuttle names are
    a. Columbia, Challenger and Kearsarge
    b. Atlantis, Challenger, and Columbia
    c. Columbus, and Extmeler, Atlantis
    d. Indemnity, Columbia and Challenger
12. Where did the Space Shuttles commonly land?
   a. Atlantic Ocean
   b. Briggs Space Center
   c. Kennedy Space Center
   d. White Sands Space Harbor

13. Like any other object in low-Earth orbit, a Space Shuttle must reach speeds of about _________ to remain in orbit.
   a. 53,000 mph
   b. 12,000 mph
   c. 32,000 mph
   d. 17,500 mph

14. The space shuttle program is officially known as
   a. the Space Voyager (SV)
   b. the Space Transportation System (STS)
   c. Starpath (SPT)
   d. the Gateway to ISS (GISS)

15. Liquid hydrogen and liquid oxygen make up most of a shuttle’s fuel; this makes the exhaust of the launch
   a. a mixture of more gas than water
   b. mostly water vapor
   c. a flammable mixture of gas vapors
   d. there is no exhaust on a shuttle

16. Which shuttle was the first to be built?
   a. Columbia
   b. Atlantis
   c. Enterprise
   d. None of the above

17. Which two shuttles ended in fatal disasters?
   a. Atlantis, Columbia
   b. Discovery, Challenger
   c. Columbia, Endeavor
   d. Challenger, Columbia
18. Due to the speed of the shuttles, the crews were able to see a sunset or sunrise every
   a. 12 hours
   b. 45 minutes
   c. hour
   d. 5 minutes

19. The space shuttle's Thermal Protection System, or heat shield, contains what approximate amount of sand tiles?
   a. 30,000
   b. 50,000
   c. 15,000
   d. 300,000

20. The space shuttle has landed on the moon how many times?
   a. 2 times
   b. 12 times
   c. 5 times
   d. Never

21. NASA has a vision to develop new ways to transport people and goods within space, not particularly to develop systems that transport people to space. The job of transporting people and goods into space will now be the job of
   a. Russia
   b. Private industry
   c. NASA engineers
   d. Great Britain

22. NASA is conducting numerous missions that will seek new knowledge and understanding of Earth, the solar system and the universe. This will include discovering aspects as practical as hurricane formation, as enticing as the prospect of lunar resources, and as profound as the origin of the Universe. This is part of NASA’s new focus area:
   a. Science missions
   b. Human exploration
   c. Aeronautics
   d. International Space Station
23. These are small groups of two or three students formed impromptu to discuss a topic for a short period.
   a. Spuz groups
   b. Bee groups
   c. Team groups
   d. Buzz groups

24. This transportation subsystem controls speed and direction of a vehicle's path. Examples: steering, brakes, etc.
   a. steering
   b. guidance
   c. control
   d. frame

25. The smallest piece of a design
   a. spec
   b. part
   c. unit
   d. fraction

26. NASA is designing and building the capabilities to send humans to explore the solar system, working toward a goal of landing humans on Mars. NASA calls this part of their new focus
   a. Human exploration
   b. Aerospace
   c. Science missions
   d. International Space Station

27. A group of related parts that form a whole functioning device is called a
   a. System
   b. Task
   c. Part
   d. Subsystem

28. This subsystem accommodates a vehicle's cargo and forms the basic framework of the vehicle
   a. Support
   b. Propulsion
   c. Structure
   d. Guidance
29. This subsystem is used to maintain vehicles and other transportation technologies
   a. Support
   b. Propulsion
   c. Structure
   d. Guidance

30. This is the centerpiece of NASA’s spaceflight activities in low Earth orbit. Part of the
    U.S. portion of it has been designated as a national laboratory, and NASA is
    committed to using this unique resource for scientific research.
    a. International Satellite System
    b. International Space Craft
    c. International Space Station
    d. International Space System

31. A vehicle’s weight is supported by this subsystems as it moves down or through a
    pathway. Examples: springs, wings, etc.
    a. Suspension
    b. Propulsion
    c. Control
    d. Guidance

32. This force propels a system from a starting point to a destination.
    a. Suspension
    b. Support
    c. Propulsion
    d. Guidance

33. This provides information concerning control of the vehicle, like maps, GPS, etc.
    a. Suspension
    b. Support
    c. Propulsion
    d. Guidance

34. Something within a system or subsystem that performs a specific function
    a. Switch
    b. Starter
    c. Support
    d. Component
35. NASA is researching ways to design and build aircraft that are safer, more fuel-efficient, quieter, and environmentally responsible.
   a. NASA Aeronautics
   b. Science missions
   c. Space exploration
   d. Flight exploration

36. A system of components and parts that is part of a larger system
   a. Part
   b. Subsystem
   c. Station
   d. Component

37. A set of steps to follow to develop a solution to a problem
   a. Scientific method
   b. Loop Process
   c. Engineering Design Process
   d. Discovery pathway

38. Crucial components of the Constellation Program, meant to transport humans and cargo to space
   a. ISS
   b. Orion
   c. Ares
   d. Apollo

39. The only spacecraft capable of delivering and returning large payloads and scientific experiments to and from space recently retired.
   a. Ares I
   b. Space shuttle
   c. Orion spacecraft
   d. Constellation

40. The program that was working on new spacecraft (rockets) that would have been capable of traveling to the ISS and one day to the moon.
   a. Ares I
   b. Constellation
   c. Orion spacecraft
   d. Hubble satellite
# Class Participation Rubric

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

**Comments:**

**Grade:**
## Engineering Design Journal Rubric

<table>
<thead>
<tr>
<th>Name</th>
<th>Assessment:</th>
<th>4</th>
<th>3</th>
<th>3</th>
<th>1</th>
<th>0</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Complete All areas addressed</td>
<td>Most areas well done</td>
<td>Some areas well done</td>
<td>Minimal effort</td>
<td>Not attempted, missing</td>
<td></td>
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<tr>
<td>Budget Link Video comments</td>
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<td></td>
<td></td>
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<tr>
<td>Notes- New focus of NASA</td>
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<tr>
<td>Notes- System PPT</td>
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<tr>
<td>Research findings- As simple as a bicycle</td>
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<tr>
<td>Activity- Design a better paper clip</td>
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<tr>
<td>Notes</td>
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<tr>
<td>Sketches</td>
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<tr>
<td>Activity- Vision of a launch system</td>
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<tr>
<td>Notes</td>
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<tr>
<td>Sketches</td>
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<td>Test results</td>
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<tr>
<td>Extension activity- Design a space craft</td>
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<td>Notes</td>
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<tr>
<td>Sketches</td>
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<tr>
<td>SpaceX math problems</td>
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<tr>
<td>Ability to understand and interpret images, notes and sketches</td>
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<tr>
<td>Bonus: Additional materials</td>
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<td>Comments:</td>
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Grade:
## BCR Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Below Target</th>
<th>At Target</th>
<th>Above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding</strong></td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question</td>
<td>Response demonstrates an understanding of the text</td>
<td>Response demonstrates an understanding of the complexities of the text</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Lacks transitional information to show the relationship of the support to the question</td>
<td>Addresses the demands of the question</td>
<td>Exceeds the demands of the question</td>
</tr>
<tr>
<td><strong>Use of Related Information</strong></td>
<td>Uses minimal information from the text to clarify or extend meaning</td>
<td>Uses some expressed or implied information from the text to clarify or extend meaning</td>
<td>Effectively uses expressed or implied information from the text to clarify or extend meaning</td>
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</tbody>
</table>
Unit 6: The Refocus of NASA

Lesson 2: The Future of the Space Program

Assessment Resource 6.2.4: Reflective Writing Rubric

<table>
<thead>
<tr>
<th>Reflective Writing Rubric</th>
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<td><strong>Category</strong></td>
<td><strong>Below Target</strong></td>
</tr>
<tr>
<td>Understanding</td>
<td>Response demonstrates an implied, partial, or superficial understanding of the text and/or the question</td>
</tr>
<tr>
<td>Focus</td>
<td>Lacks transitional information to show the relationship of the support to the question</td>
</tr>
<tr>
<td>Use of Related Information</td>
<td>Uses minimal information from the text to clarify or extend meaning</td>
</tr>
<tr>
<td>Ability to apply information gained in class to prior knowledge</td>
<td>Lacks connections to knowledge or experience, some applications of knowledge are incorrect</td>
</tr>
</tbody>
</table>

Comments:

Grade:
### Engineering Design Team Rubric

Using the grading scale of A, B, C, D, F, complete a self-grade and a grade for each team member on the following aspects of the lesson:

<table>
<thead>
<tr>
<th>Name</th>
<th>Lesson #</th>
<th>Team Member #1</th>
<th>Team Member #2</th>
<th>Team Member #3</th>
<th>Team Member #4</th>
<th>Team Member #5</th>
<th>Self</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Overall Participation</td>
<td></td>
<td></td>
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<tr>
<td>Contributions to the group</td>
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<tr>
<td>Focus on project</td>
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<tr>
<td>Teamwork</td>
<td></td>
<td></td>
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<tr>
<td>Strengths and weaknesses</td>
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<td>Special Contributions</td>
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<tr>
<td>Overall Grade</td>
<td></td>
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</tr>
</tbody>
</table>
## Technology Systems: Unit - Lesson 2
### Materials/Supplies List

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Vendor (use key)</th>
<th>Qty. per 25 Students</th>
<th>Approx. price (total)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MATERIALS/SUPPLIES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wire, various gauges</td>
<td>BSS, CHS, DS, TEC</td>
<td>10 yards</td>
<td>6.00</td>
</tr>
<tr>
<td>Various styles and sizes of paperclips</td>
<td>DS, OSS</td>
<td>50</td>
<td>2.00</td>
</tr>
<tr>
<td>Liter soda bottles (empty)</td>
<td>GS</td>
<td>8</td>
<td>8.00</td>
</tr>
<tr>
<td>Corrugated cardboard</td>
<td>GS</td>
<td>3 yards</td>
<td>free</td>
</tr>
<tr>
<td>Brass tubing</td>
<td>BSS</td>
<td>1 yard</td>
<td>8.00</td>
</tr>
<tr>
<td>35 mm film canisters</td>
<td>CHS, DS, TEC</td>
<td>12</td>
<td>4.00</td>
</tr>
<tr>
<td>Craft sticks</td>
<td>CHS, DS, TEC</td>
<td>50</td>
<td>4.00</td>
</tr>
<tr>
<td>Dowels</td>
<td>CHS, DS, TEC</td>
<td>8</td>
<td>5.00</td>
</tr>
<tr>
<td>Package tape, 2” wide</td>
<td>DS, OSS</td>
<td>1-2</td>
<td>3.00-6.00</td>
</tr>
<tr>
<td>25-50 pounds (11-23 kilograms) of sand</td>
<td>BSS</td>
<td>1</td>
<td>5.00</td>
</tr>
<tr>
<td>A sturdy cloth bag to hold the sand (pillow case)</td>
<td>home</td>
<td>1-2</td>
<td>free</td>
</tr>
<tr>
<td>Cool melt glue sticks</td>
<td>CHS, DS, TEC</td>
<td>30</td>
<td>2.50</td>
</tr>
<tr>
<td>Engineering Design Journals or blank paper</td>
<td>DS, OSS</td>
<td>1 per student</td>
<td>25.00</td>
</tr>
<tr>
<td><strong>TOOLS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety glasses or goggles</td>
<td>BSS, CHS, DS, TEC</td>
<td>1 per student</td>
<td>100.00</td>
</tr>
<tr>
<td>Cool melt glue guns</td>
<td>BSS, CHS, DS, TEC</td>
<td>8</td>
<td>25.00</td>
</tr>
<tr>
<td>Cardboard cutter (utility knife or box cutter)</td>
<td>BSS, CHS, DS, TEC</td>
<td>2</td>
<td>8.00</td>
</tr>
<tr>
<td>Several sets needle-nosed pliers</td>
<td>BSS, CHS, DS, TEC</td>
<td>8</td>
<td>5.00 ea</td>
</tr>
<tr>
<td>*Strong scissors</td>
<td>BSS, CHS, DS, TEC</td>
<td>8</td>
<td>3.00 ea</td>
</tr>
<tr>
<td>*Rulers</td>
<td>BSS, CHS, DS, TEC</td>
<td>10</td>
<td>1.00 ea</td>
</tr>
<tr>
<td>Yard sticks</td>
<td>BSS, CHS, DS, TEC</td>
<td>2</td>
<td>1.00 ea</td>
</tr>
<tr>
<td>*Computer w/Internet Access</td>
<td>OSS</td>
<td>At least 1</td>
<td></td>
</tr>
<tr>
<td>*Presentation projector</td>
<td>OSS</td>
<td>1</td>
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</tr>
</tbody>
</table>

### Vendor Key
- BSS = Building Supply Store (Lowe’s, Home Depot, etc.)
- CHS = Craft/Hobby Store (Michael’s, AC Moore, Jo Ann’s Fabric and Crafts, etc.)
- DS = Department Store (WalMart, Target, KMart, etc.)
- GS = Grocery Store (Super WalMart, Krugers, Giant, Stop & Shop, Safeway, etc.)
- TEC = Technology Education Store (Kelvin, Paxton/Patterson, Pitsco, IASCO, etc.)
- OSS = Office Supply Store (Office Depot, Staples, PaperMart, etc.)
*indicates a material that is also used in another lesson

### Resources:


