LUNAR PLANT GROWTH CHAMBER

OVERVIEW

ENDURING UNDERSTANDINGS

This unit involves the Space Shuttle (which has been discontinued) and the Constellation Program vehicles designed as part of the Vision for Space Exploration. As of this writing, the Obama Administration's budget plan cancelled the Constellation Program. In response, Congress passed a compromise budget that may keep some parts of the program alive. President Obama signed the NASA Authorization Bill on October 10, 2010, and it is now undergoing the appropriations process by Congress. The Orion crew capsule may continue development as a crew lifeboat for the International Space Station, and Congress proposed accelerating the development of a heavy lift vehicle that uses shuttle technology.

BIG IDEA

The engineering design process is a comprehensive, valuable tool that can be used to provide solutions to complex challenges, on Earth and beyond.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board, reading them aloud, and/or posting them on worksheets associated with the lessons. 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 THE UNIT

This unit will enable students to learn to perform research on plant requirements and apply the engineering design process to create designs for lunar plant growth chambers.

Teacher's Note: Design is a creative problem-solving process. In this unit, students design and build a lunar plant growth chamber using the Engineering Design Process. This Design Challenge has been written with two tracks in mind. Track 1 provides a more comprehensive learning experience. Teachers are encouraged to consider Track 1, perhaps working with other teachers in the school to provide students with resources and a laboratory/classroom with the necessary tools and equipment.

- Track 1: The Design, Build, and Evaluate Challenge is a twelve-to-sixteen hour challenge for those teachers and students who have the resources available to build a larger model with operational subsystems. Teachers need to determine what tools and materials are available to students and whether students will build a full-sized or scaled-down version of the Lunar Plant Growth Chamber (LPGC). This track continues after the Preliminary Design Review (PDR) with the students constructing their working prototype and presenting it at the Critical Design Review (CDR) in Learning Cycle 4.

- Track 2: The Design and Evaluate Challenge is a seven-to-nine hour challenge. It requires students to design and build a small model of a Lunar Plant Growth Chamber (LPGC). This challenge ends with the Preliminary Design Review (PDR) in Learning Cycle 4.

INSTRUCTIONAL TIME

The Engineering Design Process requires 9 weeks of instructional time based on one hour per day. Each of the four units in the Invention and Innovations course require the following number of hours to cover the content:

REQUIRED UNIT HOURS	ENRICHMENT HOURS	TOTAL UNIT HOURS	TOTAL UNIT WEEKS
39 Hours	6 Hours	45 Hours	9 Weeks

STANDARDS AND BENCHMARKS THAT ARE ADDRESSED

This unit is based on three sets of Standards:

1. Standards for Technological Literacy (STL)
2. Next Generation Science Standards (NGSS)
3. Common Core State Standards (CCSS)

Technology: Standards for Technological Literacy (STL) (ITEA/ITEEA, 2000/2002/2007)	
STL 2	Students will develop an understanding of the core concepts of technology.
Y	The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.
AA	Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
BB	Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
FF	Complex systems have many layers of controls and feedback loops to provide information.
STL 8	Students will develop an understanding of the attributes of design.
H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
I	Design problems are seldom presented in a clearly defined form.
J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.
K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.
STL 9	Students will develop an understanding of engineering design.
K	A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.
STL 11	Students will develop abilities to apply the design process.
N	Identify criteria and constraints and determine how these will affect the design process.
O	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.

P	Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.

Science: Benchmarks for Science Literacy (AAAS, 1993/2009) [1]

The Nature of Technology/Technology and Science

- Technological problems and advances often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances. AAAS-3A/H1*
- In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design. AAAS-3B/H1
- The more parts and connections a system has, the more ways it can go wrong. Complex systems usually have components to detect, back up, bypass, or compensate for minor failures. AAAS-3B/H5
- To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable. AAAS-3B/H6

The Living Environment/Flow of Matter and Energy

- The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures, but much is dissipated into the environment. Continual input of energy from sunlight keeps the process going. AAAS-5E/H3

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000) [2]

Algebra Standard (NCTM, 9-12)

Represent and analyze mathematical situations and structures using algebraic symbols (Grades Pre-K-12)

- Write equivalent forms of equations, inequalities, and systems of equations and solve them with fluencyâ€”mentally or with paper and pencil in simple cases and using technology in all cases. (Grades 9-12)
- Use symbolic algebra to represent and explain mathematical relationships. (Grades 9-12)

Geometry Standard (NCTM, 9-12)

Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships. (Grades Pre-K-12)

- Analyze properties and determine attributes of two- and three-dimensional objects, (Grades 9-12)

Use visualization, spatial reasoning, and geometric modeling to solve problems (Grades Pre-K-12)

- Draw and construct representations of two- and three-dimensional geometric objects using a variety of tools, (Grades 9-12)

Measurement Standard (NCTM, 9-12)

Understand measurable attributes of objects and the units, systems, and processes of measurement (Grades Pre-K-12)

- Make decisions about units and scales that are appropriate for problem situations involving measurement. (Grades 9-12)

Apply appropriate techniques, tools, and formulas to determine measurements. (Grades Pre-K-12)

- Analyze precision, accuracy, and approximate error in measurement situations (Grades 9-12)

- Understand and use formulas for the area, surface area, and volume of geometric figures, including cones, spheres, and cylinders (Grades 9-12)

UNIT OBJECTIVES

CYCLE	BIG IDEA	OBJECTIVES
Learning Cycle 1: Introduction to STS-118 Mission and the Design Challenge	The Constellation Program employs two vehicles to continue the vision of space exploration.	Explain that the design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating process and results.
		Explain how problems are seldom presented in a clearly defined form.
		Explain that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and to think abstractly.
		Describe how technological problems often create a demand for new scientific knowledge and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research.
		Describe how to analyze properties and determine attributes of two- and three-dimensional objects.
		Describe how to use visualization, spatial reasoning and geometric modeling to solve problems.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others and focusing on the task.
Learning Cycle 2: Choosing Plant Species	Land, air, water, and space means of transportation are integrated to move people and goods from one location to another.	Explain how problems are seldom presented in a clearly defined form.
		Explain that requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.
		Explain that the chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly-made structures, but much is dissipated into the environment as heat.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Actively participate in group discussions, exercises, and debates.
		Explain how problems are seldom presented in a clearly defined form.
		Explain that requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.

		Explain that the chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly-made structures, but much is dissipated into the environment as heat.
Learning Cycle 3: Identifying Criteria and Specifying Constraints	In any system, large or small, checklists and a comprehensive testing program will ensure the best possibility of success.	Explain that the stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.
		Explain that requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
		Describe how optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
		Describe how complex systems have many layers of controls and feedback loops to provide information.
		Identify criteria and constraints and determine how these will affect the design process.
		Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.
		Explain that the more parts and connections a system has, the more ways it can go wrong. Complex systems usually have components to detect, back up, bypass, or compensate for minor failures.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Actively participate in group discussions, ideation exercises, and debates.
Learning Cycle 4: Designing the Plant Growth Chamber	Decision making procedures assist in the proper operation and integration of systems.	Explain that a design needs to be continually checked and critiqued, and the ideas of the design must be refined and improved.
		Explain that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and to think abstractly.
		Describe how to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
		Explain that when designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design.
		Explain that the more parts and connections a system has, the more ways it can go wrong. Complex systems usually have components to detect, back up, bypass, or compensate for minor failures.

		Explain that to reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Actively participate in group discussions, ideation exercises, and debates.
		Explain that a design needs to be continually checked and critiqued, and the ideas of the design must be refined and improved.
Learning Cycle 4: Building the Plant Growth Chamber		Describe how to refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.
		Describe how to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
		Explain that when designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design.
		Explain that the more parts and connections a system has, the more ways it can go wrong. Complex systems usually have components to detect, back up, bypass, or compensate for minor failures.
		Explain that to reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable.
		Work safely and accurately with a variety of tools, machines, and materials.
Total for This Unit = 39 Hours plus 6 hours Enrichment		

ASSESSMENT TOOLS

Learning assessed using:

- Selected Response Items
- Brief Constructed Response Item
- Performance Rubrics

Specific tools are incorporated into each lesson as Supporting Files.