THE ENGINEERING DESIGN PROCESS

OVERVIEW

ENDURING UNDERSTANDINGS

This unit will enable students to apply the engineering design process as they solve a variety of problems.

BIG IDEA

The Engineering Design process is a systematic iterative problem-solving method that produces solutions to meet human wants and desires.

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 apply the engineering design process as they solve a variety of problems.

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 8	**Students will develop an understanding the attributes of design.**
H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constrains, 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.
STL 9	**Students will develop an understanding of engineering design.**
I	Established design principles are used to evaluate existing designs, to collect data and to guide the design process.

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.
R	Evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.
STL 12	**Students will develop the abilities to use and maintain technological products and systems.**
L	Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
P	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the finished product.
STL 13	**Students will develop abilities to assess the impact of products and systems.**
J	Collect information and evaluate its quality.

SCIENCE: **Next Generation Science Standards (NGSS, 2013)**	
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
HS-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

MATHEMATICS: **Common Core State Standards (CCSS, 2012)**	
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
HAS.SEE.A.1	Interpret expressions that represent a quantity in terms of its context.
HAS.SEE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
HAS.CED.A.4	Rearrange formulas to highlight a quantity of interest using the same reasoning as in solving equations. *For example, rearrange Ohm's law V=IR to highlight resistance R.*
HAS.REI.B.3	Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
HSG.MG.A.1	Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
HSG.MG.A.2	Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
HSB.MG.A.3	Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).
HSG.SRT.B.4	Prove theorems about triangles. *Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely; the Pythagorean Theorem probed using triangle similarity.*

HSS.IC.A.1	Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
HSS.IC.B.3	Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.
HSS.ID.A.2	Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
HSS.ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
HSS.ID.A.4	Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and table to estimate areas under the normal curve.

ENGLISH-LANGUAGE ARTS: **Common Core State Standards (CCSS, 2012)**	
RST.9-10.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
RST.9-10.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
RST.9-10.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
RST.9-10.5	Analyze the structure of the relationships among concepts in a text including relationships among key terms (e.g., force, friction, reaction force, energy).
RST.9-10.6	Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
RST.9-10.9	Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
RST.9-10.10	By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.
WHST.9-10.1	Write arguments focused on discipline-specific content.
WHST.9-10.2	Write informative/explanatory tests, including the narration of historical events, scientific procedures/experiments, or technical processes.
WHST.9-10.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
WHST.9-10.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
WHST.9-10.6	Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
WHST.9-10.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
WHST.9-10.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question;

	integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
WHST.9-10.9	Draw evidence from informational texts to support analysis, reflection, and research.
WHST.9-10.10	Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

UNIT OBJECTIVES

CYCLE	BIG IDEA	OBJECTIVES
Learning Cycle 1: The Engineering Design Process (8 hours)	The engineering design process is a systematic, iterative problem-solving method that produces solutions to meet human wants and desires.	Apply the steps of the design process, including defining a problem, brainstorming, researching and generating ideas, identifying criteria, specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing, and communicating results.
		Use symbolic algebra to represent and explain mathematical relationships.
		Draw symbolic algebra to represent and explain mathematical relationships.
		Draw reasonable conclusions about a situation being modeled.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Work safely and accurately with a variety of tools, machines, and materials.
		Actively participate in group discussions, ideation exercises, and debates.
Learning Cycle 2: Criteria and Constraints (5 hours)	Specifying criteria and identifying constraints is essential when defining a problem and determining the most appropriate solution.	Distinguish the criteria and constraints and reflect on how the criteria and constraints affected the final solution.
		Identify pertinent information needed to solve a given problem on two or more case studies.
		Draw reasonable conclusions about a situation being modeled.
		Explain how design usually requires taking into account not only physical constraints but also economic, political, social, ethical, and aesthetic ones.
		Identify human values and limitations when using scientific knowledge to solve practical design problems.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Work safely and accurately with a variety of tools, machines, and materials.
		Actively participate in group discussions, ideation exercises, and debates

Learning Cycle 3: Design Principles (8 hours)	There are several factors that significantly influence the design process.	Identify the design principles used in a current design, collect data on the effectiveness of the design principles used, and propose a redesign using the design process.
		Use mathematical modeling aids in technological design by simulating how a proposed system might behave.
		Explain how engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. They usually also have to take human values and limitations into account.
		Discuss the aesthetic constraints imposed upon a design.
		Use symbolic algebra to represent and explain mathematical relationships.
		Use geometric ideas to solve problems in and gain insight into other disciplines and other areas of interest such as art and architecture.
		Contribute to a group endeavor by offering useful ideas, support the efforts of other, and focusing on the task.
		Work safely and accurately with a variety of tools, machines, and materials.
		Actively participate in group discussions, ideation exercises, and debates.
Learning Cycle 4: Prototypes and Modeling (3 hours)	At various intervals of the engineering design process, conceptual, mathematical, and physical models are used to evaluate the design solution.	Use prototypes and models to ensure quality, efficiency, and productivity of their final product.
		Visualize three-dimensional objects and spaces from different perspectives and analyze their cross-sections.
		Draw and construct representations of two- and three-dimensional objects.
		Analyze properties and determine attributes of two- and three-dimensional objects.
		Use symbolic algebra to represent and explain mathematical relationships.
		Use mathematical modeling aids in technological design by simulating how a proposed system might behave.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Work safely and accurately with a variety of tools, machines, and materials.
		Actively participate in group discussions, ideation exercises, and debates.
Learning Cycle 5: Collecting and Processing Information (6 hours)	Computers assist in organizing and analyzing data used in the Engineering Design Process.	Collect data and information and use computers and calculators to organize, process, and present the collected data and information.
		Collect information and evaluate its quality.
		Draw reasonable conclusions about a situation being modeled.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Work safely and accurately with a variety of tools, machines, and materials.
		Actively participate in group discussions, ideation exercises, and debates.

Learning Cycle 6: Documenting the Design Process (8 hours)	Documentation of the engineering design process is essential so that the solution can be communicated to the intended audience.	Communicate the observations, processes, and results of the entire design process and the final solution, using appropriate verbal, graphic, quantitative, virtual, and written means in addition to three-dimensional models.
		Present the completion of the design process through a presentation, using appropriate oral and written techniques.
		Analyze the cross sections of three-dimensional objects and spaces from different perspectives.
		Draw and construct representations of two- and three-dimensional geometric objects using a variety of tools.
		Contribute to a group endeavor by offering useful ideas, supporting the efforts of others, and focusing on the task.
		Work safely and accurately with a variety of tools, machines, and materials.
		Actively participate in group discussions, ideation exercises, and debates.
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.