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| **Unit 1 Design Process** |

**Preface**

Each time that you solve a problem, a design process is used. Some processes are as simple as realizing that you are hungry for something new and then designing a new combination of foods. Process can be as complex as designing a clean water solution for a village in an emerging nation. The design process (i.e., method to solve a problem or create a new product) is a cornerstone of all engineering professions.

This lesson provides a foundation for engineering knowledge and professional practices that will be used through this and other pathway to engineering courses and throughout a student’s career. Students will develop skills such as concept sketching, setting up, and maintaining an engineering notebook and portfolio.

Engineering is a professional practice that has evolved through centuries of experience. Learning concepts and practicing skills in this course will provide a foundation for a lifelong engineering career.

**Unit 1 – Concepts & Objectives**

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| **Concepts** | **Objectives** |
| An engineering design process involves a characteristic set of practices and steps. |          Identify and define the terminologyused in engineering design and development.         Identify the steps in an engineering design process and summarize the activities involved in each step of the process.         Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements. |
| Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem. |          Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief.  |
| A problem and the requirements for a successful solution to the problem should be clearly communicated and justified. |          Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders.         Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution.         Write a design brief to communicate the problem, problem constraints, and solution criteria. |
| Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time. |          Generate and document multiple ideas or solution paths to a problem through brainstorming. |
| A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints. |          Clearly justify and validate a selected solution path. |
| Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution. |          Construct a testable prototype of a problem solution. |
| Problem solutions are optimized through evaluation and reflection and should be clearly communicated. |          Describe the design process used in the solution of a particular problem andreflect on all steps of the design process.          Justify and validate a problem solution.         Identify limitations in the design process and the problem solution and recommend possible improvements or caveats. |
| The scientific method guides the testing and evaluation of prototypes of a problem solution. |          Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements. |
| Geometric shapes and forms are described and differentiated by their characteristic features. |          Explain the concept of proportion and how it relates to freehand sketching. |
| Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object. |          Generate non-technical concept sketches to represent objects or convey design ideas. |
| Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms. |          Organize and express thoughts and information in a clear and concise manner.         Adjust voice and writing style to align with audience and purpose.         Support design ideas using a variety of convincing evidence.         Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design.         Document information sources using appropriate formats. |
| Specific oral communication techniques are used to effectively convey information and communicate with an audience. |          Deliver organized oral presentations of work tailored to the audience.         Establish objectives for the presentation that are appropriate for the audience.         Facilitate engaging and purposeful dialog with the audience. |
| Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication. |          Create drawings or diagrams as representations of objects, ideas, events, or systems.         Select and utilize technology (software and hardware) to create high impact visual aids.         Use presentation software effectively to support oral presentations. |
| Engineering has a global impact on society and the environment. |          Define and differentiate invention and innovation.         Assess the development of an engineered product and discuss its impact on society and the environment.         Identify and discuss a Grand Challenge for Engineering (as identified by the National Academy of Engineering) and its potential impact on society and the environment. |
| Engineering consists of a variety of specialist sub-fields, with each contributing in different ways to the design and development of solutions to different types of problems. |          Identify and differentiate between mechanical, electrical, civil, and chemical engineering fields.         Describe the contributions of engineers from different engineering fields in the design and development of a product, system, or technology. |
| In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies. |          Demonstrate positive team behaviors and contribute to a positive team dynamic. |

**Essential Questions (Unit-Specific)**

1.    How might we create the best possible solution to a problem?

2.    What is the most effective way to generate potential solutions to a problem?  How many alternate solutions should you generate?

3.    What are the most pressing engineering/technical problems of our time?

4.    What is an engineer? What types of work do engineers do?

**Essential Questions (Course-Wide)**

1.    How does the design process promote the development of good solutions to technical problems?

2.    How can an engineer or technical professional effectively communicate ideas and solutions in a global community?

3.    How do inventors and innovators impact and shape society?

**Day-by-Day Plans**

*Time: 8 days*

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| **Day 1** | * **Essential Question: What is an engineer?  What does he/she do?**
* Students will complete **Activity 1.1 Instant Challenge: Cable Car**.
* The teacher will assess Activity 1.1 Instant Challenge: Cable Car using thescoring criteria included in the activity.
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| **Day 2** | * The teacher will present **Objectives**, **Concepts**, **Key Terms**, **Essential Questions**, and provide a unit overview.
* The teacher will distribute **Engineering Notebook Samples** in preparation for the associated presentation.
* The teacher will present **Engineering Notebook.ppt**.
* Students will take notes.
* Students will set up their engineering notebooks.
* The teacher will distribute the **Engineering Formula Sheet** for students to use throughout the course.
* **Essential Question: How might we create the best possible solution to a problem?**
* Teacher will debrief Instant Challenge from previous day. How could the design process be improved?
* Students will complete **Activity 1.2 Instant Challenge: Aerodynamic Distance**.
* The teacher will assess Activity 1.2 Instant Challenge: Aerodynamic Distance using the scoring criteria included in the activity.
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| **Day 3- 6** | * The teacher will present **Evolution of Product Design.ppt.**

        Students will take notes in their notebooks.* The teacher will distribute **Activity 1.5 Evolution of Product Design**.
* Students will complete **Activity 1.5 Evolution of Product Design**.
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| **Day 7** | * **Essential Question: What is the most effective way to generate potential solutions to a problem?**
* The teacher will assess student work in Activity 1.4 Concept Sketching using the Activity 1.4 Concept Sketching Rubric**.**
* The teacher will present **Brainstorming Solutions.ppt**.
* Students will take notes.

         **Essential Question: How might we create the best possible solution to a problem?*** The teacher will distribute **Activity 1.8 Instant Challenge:  Paper Bridge**.
* Students will complete Activity 1.8 Instant Challenge:  Paper Bridge following the design process and documenting each step in the engineering notebook using **Instant Challenge: Paper Bridge.ppt** as a guide.
* The teacher will assess Activity 1.8 Instant Challenge:  Paper Bridge using thescoring criteria included in the activity.
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| **Day 8** | * The teacher will present **Design Process.ppt**.
* Students will take notes.
* The teacher will distribute **Activity 1.6 Deep Dive**.
* The teacher will show The Deep Dive video (or another video that presents a design process).
* Students will watch the video and complete Activity 1.6 Deep Dive. .
* The teacher will assess Activity 1.6 Deep Dive using **Activity 1.6 Deep Dive Answer Key** or **The Deep Dive.ppt**.
* **Essential Question: What are the most pressing engineering/technical problems of our time?**
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**Standards and PLTW Concept and Objective Overviews**

***National Science Education Standards addressed in unit.***

**Unifying Concepts and Processes:**  As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes.

         **Evidence, models, and explanation**

         **Evolution and equilibrium**

         **Form and function**

**Physical Science Standard B:** As a result of activities in grades 9-12, all students should develop an understanding of

         **Motions and forces**

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop

         **Abilities of technological design**

         **Understandings about science and technology**

**History and Nature of Science Standard G:** As a result of activities in grades 9-12, all students should develop understanding of

         **Science as a human endeavor**

         **Nature of scientific knowledge**

         **Historical perspectives**

 ***Standards for English Language Arts addressed in unit.***

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| **Standard 3** | Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). |
| **Standard 4** | Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. |
| **Standard 6** | Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts. |
| **Standard 7** | Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and non-print texts, artifacts, and people) to communicate their discoveries in ways that suit their purpose and audience. |
| **Standard 8** | Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. |

***Standards for Technological Literacy addressed in unit.***

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| **Standard 1:  Students will develop an understanding of the characteristics and scope of technology.** |
| **BM J:** | The nature and development of technological knowledge and processes are functions of the setting. |
| **BM K:** | The rate of technological development and diffusion is increasing rapidly.  |
| **BM L:** | Inventions and innovations are the results of specific, goal-directed research. |
| **BM M:** | Most development of technologies these days is driven by the profit motive and the market. |
| **Standard 2:  Students will develop an understanding of the core concepts of technology.** |
| **BM W:** | Systems’ thinking applies logic and creativity with appropriate compromises in complex real-life problems.  |
| **BM X:** | Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.  |
| **BM Y:** | The stability of a technological system is influenced by all of the components in the system especially those in the feedback loop.  |
| **BM Z:** | Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.  |
| **BM 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.  |
| **BM BB:** | Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. |
| **BM CC:** | New technologies create new processes.  |
| **BM DD:** | Quality control is a planned process to ensure that a product, service, or system meets established criteria.  |
| **Standard 3:  Students will develop an understanding of the relationships** **among technologies and the connections between technology and other fields of study.** |
| **BM G:** | Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function |
| **BM H:** | Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.  |
| **BM I:** | Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. |
| **BM J:** | Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. |
| **Standard 4:  Students will develop an understanding of the cultural, social, economic, and political effects of technology.** |
| **BM H:** | Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.  |
| **BM I:** | Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.  |
| **BM J:** | Ethical considerations are important in the development, selection, and use of technologies.  |
| **BM K:** | The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. |
| **Standard 5:  Students will develop an understanding of the effects of** **technology on the environment.** |
| **BM G:** | Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing and recycling.  |
| **BM H:** | When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.   |
| **BM I:** | With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making.  |
| **BM J:** | The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.  |
| **BM K:** | Humans devise technologies to reduce the negative consequences of other technologies.  |
| **BM L:** | Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. |
| **Standard 6:  Students will develop an understanding of the role of society in the development and use of technology.**  |
| **BM H:** | Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.  |
| **BM I:** | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.   |
| **BM J:** | A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. |
| **Standard 7:  Students will develop an understanding of the influence of** **technology on history.**  |
| **BM G:** | Most technological development has been evolutionary, the result of a series of refinements to a basic invention.  |
| **BM H:** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.  |
| **BM I:** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.  |
| **BM O:** | The Information Age places emphasis on the processing and exchange of information. |
| **Standard 8:  Students will develop an understanding of the attributes of design.**  |
| **BM 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.   |
| **BM I:** | Design problems are seldom presented in a clearly defined form.  |
| **BM J:** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.   |
| **BM K:** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. |
| **Standard 9:  Students will develop an understanding of engineering design.**  |
| **BM I:** | Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.  |
| **BM J:** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. |
| **BM K:** | A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.  |
| **BM L:** | The process of engineering design takes into account a number of factors. |
| **Standard 10:  Students will develop an understanding of the role of** **troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** |
| **BM I:** | Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.  |
| **BM J:** | Technological problems must be researched before they can be solved.  |
| **BM K:** | Not all problems are technological, and not every problem can be solved using technology.  |
| **BM L:** | Many technological problems require a multidisciplinary approach. |
| **Standard 11:  Students will develop abilities to apply the design process.**  |
| **BM M:** | Identify the design problem to solve and decide whether or not to address it. |
| **BM N:** | Identify criteria and constraints and determine how these will affect the design process.   |
| **BM O:** | Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.   |
| **BM 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.   |
| **BM Q:** | Develop and produce a product or system using a design process.    |
| **BM R:** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. |
| **Standard 17:  Students will develop an understanding of and be able to select and use information and communication technologies.**  |
| **BM M:** | Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.  |
| **BM N:** | Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.  |
| **BM P:** | There are many ways to communicate information, such as graphic and electronic means. |
| **BM Q:** | Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. |