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| **Lesson 2.1 Designing for Manufacturability**  |

**Preface**

Most soft drink cans have the same basic shape. Why? Is there only one way to create a container that will hold 12 ounces of liquid? Many factors affect design, including cost, safety, functionality, and others. Can we design products that meet the needs of our clients while realizing a comfortable profit margin? Why is it so important to follow a detailed process when designing new products for the consumer?

In this lesson students will analyze bad designs and discuss ways in which they might be improved. They will use solid modeling software to improve some of the bad designs they encounter. Safety and ethics will be discussed, and students will be asked to analyze manufacturing scenarios with those in mind. Finally, students will design a product of choice using the solid modeling software.

**Concepts**

1.    Design is a process that is used to systematically solve problems.

2.    Many considerations must be made when manufacturing a quality part.

3.    Material properties must be considered as part of the design process.

4.    Manufacturers have an ethical responsibility to create safe products and to provide a safe work environment.

5.    Manufacturers have a legal responsibility to provide safety information about their products.

6.    Many engineering disciplines have a code of conduct or code of ethics that their members are expected to follow.

7.    Analyzing case studies of engineering failures is a good way for engineers to avoid future failures.

**Standards and Benchmarks Addressed**

***Standards for Technological Literacy***

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| **Standard 1:** | Students will develop an understanding of the characteristics and scope of technology. |
| **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.  |
| **Standard 4:** | Students will develop an understanding of the cultural, social, economic, and political effects of technology. |
| **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 K:** | Humans devise technologies to reduce the negative consequences of other technologies. |
| **Standard 6:** | Students will develop an understanding of the role of society in the development and use of technology.  |
| **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. |
| **Standard 8:** | Students will develop an understanding of the attributes of design. |
| **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 J:** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. |
| **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 K:** | Not all problems are technological, and not every problem can be solved using technology. |

***National Science Education Standards***

**Science in Personal and Social Perspectives Standard F:** As a result of activities in grades 9-12, all students should develop understanding of

         **Natural resources**

         **Environmental quality**

         **Natural and human-induced hazards**

         **Science and technology in local, national, and global challenges**

***Principles and Standards for School Mathematics***

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| **Number Operations:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; compute fluently and make reasonable estimates. |
| **Algebra:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; analyze change in various contexts. |
| **Geometry:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to [**analyze characteristics**](file:///D%3A%5CStandards%5Cdocument%5Cchapter3%5Cgeom.htm#bp1#bp1) and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; specify locations and describe spatial relationships using coordinate geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; use visualization, spatial reasoning, and geometric modeling to solve problems. |
| **Data Analysis and Probability Standard:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; select and use appropriate statistical methods to analyze data; develop and evaluate inferences and predictions that are based on data; |
| **Problem Solving:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems; monitor and reflect on the process of mathematical problem solving. |
| **Communication:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others. |
| **Connections:**  | Instructional programs from pre-kindergarten through grade 12 should enable all students to recognize and use connections among mathematical ideas; understand how mathematical ideas interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics. |
| **Representation:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; model and interpret physical, social, and mathematical phenomena. |

***Standards for English Language Arts***

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| **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 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. |

**Performance Objectives**

*It is expected that students will:*

    Use the design process.

    Use knowledge of design to analyze products with flaws.

    Use calculated volume, mass, surface area of parts to determine material cost, waste, and packaging requirements.

    Use solid modeling software to improve a flawed design.

    Determine whether a product is safe for a given audience (e.g., children under the age of three).

    Make ethical decisions about manufacturing.

    Create a product using solid modeling software.

**Assessment**

*Explanation*

1.    Students will identify flaws in a design and explain why they are considered flaws.

2.    Students will explain how to redesign a product to remove flaws.

3.    Students will explain how the Engineering Code of Ethics is related to manufacturing.

*Application*

4.    Students will apply their knowledge of design in the modeling of a product.

5.    Students will analyze a manufacturing scenario and apply their knowledge of inherent design flaws and ethics.

6.    Students will apply their understanding of ethics to a past real-life engineering disaster to explain how it was caused and how it might have been avoided.

7.    Students will apply their knowledge of manufacturing processes to determine why a modeled design is not plausible.

*Empathy*

8.    Students will analyze a scenario to determine the ethical dilemma and recommend an appropriate action(s).

**Essential Questions**

1.    What are some major causes of defects in products?

2.    How do safety and ethics affect product design?

3.    When performing a redesign or improving a product, why is it important to follow a design process?

4.    What properties are important when creating a new product?

5.    What restrictions must you consider when modeling a product?

**Key Terms**

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| **Competent** | Properly or sufficiently qualified; capable or efficient. |
| **Defective** | Imperfect in form or function. |
| **Design Flaws** | An imperfection in an object or machine. |
| **Durability** | The quality of equipment or goods of continuing to be useful after an extended period of time and usage.  |
| **Economics** | Dealing with production, distribution, and consumption of products or wealth.  |
| **Ethics** | The standards for ethical or moral behavior of a particular group. In our case it will be the Engineering Code of Ethics. |
| **Functionality** | The ability of a product to do the job for which it was intended.  |
| **Morality** | Rules relating to principles of right and wrong in behavior. |
| **Purpose** | What one intends to do or bring about. |
| **Quality Control** | The process of making sure that products or services meet consistently high standards. |

**Day-by-Day Plans**

*Time: 5 Days*

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**Day 1:**

    The teacher will present **Concepts**, **Key Terms**, and **Essential Questions** in order to provide a lesson overview.

    The teacher will present **Design Process.ppt**.

    Students will take notes on the design process in their journals.

    The teacher will present **Bad Designs.ppt**.

    Students will take notes on the processes using **Activity 2.1.1 Design Flaws****.**

    Students will work on **Activity 2.1.1 Design Flaws**, documenting their progress in their engineer’s notebooks.

    The teacher will assess students on completion.

**Day 2-3:**

    The teacher will present **Design Considerations for Manufacturability.ppt****.**

    The teacher will distribute **Activity 2.1.2 Mass Properties Analysis**.

    Students will complete **Activity 2.1.2 Mass Properties Analysis**, documenting progress in their engineer’s notebooks.

    The teacher will assess student work using **Activity 2.1.2 Mass Properties Analysis Answer Key**.

    Optional: The teacher will present **Dial Calipers.ppt**.

**Day 4-5:**

    The teacher will distribute **Activity 2.1.3 Ethics & Safety****.**

    Students will work on **Activity 2.1.3 Ethics & Safety**.

**Instructional Resources**

Presentations

**Design Process**

**Bad Designs**

**Design Considerations for Manufacturability**

**Dial Calipers**

Word Documents

**Activity 2.1.1 Design Flaws**

**Activity 2.1.2 Mass Properties Analysis**

**Activity 2.1.3 Ethics & Safety**

**Key Terms 2.1 Crossword Puzzle**