Unit 6 Reverse Engineering

Preface

Reverse Engineering is an important process in the documentation and redesign of products. Through reverse engineering all aspects of a product can be analyzed. There are many reasons to reverse engineer a product. The information gathered during this process can provide information on products for which documentation has been lost. Reverse engineering can help the designer or team determine what they can do to make the product better and optimize manufacturing potential to increase company profits. Often, reverse engineering is necessary in order to provide details necessary to provide interoperability between existing and new products or to provide information on competitor products.

The process of Reverse Engineering involves analyzing the product's function, structure, and visual elements. In this unit, students will get an opportunity to assess all three aspects of a product.

Visual design principles and elements constitute a language that can be used to describe any object without reference to its function or formal title. It is important for engineers, as well as other design professionals, to have an understanding of visual design principles and elements in order to control the visual impact of the products and spaces that they create. Students will learn the basic terminology essential to the understanding of the visual language of design in order to communicate what they see and design visually impactful products.

Students will perform a functional analysis through non-destructive methods of observation – the product under investigation will remain intact. As part of the functional analysis students will then generate hypotheses of the sequential operations of their products, and identify the inputs and outputs that are indicative of those systems.

As a final step in the reverse engineering process, students will physically disassemble a product and document the constituent parts, their properties, and their operation with the intent of providing students with a better understanding of the product's strengths, weaknesses and the manufacturing processes used in manufacturing.

Unit 6 – Concepts & Objectives

Concepts	Objectives
Material and fastener choices used in a product design should be carefully chosen based on the impact to the product's design, cost, performance, marketability, environmental impact, and expected service life. **Note: This aligns with the 2012-2013 PREVIEW curriculum.**	• Evaluate and compare multiple materials and fastener choices for a product design based on the impact on the design's cost, performance, marketability, environmental impact, and expected service life. **Note: This aligns with the 2012-2013 PREVIEW curriculum.**
Error is unavoidable when measuring a physical property and a measurement is characterized by the precision and accuracy of the measurement.	• Measure linear distances (including length, inside diameter, and hole depth) with accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision. • Measure mass with accuracy using a scale and report the measurement using an appropriate level of precision.
Technical drawings convey information according to an	• Determine the minimum number and types of views necessary to

established set of drawing practices which allow for detailed and universal interpretation of the drawing.	fully detail a part. • Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings.
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.	• Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. • Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object.
Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. • Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice.
Computer aided drafting and design (CAD) software packages allow virtual testing and analysis of designs using 3D models, assemblies, and animations.	• Assign a specific material (included in the software library) to a part and use the capabilities of the CAD software to determine the mass, volume, and surface area of an object for which a 3D solid model has been created.
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. • 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.
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.
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.
Visual elements and principles of design are part of an aesthetic vocabulary that is used to describe the visual characteristics of an object, the application of which can affect the visual appeal of the object and its commercial success in the marketplace.	• Identify and describe the visual principles and elements of design apparent in a natural or man-made object. • Define aesthetics and explain how the visual elements and principles of design affect the aesthetics and commercial success of a product.
Reverse engineering	• Describe the process of reverse engineering.

involves disassembling and analyzing a product or system in order to understand and document the visual, functional, and/or structural aspects of its design.	• Justify the use of reverse engineering and explain the various reasons to employ reverse engineering, including discovery, documentation, investigation, and product improvement. • Perform a functional analysis of a product in order to determine the purpose, inputs and outputs, and the operation of a product or system. • Perform a structural analysis of a product in order to determine the materials used and the form of component parts as well as the configuration and interaction of component parts when assembled (if applicable). • Analyze information gathered during reverse engineering to identify shortcoming of the design and/or opportunities for improvement or innovation.
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. What considerations should be made in when reverse engineering?
2. What makes a product aesthetically pleasing or eye-catching?
3. How are principles and elements of design used with engineering practice to develop a successful product?

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?

Instructional Resources

Activities, Projects, & Problems
Activity 6.1 Elements and Principles of Design Identification ***preview download*** **Instructor Notes / Resources** ***preview download***
Activity 6.2 Visual Analysis ***preview download*** **Instructor Notes / Resources** ***preview download***
Activity 6.2a Visual Analysis (Automoblox) PREVIEW ***preview download***
Project 6.3 Functional Analysis ***preview download*** **Example Solution Instructor Notes / Resources**

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Project 6.3 Functional Analysis (Automoblox) PREVIEW ***preview download***		
Activity 6.4 Product Disassembly ***preview download*** **Instructor Notes / Resources** ***preview download***		
Activity 6.4a Product Disassembly (Automoblox) PREVIEW ***preview download***		
Activity 6.5 Product Disassembly Display ***preview download*** **Rubric Instructor Notes / Resources** ***preview download preview download***		
Support Resources	**Type**	**Corresponding APBs**
Key Terms ***preview download***	Document	
Elements and Principles of Design ***download***	Presentation	A 6.1 A 6.2
Simple Machines ***download***	Presentation	A6.3
Reverse Engineering and Functional Analysis ***download*** **Instructor Notes / Resources** ***preview download***	Presentation	A 6.3 A 6.4 A 6.5
Product Observation Example ***preview download***	Document	A 6.3
Product Disassembly Chart ***preview download*** **Instructor Notes / Resources** ***preview download***	Document	A 6.4
Product Disassembly Material Usage Chart ***preview download*** **Instructor Notes / Resources** ***preview download***	Document	A 6.4
Product Disassembly ***download*** **Instructor Notes / Resources** ***preview download***	Presentation	A 6.5

Day-by-Day Plans

Time: 9 days

Day 1	• The teacher will present **Objectives**, **Concepts**, **Key Terms**, and **Essential Questions**, and provide a lesson overview. • **Essential Question: What makes a product aesthetically pleasing or eye-catching?** • The teacher will present **Elements and Principles of Design.ppt**. • Students will take notes. • The teacher will distribute **Activity 6.1 Elements and Principles of Design Identification.** • Students will work on Activity 6.1 Elements and Principles of Design Identification and complete the activity for homework.
Day 2	• The teacher will distribute **Activity 6.2 Visual Analysis (Automoblox) PREVIEW**. • Students will complete Activity 6.2 Visual Analysis (Automoblox) PREVIEW. • The teacher will check Activity 6.2 Visual Analysis or Activity 6.2 Visual Analysis (Automoblox) PREVIEW for completion. • **CFU: What do you think Reverse Engineering means? What are some reasons why a person or company would want to reverse engineer a product?** • The teacher will check Activity 6.1 for completion. • Students will present one item for which they performed a visual analysis in Activity 6.1 Elements and Principles of Design Identification.
Day 3	• The teacher will present **Reverse Engineering and Functional Analysis.ppt.** • Students will take notes. • The teacher will distribute **Activity 6.3 Functional Analysis (Automoblox) PREVIEW** and **Activity 6.3 Example Product Observation.** • Students will work on Activity 6.3 Activity 6.3 Functional Analysis (Automoblox) . • The teacher will present **Simple Machines.ppt**. • Students will take notes. • Students will complete Activity 6.3 Functional Analysis or Activity 6.3 Functional Analysis (Automoblox) PREVIEW incorporating simple machines terminology. •
Days 4-5	• **CFU: How can information gained from reverse engineering it be misused?** • The teacher will present **Product Disassembly Display.ppt**. • The teacher will distribute **Activity 6.4 Structural Analysis (Automoblox) PREVIEW** • The teacher will distribute **Activity 6.4 Product Disassembly Material Usage Chart**. • Students will complete Activity 6.4 Product Disassembly. • The teacher will check Activity 6.4 Product Disassembly for completion.
Day 6 - 9	• The teacher will distribute **Activity 6.5 Product Improvement Presentation** • Students will complete Activity 6.5 Product Improvement Presentation. • Students will present Activity 6.5 Product Improvement Presentation. • **CFU: What makes a product successful in the marketplace?** • **CFU: What attributes add to the success of a team's presentation?**

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.

- **Systems, order, and organization**

- **Evidence, models, and explanation**
- **Change, constancy, and measurement**
- **Form and function**

Science As Inquiry Standard A: As a result of activities in grades 9-12, all students should develop
- **Abilities necessary to do scientific inquiry**
- **Understanding about scientific inquiry**

Physical Science Standard B: As a result of activities in grades 9-12, all students should develop an understanding of
- **Structure and properties of matter**
- **Motions and forces**
- **Interactions of energy and matter**

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**

Science in Personal and Social Perspectives Standard F: As a result of activities in grades 9-12, all students should develop understanding of
- **Natural and human-induced hazards**
- **Science and technology in local, national, and global challenges**

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.

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 5 Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of 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.

Standards for Technological Literacy addressed in unit.

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.

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 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.

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 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.

Standard 5: Students will develop an understanding of the effects of technology on the environment.

BM H: When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.

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 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.

Standard 12: Students will develop the abilities to use and maintain technological products and systems.

BM L: Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.

BM P: Use computers and calculators to access, retrieve, organize and process, maintain, interpret, and evaluate data and information in order to communicate.

Standard 13: Students will develop the abilities to assess the impacts of products and systems.

BM J: Collect information and evaluate its quality.

BM K: Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.

BM L: Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology.

BM M: Design forecasting to evaluate the results of altering natural systems.

Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.

BM J: Energy cannot be created or destroyed; however, it can be converted from one form to another.

BM N: Power systems must have a source of energy, a process, and loads.

Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.

BM L: Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.

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.

Standard 19: Students will develop an understanding of and be able to select and use

manufacturing technologies.

BM M: Materials have different qualities and may be classified as natural, synthetic, or mixed.

BM P: The interchangeability of parts increases the effectiveness of manufacturing processes.

BM R: Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it.