Unit Overview – Socially Responsible Engineering & Technology (POS)
Course: Y1U4
Unit Title: How does this Work? **(Reverse Engineering)**
Approximate Length of Unit: 2-3 Weeks (based on five day weeks; 45 minute periods each day)

Unit Summary

This unit will raise student interest in principles of mechanical, electrical, and structural engineering. Students will be presented with the following problem:

You are a Systems Engineer for a local engineering firm. You have been approached by your supervisor with a serious concern….the competing firm downtown appears to be taking the lead on an emerging product design. In order for you to better understand what is happening in their product, reverse engineering is required. Products in the designed world are comprised of a series of sub-systems working together. Reverse engineering allows the user to analyze the different sub systems in operation within a product, classify the component parts, associate the functions, and analyze the environmental responsibility in its design. These skills are essential to troubleshooting, and the ability to communicate findings to others is essential to making sure that your company once again takes control of the consumer market for this product. You will be provided with a real world product, and as design teams work collaboratively to reverse engineer it. Each design team will capture in a technical report with text and images the specific steps of the process and provide concise directions that will allow other design teams to reassemble the product back to its original form.

In order to prepare them with the understandings they will need to communicate their findings, students will need to understand how the product works and how to capture documentation accurately. Once an understanding is acquired, students can then collaborate as a team to methodically disassemble the product, and then using the directions from another team reassemble a different product without any verbal interaction.

Throughout the unit, students will acquire insight into basic foundations of potential careers in mechanical, structural, electrical, and systems engineering.

Primary Interdisciplinary Connections: Engineering, Mathematics

21st Century Themes:

Unit Rationale

The designed world is compromised of thousands of manmade products. Even though most consumers are concerned with repeatability, reliability, and aesthetic appearance exclusively, aspiring engineers must understand what is happening inside these products in order to maximize marketability, dependability, and efficiency.

Reverse engineering provides insights into how different mechanical, electrical, and structural sub systems work together. Using various forms of written and visual communication, design teams will be challenged to capture the process in a manner that will allow others to reassemble the product without any verbal communication. Proper terminology, a sense of sequence, and mechanical aptitude will be required.

Suggested Materials:

- Product to be reverse engineered should have multiple subsystems, specifically mechanical, electrical, and structural.

- Product should be able to be disassembled and reassembled without any permanent damage to the product. Product should function properly upon reassembly.

Suggested Tools and Machines:

- Hand tools

Unit Assumptions: Student has understanding of basic mechanical, electrical, and structural systems. Student can communicate in an organized, sequential manner using text and visual images.

Learning Targets

Standards for Technological Literacy (ITEEA)

Standard 2: Students will develop an understanding of the core concepts of technology. **X**. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.

Standard 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.

Math (NJCCCS 4) –

Standard 4.2 (Geometry and Measurement) – All students will develop spatial sense and the ability to use geometric properties, relationships, and measurement to model, describe, and analyze phenomena.

CPI #	Cumulative Progress Indicator (CPI)
4.2.12.D.2	Choose appropriate tools and techniques to achieve the specified degree of precision and error needed in a situation.

Science (NJCCCS 5)

5.1 Science Practices: All students will understand that science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

CPI #	Cumulative Progress Indicator (CPI)
5.1.12.C.1	Reflect on and revise understandings as new evidence emerges.

Educational Technology (NJCCCS 8.1)

8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaboratively and to create and communicate knowledge.

CPI #	Cumulative Progress Indicator (CPI)
8.1.12.A.1	Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs and interpret the results.

Engineering and Technological Literacy (NJCCCS 8.2)

8.2 Technology Education, Engineering, and Design: All students will develop an understanding of the nature and impact of technology, engineering, technological design, and the designed world, as they relate to the individual, global society, and the environment.

CPI #	Cumulative Progress Indicator (CPI)
8.2.12.D.1	Reverse engineer a product to assist in designing a more eco-friendly version guided by an analysis of trends and data about renewable and sustainable

	materials.
8.2.12.F.2	Explain how material science impacts the quality of products.

21st Century Skills (NJCCCS 9.1)

9.1 21st-Century Life & Career Skills: All students will demonstrate the creative, critical thinking, collaboration, and problem-solving skills needed to function successfully as both global citizens and workers in diverse ethnic and organizational cultures.

CPI #	Cumulative Progress Indicator (CPI)
9.1.12.A.1	Apply critical thinking and problem-solving strategies during structured learning experiences.
9.1.12.B.2	Communicate and comprehend written and verbal thoughts, ideas, directions, and information relative to educational and occupational settings.
9.1.12.B.5	Demonstrate teamwork and leadership skills that include student participation in real world applications of career and technical education skills.

Standard 9.2 Consumer, Family, and Life Skills -All students will demonstrate critical life skills in order to be functional members of society. All students need to develop consumer, family, and life skills necessary to be functioning members of society. All students will develop original thoughts and ideas, think creatively, develop habits of inquiry, and take intellectual and performance risks.

CPI#	Cumulative Progress Indicator (CPI)
9.2.12.C.2	Communicate effectively in a variety of settings with a diverse group of people.
9.2.12.F.4	Practice the safe use of tools and equipment.

Standard 9.4 Career and Technical Education All students who complete a career and technical education program will acquire academic and technical skills for careers in emerging and established professions that lead to technical skill proficiency, credentials, certificates, licenses, and/or degrees.

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.O.4	Select and employ appropriate reading and communication strategies to learn and use technical concepts and vocabulary in practice.
9.4.12.O.9	Develop and deliver formal and informal presentations using appropriate media to engage and inform audiences.
9.4.12.O.15	Prepare science, technology, engineering, and mathematics material in oral, written, or visual formats to provide information to an intended audience and to fulfill the specific communication needs of that audience.
9.4.12.O.68	Employ planning and time management skills and tools to enhance results and complete work tasks.
9.4.12.O.(1).12	Model technical competence by developing and applying processes and concepts in the design process.

English Language Arts Writing (Common Core)

- W.11-12.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

- L.11-12.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.

Mathematics (Common Core)

- N-Q.3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Industry Standards

NOCDI

- STEM – Pre-Engineering, Engineering Technology

Unit Essential Questions	**Unit Enduring Understandings**
• How do products function? • What is the role of dependability and reliability in product design? • What is the role of reverse engineering in research and development? • What is the connection between reverse engineering and reassembly? • What is the connection between reverse engineering and budgeting? • Who should reverse engineer products?	• Products function because of a series of sub systems working together. • Troubleshooting can require reverse engineering. • A decision as to whether a product must be re-assembled must be made prior to beginning the reverse engineering process. • The failure of one subsystem may result in malfunction. • All stakeholders have a vested interest in the long term durability and reliability of products.

Design Brief

Background/Scenario:

You are a Systems Engineer for a local engineering firm. You have been approached by your supervisor with a serious concern….the competing firm downtown appears to be taking the lead on an emerging product design. In order for you to better understand what is happening in their product, reverse engineering is required. Products in the designed world are comprised of a series of sub-systems working together. Reverse engineering allows the user to analyze the different sub systems in operation within a product, classify the component parts, associate the functions, and analyze the environmental responsibility in its design. These skills are essential to troubleshooting, and the ability to communicate findings to others is essential to making sure that your company once again takes control of the consumer market for this product.

Problem/Opportunity Statement:

You will be provided with a real world product, and as design teams work collaboratively to reverse engineer it. Each team will develop a technical report with text and images of the specific steps of the process and provide concise directions that will allow other design teams to reassemble the product back to its original form.

Specifications/Criteria:

The student design teams will:

- Be provided with a product with multiple subsystems.
- Disassemble the product, archiving the images of the sequential process and documenting findings.
- Utilize the written directions from another design team to reassemble another product.
- Compare and contrast the differences between reverse engineering and reassembly.
- Demonstrate the proper function of a product.
- Present findings and insights to peers.

Constraints:

Time –

- 2-3 weeks.

Money -

- Students will be provided with the product.

Energy-

- Human energy to disassemble the original and reassemble the other product.

Tools/Machines-

- Use safety as needed.
- Necessary hand tools.

People-

- Maximum of two people per group.

Information-

- Students most have basic understanding of hand tools and computer applications.

Materials-

- Use the product only.

Stakeholders:

- All students who will advance in course outline.
- All students who are looking to pursue career in engineering or technical field.

Student Grouping Notes:

Groups of two will allow both parties to be involved with disassembly, documentation, image acquisition, and reassembly of the other product. Larger groups will garner a less efficient distribution of tasks.

Material Notes: In order to maintain more control of the time frame and course, it is recommended that the teacher purchase and provide the products to be reverse engineered through the classroom budget. However if necessary, students can purchase the products as long as strict parameters are set.

Recommendations include:

- Disposable Cameras
- Electronic Toothbrushes
- Animated Toys / Figurines
- Electronic Children's Toys

Unit Learning Targets

Throughout the unit, students will analyze and document the reverse engineering and reassembly process.

Students will . . .

1. Recognize that products in the designed world function as a result of multiple sub systems working together. (8.2.12.F.2)

2. Recognize the challenges of design under constraint. (9.1.12.A.1)
3. Identify how different products work. (8.2.12.D.1, 8.2.12.F.2)
4. Differentiate between the various sub systems; their functions and their components. (5.1.12.C.1)
5. Demonstrate the mechanical aptitude to complete the reverse engineering process without damaging the product and its subsystems. (9.2.12.F.4, 9.1.12.B.5, 9.4.12.O.(1).12)
6. Document the proper sequence of the reverse engineering process through text and images. (8.1.12.A.1, 9.4.12.O.4, 9.4.12.O.15)
7. Demonstrate the ability to reconstruct a different product using only text and images without any verbal interaction. (9.1.12.B.2)
8. Demonstrate effective use of hand tools. (4.2.12.D.2, 9.4.12.O.68)
9. Present evidence of working product to class and instructor upon completion. (9.2.12.F.4, 9.4.12.O.9)
10. Discuss multiple ways to assess product design in order to facilitate disassembly and reassembly. (9.1.12.A.1)

Project-Based Learning Plan:
Engineering Design Process (Sequence and Assessments)

Teacher Instruction	Student Evaluation
Step One: Identify the Problem	
Lesson 1: Why Reverse Engineer a product? • Understanding sub-systems • Marketplace Competitiveness • Defining our problem for this unit	**<u>Formative Assessments: (must have feedback)</u>** ○ Teacher questions background knowledge of reverse engineering **<u>Summative Assessments:</u>** • Quiz – Foundations of Reverse Engineering (ULT#1)
Notes: • Discuss impact of reverse engineering in the designed world.	**Notes:**
Step Two: Frame the Design Brief	
Lesson 2: Framing the design brief for the Reverse Engineering Project • Review of design brief requirements • Review of specifications • Review of constraints • Review of engineering design process • Provide examples of previous student work if available Lesson 3: Hand Tool Usage • Review measurement math associated with tool usage (ruler, tape measure, etc.)	**<u>Formative Assessments:</u>** • Teacher will provide feedback in regard to proper hand tool usage • Teacher will conference with student groups to reinforce specifications. **<u>Summative Assessments:</u>** • Quiz summarizing primary constraints and specifications of design brief. (ULT#2) • Demonstration w/rubric - Students will demonstrate proper hand tool usage. (ULT #8)

Notes: Teacher will provide examples (see design brief) of the various products to be reverse engineered. The quantity and variety will be determined by the size of the class and the actual time available.	**Notes:**
Step Three: Research & Brainstorming	
Lesson 4 – Product Sub Systems Lesson 5 – Research through Reverse Engineering	**Formative Assessments:** ▪ Teacher will conference with student groups on subsystem components and function. **Summative Assessments:** • Subsystems Quiz (ULT #4)
Notes: Teacher will reinforce the need for reverse engineering in order to determine how a product functions.	
Step Four: Generation Alternate Solutions	
Lesson 6: Modeling the Brainstorming Process Lesson 7: How to Design a Template for Directions Lesson 8: Communicating Possible Solutions	**Formative Assessments:** ▪ Teacher will critique student thoughts on upcoming reverse engineering process and provide feedback. ▪ Teacher will question choice of hand tools and sequence to maximize safety. **Summative Assessments:** • Quiz: Principles of Brainstorming (ULT #10) • Quiz: Template for Re-assembly Directions (ULT#6)
Notes: Teacher will model the brainstorming process using an actual example or a more formal brainstorming process such as morphological charts. The goal here is for students to see how "experts" approach brainstorming. Before students actually start brainstorming the solutions for this unit, the instructor should give students practice. Once this is done, then move into the brainstorming for this unit's problem. Encourage students to brainstorm multiple ways to dissemble the product. Teacher will continue to emphasize that the part must be re-assembled to the point of full function upon completion.	**Notes:** Student will design format for the template where all re-assembly directions and images will be. Student will choose the software most applicable to the format. Examples may include but are not limited to Microsoft Word, Publisher, or Powerpoint.

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<tr><td>Teacher will ensure that template is completed done prior to the reverse engineering process to ensure that the process is fluid and sequential. Minimal interruption is recommended.</td><td></td></tr>
<tr><td colspan="2">Step Five: Chosen Solution with Rationale</td></tr>
<tr><td>Lesson 9:
Using Pictures as a Form of Documentation Development.</td><td><u>Formative Assessments:</u>
Teacher will critique photos of reverse engineering process and encourage more detailed annotations.
Teacher will conference with student groups about pacing and sequence and provide feedback.
<u>Summative Assessments:</u>
Performance activity w/rubric: students individually demonstrate uploading of pictures to portfolio (UTL#6)</td></tr>
<tr><td>Notes:
Title not fully applicable here as design teams will reverse engineering their original product at this step. As this occurs, detailed directions will be written for how another group of students will reassemble the same product.

Teacher will re-emphasize that no verbal communication can take place between the design team who reverse engineered the product and the other group who will reassemble it.</td><td>Notes:
Students must thoroughly document reverse engineering process through text and image at each step.</td></tr>
<tr><td colspan="2">Step Six: Developmental Work</td></tr>
<tr><td>Lesson 10: Finalizing a Technical Report</td><td><u>Formative Assessments:</u>
Teacher will question all design teams on picture clarity, sequence, and organization.
Teacher will review with design teams the specifics of the rubric and provide feedback.
<u>Summative Assessments:</u>
Performance activity w/rubric: Reverse Engineering Process / Technical report outlining Re-assembly instructions. (UTL#5)</td></tr>
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<tr><td>Notes: Teacher should ensure that products are completely disassembled at this point.

All classroom tools should be returned. All directions on tool usage should be found in the report.</td><td>Notes:</td></tr>
<tr><td colspan="2">Step Seven: Prototype</td></tr>
<tr><td>Lesson 11: Compare and Contrast Product Design
• Review requirements and reference specific components of electrical, structural, and mechanical systems.</td><td><u>Formative Assessments:</u>
• Teacher will conference with student groups to follow the technical report prepared for them on another product by another team.
• Teacher will keep anecdotal records on hand tool usage with new product parts and provide feedback if necessary to maintain classroom safety.
<u>Summative Assessments:</u>
▪ Paper with Rubric – Compare and Contrast the Subsystems and Function of Different Products (ULT#3)
▪ Performance Activity w/ Rubric – Reassemble product (ULT #7)</td></tr>
<tr><td>Notes: Teacher can choose which groups get to reassemble which products, or allow the students to do so. Decision should be based on student ability and time.

Teacher should not allow any interaction between design teams. Teacher should not answer any student questions.</td><td>Notes:
Students cannot collaborate with any other groups about their product. The technical report provided will serve as the only resource.</td></tr>
<tr><td colspan="2">Step Eight: Testing and Evaluation</td></tr>
<tr><td>Lesson 12: Demonstration Expectations
• Review rubric with students</td><td><u>Formative Assessments:</u>
• Teacher conferences with student groups for frequent safety and parts checks.

<u>Summative Assessment:</u>

▪ Demonstration w/ Rubric – Product Function (ULT #7)</td></tr>
<tr><td>Notes:
Teacher must be flexible with time allocation at this step. Length of process will be contingent upon complexity of the product and ability of the students.</td><td>Notes:
Teachers and students should continue to recognize safety concerns associated with reassembly process, especially in regard to electronics. (example: capacitor from disposable camera may cause shock if not discharged)</td></tr>
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Step Nine: Redesign and Reflect	
Lesson 13: Product Dependability and Efficiency • Review of specifications and rubric for reflection paper	**Formative Assessments:** • Teacher will question construction and fastening techniques to all student groups and provide feedback if potential problems exist. **Summative Assessments:** • Paper w/ Rubric: Reflection of Product Function and Design "Does it still work the same?" (ULT #1, 7)
Notes: Teacher will approve breakdown of first system and the design of the second system. Testing procedures will be repeated for this system. After providing time for both formal tests, instructor will provide time for student reflection and dialogue within each group and within the class.	**Notes:**
Step Ten: Communicate	
Lesson 14: Delivering Effective Presentations	**Formative Assessments:** • Students will practice using presentation software/equipment delivery; including pacing, presence, and readability. Constructive feedback from peers and instructor will be provided. **Summative Assessments:** ○ Performance activity w/ rubric: presentation of completed project function to peers. (ULT# 9)
Notes: Teacher should prompt students to discuss how easy or difficult it was to interpret directions and images for reassembly without human interaction.	**Notes:** Students should compare and contrast the benefits and challenges of reverse engineering versus reassembly.
Corresponding Technology Student Association (TSA) Activities	
Animatronics **Engineering Design** **CAD Engineering**	
Curriculum Development Resources	

Lesson Plans

Lesson	Timeframe
Lesson 1 Why Reverse Engineer a Product	45 minutes / 1 day
Lesson 2 Framing the Design Brief	25 minutes / ½ day
Lesson 3 Hand Tool Usage	20 minutes / ½ day
Lesson 4 Product Sub Systems	45 minutes / 1 day
Lesson 5 Research through Reverse Engineering	45 Minutes / 2 day
Lesson 6 Modeling the Brainstorming Process	25 Minutes / 1/2 day
Lesson 7 How to design a template for directions	25 Minutes / 1/2 day
Lesson 8 Communicating Possible Solutions	25 Minutes / 1/2 day
Lesson 9 Using Pictures as a Form of Documentation Development	45 minutes / 2.5 days
Lesson 10 Finalizing a Technical Report	45 minutes / 2 days
Lesson 11 Compare and Contrast Product Design	25 minutes / ½ day
Lesson 12 Demonstration Expectations	25 minutes / ½ day
Lesson 13 Product Dependability and Efficiency	45 minutes /2 days
Lesson 14 Delivering Effective Presentations	20 minutes / 1 day

Teacher Notes:

Curriculum Development Resources