SNAPSHOT

MANUFACTURING LEARNING CYCLE 3

Looping Through Design

ENDURING UNDERSTANDINGS

Students will be able to understand that technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.

BIG IDEA

In this learning cycle, students will be focusing on applications of the engineering design model and a set of design principles that will guide their thinking as they solve technological problems. Many instructors have adapted unique forms of the engineering design model; however, they all tend to share common characteristics.

PURPOSE OF THE LEARNING CYCLE

The purpose of learning Cycle 3 is to generate a viable solution to a technological problem using a design model (the design loop), and to identify and change a set of characteristics within a design as they pertain to a set of design principles (i.e., function, efficiency, aesthetics, ergonomics, and anthropometrics) and apply those characteristics to the development of a product and a system.

LESSON DURATION:

6 Hours

HIGHLIGHTS OF THE LEARNING CYCLE

ENGAGE

Students will be exposed to the Engineering Design Process by watching the explanation of the 12 step design process and one of two videos on the process. Students will also learn about the design process by view slides 1-13 in ManCyc3 Presentation 1.1 Looping through Design.

EXPLORE

The students will focus on the engineering design process and the design principles that are used to guide the development of a product. They will view slides 14-17 in ManCyc3 Presentation 1.1 Looping through Design. The students will use ManCyc3 File 1.1 Looping through Design Flashlight Design Activity to think about the design principles as they generate their own set of questions.

EXPLAIN

Students will need time to review the five design principles in order to categorize the questions they have developed. View slides 18-22 of in ManCyc3 Presentation 1.1 Looping through Design to understand the principles of design. The students will then answer the questions in ManCyc3 File 1.1 Looping through Design Flashlight Design Activity.

eNGINEER

The students will make a flashlight using the classroom as the manufacturing facility. They will design and implement an assembly line using the five general design principles. The students will complete in ManCyc3 File 1.2 Looping through Design Brief.

Enrich

The students will identify the characteristics that their dispensing device must have to accommodate the process and the variables involved (flavor, color, and type) for their Primary Challenge. The teacher will have the students complete ManCyc3 File 1.3 Looping through Design Product Costs Activity.

Evaluate

Student knowledge, skills and attitudes are assessed using selected response items, brief constructed response items, performance rubrics, and Engineering Design Journal entries. You can use ManCyc3 File 1.4 Looping through Design Rubric.

STANDARDS/BENCHMARKS

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 1	**Students will develop an understanding of the characteristics and scope of technology.**
M	Most development of technologies these days is driven by the profit motive and the market.
STL 2	**Students will develop an understanding of the core concepts of technology.**
W	Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.
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.
EE	Management is the process of planning, organizing, and controlling work.
STL 3	**Students will develop an understanding of the relationships among technologies and connections with other fields of study.**
G	Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
H	Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
STL 6	**Students will develop an understanding the role of society in the development and use of technology.**
I	The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.
STL 8	**Students will develop an understanding of the attributes of design.**
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.
I	Design problems are seldom presented in a clearly defined form.
K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.
STL 9	**Students will develop an understanding of engineering design.**
J	Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
L	The process of engineering design takes into account a number factors.

STL 11	**Students will develop an understanding of and be able to apply the design process.**
Q	Develop and produce a product or system using a design process.
STL 19	**Students will develop an understanding of and be able to select and use manufacturing technologies.**
P	The interchangeability of parts increases the effectiveness of manufacturing processes.

***SCIENCE:* Next Generation Science Standards (NGSS, 2013)**	
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.
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.

***MATHEMATICS:* Common Core State Standards (CCSS, 2012)**	
MP.1	Make sense of problems and persevere in solving them.
MP.2	Reason abstractly and quantitatively.
MP.3	Construct viable arguments and critique the reasoning of others.
MP.6	Attend to precision.

***ENGLISH-LANGUAGE ARTS:* Common Core State Standards (CCSS, 2012)**	
RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

UNIT OBJECTIVES

CYCLE	BIG IDEA	OBJECTIVES
Learning Cycle 3: Looping Through Design (6 hours)	Students will be focusing on applications of the engineering design model and a set of design principles that will guide their thinking as they solve technological problems.	Generate a viable solution to a technological problem using the engineering design process.
		Identify and change a set of characteristics within a design as they pertain to a set of design principles (i.e., function, efficiency, aesthetics, ergonomics, and anthropometrics) and apply those characteristics to the development of a product and system.
Total for This Learning Cycle = 6 Hours		

RESOURCE MATERIALS

Note: Books, periodicals, pamphlets, and websites may provide teachers and students with back-ground information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by ITEEA.

Digital Materials

The 12 Step Design Process

- www.montgomeryschoolsmd.org/departments/development/resources/engineering/engage.html
- The Birth of the VRod Documentary

Print Materials

Burghardt, David, and Michael Hacker, Engineering & Technology Education: Learning by Design. Boston: Prentice Hall, 2012.

Internet Search Terms and Suggested Sites

- Engineering design process 12 steps
- 12 Step Engineering design process flash cards

REQUIRED KNOWLEDGE & SKILLS (KSB's)

Students should be able to search for information on the Internet and know how to use word processing and presentation software. They should be able to use simple hand tools to construct small models. They should also know the steps of the Engineering Design Process.

ASSESSMENT TOOLS

Assessment Instrument – Quiz

(Pre-/Post-Content Knowledge Questions).
For each of the following scenarios, identify the step in the design loop that would have helped prevent the problem.

1. A company created an idea for a new watermelon seed extractor, but did not consider alternative designs, which may have worked more effectively.

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2. The latest video game system was released for sale without appropriate quality control checks in order to meet the holiday rush demand, but the manufacturer needed to recall thousands of them due to a defect in the power switch.

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3. Your company's patent application was denied because of a lack of documentation on the product specifications.

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4. The local landfill is at capacity. Is there too much waste or is there a problem of how to handle the waste?

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5. The jigs and fixtures used to mass produce a CD rack were inadequate to ensure that all products turned out the same.

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6. A design was chosen based solely on the cost of materials, without considering durability or consumer input.

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7. Designers of a new robotic toy decided to rush the toy to market so they could sell it at a toy distributor fair. However, a working prototype was not developed before the toy was made, leading to multiple problems with the final product.

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Assessment Instrument - Brief Constructed Response (BCR)
Students are expected to respond to one of the questions described below. Students should provide examples to clarify their response.

Describe an automated system that allows users to create their own ice cream sundae. Explain how each of the design principles (function, efficiency, aesthetics, ergonomics, anthropometrics, and quality control) is integrated into the total system to provide quality control of the final product. Finally, sketch an example of your automated system.

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BCR Rubric

Category	Below Average	Average	Excellent
Understanding	Response demonstrates an implied, partial, or superficial under-standing of the question.	Response is written technically and precisely. The answer demonstrates understanding of the topic.	Response is written technically and precisely. The answer demonstrates understanding of the topic and cites specific examples.
Focus	Response lacks transitional information to show the relationship between the content and the support to the question.	Response addresses the question, includes pertinent information, and remains focused on the topic.	Response addresses the question, cites specific examples, includes pertinent information, and remains focused on the topic. Details are clearly stated and do not detract from the response.
Use of Related Information	Response uses minimal supporting information to clarify or extend meaning.	Response uses expressed and/or implied supporting information that clarifies or extends meaning.	Response uses clear and concise examples as well as supporting information that clarifies or extends meaning.

MANUFACTURING LEARNING CYCLE 3

Looping Through Design

ENGAGE:

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EXPLORE:

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  They will view slides 14-17 in in ManCyc3 Presentation 1.1 Looping through Design.
- The students will use ManCyc3 1.1 Looping through Design Flashlight Design Activity to think about the design principles as they generate their own set of questions.

EXPLAIN

- Students will need time to review the five design principles in order to categorize the questions they have developed.
- View slides 18-22 of ManCyc3 Presentation 1.1 Looping through Design to understand the principles of design.
  The students will use the students will then answer the questions in ManCyc3 File 1.1 Looping through Design Flashlight Design Activity.
- ManCyc3 File 1.1 Looping through Design Flashlight Design Activity to think about the design principles as they generate their own set of questions.

eNGINEER

- The students will make a flashlight using the classroom as the manufacturing facility.
- They will design and implement an assembly line using the five general design principles.
- The students will complete ManCyc3 File 1.2 Looping through Design Brief.

ENRICH

- The students will identify the characteristics that their dispensing device must have to accommodate the process and the variables involved (fragrance, color label) for their Primary Challenge.
- The teacher will have the students complete ManCyc3 File 1.3 Product Costs Activity.

EVALUATE

- Student knowledge, skills and attitudes are assessed using selected response items, brief constructed response items, performance rubrics, and Engineering Design Journal entries.
- You can use ManCyc3 File 1.4 Looping through the Design Rubric for grading purposes.

MANUFACTURING LEARNING CYCLE 3

Looping Through Design

TEACHER PREPARATION

Review the materials to determine the appropriate times to allocate to the viewing or reading of the materials. Instructors should ensure that the students have access to the appropriate Internet resources, particularly if print-based materials are not available for students to read. Prepare the room for multimedia presentations, including showing DVDs. It may be advantageous to read several reviews of the resources used to gain additional perspectives on the authors' messages. In addition, instructors should collaborate with the English language arts, social studies, and literature instructors to integrate these literary resources into this course.

Internet access is required for research of material/product processing. Large open areas (or room rearrangement) are necessary to allow for an assembly line.

The laboratory should provide for a flexible, resource-rich learning environment that allows presentations, demonstrations, small group discussions, design work, computer work, research, prototyping, and testing. The room should include individual work areas as well as areas for small groups to meet and work. Students should have access to research resources, including the library and the Internet. The room should be set up for multimedia presentations, including digital projectors, document cameras, sound systems, and DVD and videotape players. Computers in the classroom should be Internet-ready and have word-processing, spreadsheet, and presentation software. Although not required, CAD software for design work is recommended.

TOOLS / MATERIALS / EQUIPMENT

Below is a list of supplies and equipment needed to teach this course, assuming a class of 25 students. Optional/additional supplies required for Enrichment Activities are indicated. Where possible and appropriate, merchants are listed that support ITEEA; however, materials may often be obtained from alternative and/or local sources.

Additionally, these materials are based upon the lessons in the course and make no assumptions for classrooms with access to specialized equipment (e.g., fabrication equipment). **If the student has access to specialized equipment, the teacher may wish to incorporate the use of it into the lessons, and additional supplies may be necessary (as well as safety procedures).**

- Computers w/Internet access
- Video camera/flip camera
- Video editing software
- Drawing materials for scenery – paper, cardstock, markers, pencils, poster board as needed
- Tape
- Easily disassembled flashlights

LABORATORY CLASSROOM SAFETY AND CONDUCT

Note: Safety is of paramount importance to every classroom. While this Guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect and appreciation for the efforts of others.

STUDENT RESOURCES

ManCyc3 File 1.1 Looping through Design Flashlight Design Activity
ManCyc3 File 1.2 Looping through Design Flashlight Design Brief
ManCyc3 File 1.1 Looping through Design Product Costs Activity

TEACHER RESOURCES

ManCyc3 Presentation 1.1 Looping through Design
ManCyc3 File 1.4 Looping Through the Design Rubric

VOCABULARY

Engineering Design Process: the formulation of a plan to help an engineer build a product with a specified performance goal. This process involves a number of steps, and parts of the process may need to be repeated many times before production of a final product can begin.

Process: How the objective is achieved or the procedure (includes materials, tools, supplies, etc.).

STUDENT WORKSHEETS

MANUFACTURING LEARNING CYCLE 3
Looping Through Design

STUDENT RESOURCES

Description	Filename	Purpose
Worksheet	ManCyc3 File 1.1 Looping through Design Flashlight Design Activity	To explore design principles.
Worksheet	ManCyc3 File 1.2 Looping through Design Flashlight Design Brief	To apply five engineering design principles.
Worksheet	ManCyc3 File 1.3 Looping through Design Product Costs Activity	To identify variables for the Primary challenge.

Name:	Period:	Date:
Date Started:	Due Date:	
Group Members:		

Advanced Design Applications
Learning Cycle 3: Manufacturing Unit 4
File 1.1 Looping Through Design Flashlight Design Activity

Looping Through Design Flashlight Design Activity

Background Review the five design principles in order to categorize the questions you developed. Elaborate on how they apply to both a product and a facility.

1. Using the principles of design, categorize each of the questions you developed during the flashlight activity and count how many fall into each category. How many questions were concerned primarily with functions and so on? Identify the design principle(s) beside each of your questions.
    1.
    2.
    3.
    4.
    5.

2. Which of the design principles did your questions not address, (or address well enough) and why would it be important to include such a consideration when evaluating the design on a product?

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3. As a class, discuss some of the questions you developed and the categories your questions addressed. Were all of the design principle categories addressed by a question?

Often one design principle will be given more consideration or importance than others in the design process. For example, designers may decide that the aesthetics of a product are more important that its functionality. The target consumer is often the primary motivation for considering one design principle over another.

Consider the target consumer and answer the following design scenarios.

4. Make a list of the design characteristics that would be essential if the flashlight were to be used by an elderly member of your family. Describe why these designs characteristics would be essential.

5. Make a list of the design characteristics that would be essential if the flashlight were to be used by an individual who had limited use of his or her arms and hands. Describe why these design characteristics would be essential.

Name:	Period:	Date:
Date Started:	Due Date:	
Group Members:		

Advanced Design Applications
Learning Cycle 3: Manufacturing Unit 4
File 1.2 Looping Through Design Flashlight Design Brief

DESIGN BRIEF

Looping Through Design Flashlight Design Brief

Background

Now that you have explored the principles of design as they relate to flashlight design, let's consider the actual process involved with making a flashlight. Your instructor has selected a flashlight comprised of multiple components that require production and assembly. Given the product and your classroom as the manufacturing facility, you will be designing and implementing an assembly line using the five general design principles.

Design Problem

Create a facility for a flashlight manufacturing company.

What to Do:

To: Student Design Teams
From: Management
Re: Facility Design

Our company recently purchased a new building with the intention of dividing it into two major areas. One area would be dedicated to the actual production of the subcomponents and the second is reserved for the assembly of these components after they have been produced. We are giving your design team the challenge of creating a facility for our flashlight manufacturing company.

We, as a management team, have determined that we must address many factors before constructing the assembly portion of our facility. We hope to eventually automate the entire process, but we first must determine the general flow and order in which the subcomponents are assembled before investing the time and money into the equipment.

There are many companies in the world competing for the production of flashlights and, as management, we are very concerned about designing our facility to be as efficient as possible. Because of your experience with the basic design principles, your team has been hired to provide a solution to this problem. Specific details are provided below.

Thanks and good luck!

Management

Management

To: Student Design Teams
From: Management
Re: Facility Design

The design process can be used in a variety of ways to solve many different technological problems. Though this model is found in various forms, applying it helps to insure that a designer is taking into account the many different factors that influence design and the success of a final product.

You will be using this process to generate your solutions to the facility design. The five basic design principles should guide your research and influence your decisions about the proposed and implemented solutions. The following constraints and limitations must first be considered before solving this problem:

1. The assembly line must consist of individual cells (or stations) through which the product must pass as it is being assembled.

2. Since the cost of producing the line is expensive, each cell should consist of a person(s) rather than a machine to represent the automation.

3. The research portion of the design process should take into consideration the five design principles, as they would apply to the facility design.

4. At least two plausible solutions to the flashlight assembly problem must be proposed by the team before you are allowed to test your process design.

5. The feedback stage of the cycle must include references to how each design principle could be improved within the facility design. These responses must be recorded.

Name:	Period:	Date:
Date Started:	**Due Date:**	
Group Members:		

Advanced Design Applications
Learning Cycle 3: Manufacturing Unit 4
File 1.2 Looping Through Design Flashlight Design Folio

Define the Problem

Develop a problem statement that identifies the what, who, when and how the problem should be addressed.

Brainstorming

List/sketch <u>possible ideas</u> for a factory design that might be used in your final design. Clearly identify and describe how each of these ideas relates to the problem statement.

Research and generating ideas

In the space below, document your research. Be sure to include proper citations at the end of your notes.

Market Research
"Design thinking" linked to the flashlight assembly project starts by formulating and answering some key questions: • Who makes up the potential target market for the assembly? • What are some of the key functional, emotional, and psychological needs of the target market? • Has a budget been established for the project? • What is your schedule for completion? • What inspires you about this project?

Identifying criteria and specifying constraints

What are the criteria and constraints of the design problem?
Review the letter from Management about what they need in the plant.

List the specific criteria and constraints for your Flashlight Assembly	
Criteria	**Constraints**

Exploring possibilities

Reflect on your brainstormed ideas and research notes and describe the plusses and minuses of each design approach you have considered. Is there an alternative solution you did not consider?

Brainstorming Idea	Pluses	Minuses
Idea 1		
Idea 2		
Idea 3		
Idea 4		
Idea 5		

Did alternative solutions arise as you initially evaluated your designs? Cite examples.

Selecting an approach

a. Enter the constraints and criteria of the project in the first column.
b. Score your brainstorming ideas against each constraint or criterion and indicate how well the idea meets the criteria and constraints.
3 pts = easily meets, 2 pts = somewhat meets, 1 pt. = does not meet
c. Total the columns and circle the highest score to indicate your best design idea.

3 pts = easily meets, 2 pts = somewhat meets, 1 pt = does not meet

Constraint/Criterion	Rate your Brainstormed Ideas (3, 2, 1)					
	1	2	3	4	5	6
Total						

Justify the solution - Write a short paragraph justifying your solution. Include trade-offs that were made in the selection.

Developing a design proposal

Take your highest-scoring brainstorming ideas and create working drawings (sketches with dimensions so that you could build your project) of your complete device. Attach your working drawings to this sheet.

Material to be Used	Qty

Make Model/Prototype

Record the various tools, processes, and materials you will employee to achieve your solution.

Tools and Machines	Processes	Material

Test and Evaluate

Compare actual results to desired results

What attributes of your flashlight assembly facility design solved the problem?

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What attributes of your flashlight assembly facility design needed improvements? Describe possible changes you would make to a future model or prototype.

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Refine/Improve

Identify the problems you encountered with your solution and the modifications you used to overcome them. Then check the column to determine if your modifications made the design better.

Deficiencies of Design	Modifications	Better Results	Worse Results

Create/Make Product

Attach a photograph of your finished project below. Describe your project in a way that would allow someone unfamiliar with the assignment to understand it.

12. Communicate Results

What is the "Big Idea"? What understandings or concepts relate to math, science, and technology influenced the success of my project?

Name:	Period:	Date:
Date Started:	Due Date:	
Group Members:		

Advanced Design Applications
Learning Cycle 3: Manufacturing Unit 4
File 1.3 Looping Through Design Product Costs Activity

Looping Through Design Product Costs Activity

Background

Progress on a solution to the *Primary Challenge* is very important. By the completion of this activity it is important that your group have a completed flow chart that represents the processes they will use to dispense candy. Begin the process by considering your experiences from Learning Cycle 2. Hopefully, you have come to a conclusion about how you will create the solution to your *Primary Challenge* from the three alternative solutions you came up with. If not, here is your opportunity to refine and choose one solution.

What to Do

- You will work with your *Primary Challenge* team members.
- Complete step 7 for the Engineering Design Process on the Primary Challenge.
- Review the materials and procedures that must occur within your dispensing device to dispense the candy and solve the *Primary Challenge.*
- Consider the variables such as candy type.
- You might want to contact a company or expert with experience in manufacturing products to help resolve any problems you encounter.

Conclusion

- What steps must occur for candy to enter the machine and for a completed product to exit the vending machine?

- What must take place physically (to the material and/or product) as it passes through the vending machine?

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- What safety considerations must be made to assure the safety of the user and the safety of the machine?

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- After considering the flow process of your vending machine, with what particular process are you most concerned?

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TEACHER RESOURCES

ManCyc3 File 1.4 Looping Through the Design Rubric
ManCyc3 File 1.5 Looping Through the Design Rubric
ManCyc3 File 1.6 Looping Through the Design Rubric

Looping Through Design Learning Cycle 3 Rubric

Element	Criteria				Points
	4	3	2	1	
Overall Design Model Applications of the generic stages within the design process	Demonstrates exceptional applications of the design model in solving problems in the learning cycle.	Demonstrates good applications of the design model in solving problems in the learning cycle.	Demonstrates adequate applications of the design model in solving problems in the learning cycle.	Demonstrates poor applications of the design model in solving problems in the learning cycle.	
Exploration/Reflection Design Principles (Product) applications of each design principle	Demonstrates exceptional applications of design principles in product design.	Demonstrates good applications of design principles in product design.	Demonstrates adequate applications of design principles in product design.	Demonstrates poor applications of design principles in product design.	
Engineer Applications of each design principle through researching and documenting assembly facility design	Demonstrates exceptional applications of design principles in facility design, through research and documentation.	Demonstrates good applications of design principles in facility design, through research and documentation.	Demonstrates adequate applications of design principles in facility design, through research and documentation.	Demonstrates poor applications of design principles in facility design, through research and documentation.	
Technical Illustrations of Facility Layout	Developed exceptional technical illustrations of the facility layout.	Developed good technical illustrations of the facility layout.	Developed adequate technical illustrations of the facility layout.	Developed poor technical illustrations of the facility layout.	
				Total Points	

Category	Above Target	At Target	Below Target
Define Problem	Develops a problem statement that is clearly and precisely stated. The problem statement includes the who, what, when, and how the problem will be addressed. Recorded in the EDJ.	Develops a problem statement that includes the who, what, when, and how the problem will be addressed. Recorded in the Engineering Folio or EDJ.	Rephrases the problem with limited clarity.
Brainstorm Possible Solutions	Contributes at least three plausible ideas that are expanded upon to show understanding of the concept. All notes are recorded in the EDJ.	Contributes at least two plausible ideas that are recorded in the Engineering Folio or EDJ.	Contributes fewer than two ideas or implausible ideas.
Research Ideas/ Explore Possibilities	Contributes at least three additional plausible ideas and includes clearly documented research. Produces accurate conceptual models to show the design concepts with annotated sketches. All notes are recorded in the EDJ.	Contributes at least two additional plausible ideas and includes documented research. Produces accurate conceptual models to show the design concepts. All notes are recorded in the Engineering Folio or EDJ.	Contributes ideas, but without documented research. Produces incomplete sketches.
Specify Constraints and Identify Criteria	Clearly identifies the criteria and specifies the constraints that are listed in the design specifications and some that are not but pertain to their suggested design. All notes are recorded in the EDJ.	Clearly identifies the criteria and specifies the constraints listed in the design specifications. All notes are recorded in the Engineering Folio or EDJ.	Does not identify the criteria and/or fails to specify constraints.
Consider Alternative Solutions	Clearly did not enter the research phase with a preconceived idea of the final design. Thoroughly analyzes a variety of possible solutions, based on research and the relationship of those designs to the criteria and constraints. All notes are recorded in the or EDJ.	Satisfactorily analyzes a variety of possible solutions, based on research and the relationship of those designs to the criteria and constraints. All notes are recorded in the Engineering Folio or EDJ.	Inadequate analysis of a variety of possible solutions.
Select an Approach	Selects and thoroughly justifies a promising solution based on the problem statement, criteria, and constraints as well as evidence collected through research. Uses a quantitative evaluation method to determine the final design. All notes are recorded in the Engineering Folio or EDJ.	Selects and justifies a promising solution based on the problem statement as well as the criteria and constraints. Uses a quantitative evaluation method to determine the final design. All notes are recorded in the Engineering Folio or EDJ.	Selection of solution is not justified based on consideration of criteria and constraints or a quantitative evaluation method was not used.

Category	Above Target	At Target	Below Target
Develop a Written Design Proposal	Design proposal is written technically and precisely and contains a clear and accurate problem statement. Also includes how the solution will be developed as well as how the solution will be evaluated and what tests will be conducted to determine success as well as detailed and accurately drawn annotated sketches, notes, and technical drawings. Recorded in the EDJ.	Design proposal contains a problem statement. It includes how the solution will be developed and/or how the solution will be evaluated and/or what tests will be conducted to determine success. Includes accurately drawn annotated sketches, notes, and technical drawings. Recorded in the Engineering Folio or EDJ.	Design proposal is inadequate and lacking pertinent information.
Make Model/ Prototype	Student builds a working model that *excellently* aligns with the criteria, constraints, and intent of the problem. The working model can be tested using appropriate tools, materials and resources.	Student builds a working model that *adequately* aligns with the criteria, constraints, and intent of the problem. The working model can be tested using appropriate tools, materials, and resources.	Student builds a working model that *does not align/minimally aligns* with the criteria, constraints, and intent of the problem, however the it cannot be tested OR student builds a model that does not work.
Test and Evaluate	Student tests the working model's effectiveness to solve the problem. Excellent, *accurate and detailed* records are collected and a thorough analysis of data is present.	Student tests the working model's effectiveness to solve the problem. *Adequate*, mostly accurate records are collected and an analysis of data is present.	Student tests the working model's effectiveness to solve the problem. *Minimal* records are collected or records are mostly inaccurate. Analysis of data is *not* present.
Refine/ Improve	Student clearly *uses data* to redesign the working model into a more effective solution that aligns with the criteria, constraints, and intent of the problem.	Student redesigns the working model into a more effective solution that aligns with the criteria, constraints, and intent of the problem.	Student does *not* redesign the working model to align with the criteria, constraints, or intent of the problem.
Create/ Make Product	Student makes a final product that aligns with all criteria, constraints, and the intent of the problem.	Student makes a final product that aligns with most criteria, constraints, and the intent of the problem.	Student does not create or make the product that aligns with criteria, constraints, or intent of the problem.
Communicate Results	Student is thoroughly prepared to explain the solution. The explanation addresses all criteria, constraints, and solutions. Results from testing are summarized and communicated clearly and effectively.	Student is adequately prepared to explain the solution and results from testing are summarized and communicated clearly.	Student is inadequately prepared to explain the solution and/or results from testing are summarized or shared, but are incomplete or not clearly communicated.