GEORGIA | PEACH STATE PATHWAYS

Career, Technical, & Agricultural Education

ENGINEERING & TECHNOLOGY

PATHWAY: Engineering; Energy Systems

COURSE: Foundations in Engineering and Technology

UNIT: 5: Problem Solving in Engineering

INTRODUCTION

Annotation: Briefly describe the unit topics, tasks, methods, etc.

This unit is the beginning step of designing a solution towards an engineering problem. Students are introduced to the engineering process and engineering notebooks. This foundation will be used repeatedly throughout the pathway. There are two projects in this unit; the first is a guided practice with students to create an ornament box through the engineering process. The second is to create a cardboard chair in groups after they better understand the process.

Grade(s):

X	9th
X	10th
X	11th
X	12th

Time:

12 Hours

Author:

Matthew Flanders

Additional Author(s):

Students with Disabilities:

For students with disabilities, the instructor should refer to the student's IEP to be sure that the accommodations specified are being provided. Instructors should also familiarize themselves with the provisions of Behavior Intervention Plans that may be part of a student's IEP. Frequent consultation with a student's special education instructor will be beneficial in providing appropriate differentiation.

FOCUS STANDARDS

GPS Focus Standards: Please list the standard and elements covered.

ENGR-FET-1d – Participate in hands-on activities related to multiple engineering and technology pathways.
ENGR-FET-4 – Students will apply mathematics and science to the solution of a technological problem.
ENGR-FET-5 – Students will describe the essential systems and processes involved with invention, innovation, and entrepreneurship.
ENGR-STEM-3 – Students will design technological problem solutions using scientific investigation, analysis and interpretation of data, innovation, invention, and fabrication while considering economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints.
ENGR-STEM-4 – Students will apply principles of science, technology, engineering, mathematics, interpersonal communication, and teamwork to the solution of technological problems.
ENGR-STEM-7 – Students will develop leadership and interpersonal problem-solving skills through participation in co-curricular activities associated with the Technology Student Association.
CTAE-FS-3 – Communications: Learners use various communication skills in expressing and interpreting information.
CTAE-FS-4 – Problem Solving and Critical Thinking: Learners define and solve problems, and use problem-solving and improvement methods and tools.
CTAE-FS-8 – Leadership and Teamwork: Learners apply leadership and teamwork skills in collaborating with others to accomplish organizational goals and objectives.
CTAE-FS-11 Entrepreneurship: Learners demonstrate understanding of concepts, processes, and behaviors associated with successful entrepreneurial performance.

GPS Academic Standards:

ELA10C1. The student demonstrates understanding and control of the rules of the English language, realizing that usage involves the appropriate application of conventions and grammar in both written and spoken formats.
MM3P1. Students will solve problems (using appropriate technology).
MM3P2. Students will reason and evaluate mathematical arguments.
MM3P3. Students will communicate mathematically.
MM3P4. Students will make connections among mathematical ideas and to other disciplines.
MM3P5. Students will represent mathematics in multiple ways.
SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
SCSh3. Students will identify and investigate problems scientifically.
SCSh4. Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.
SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.
SCSh6. Students will communicate scientific investigations and information clearly.
SCSh8. Students will understand important features of the process of scientific inquiry.

National / Local Standards / Industry / ISTE:

UNDERSTANDINGS & GOALS

Enduring Understandings: Enduring understandings are statements summarizing important ideas and have lasting value beyond the classroom. They synthesize what students should understand – not just know.

Students will be able to collect data and conduct research related to a specific problem, and then evaluate and select the best solutions based on design criteria.

Essential Questions: Essential questions probe for deeper meaning and understanding while fostering the development of critical thinking and problem-solving skills. Example: Why is life-long learning important in the modern workplace?

1. What are the steps in the design process?
2. What needs to be included in an engineering notebook?
3. How can Excel be used to evaluate solutions?
4. What kind of research and data should be collected?

Knowledge from this Unit: Factual information.

1. Students will describe real life constraints in designing and implementing engineering projects.
2. Students will demonstrate the importance of maintaining precise records.
3. Students will relate real world experience to school plans.

Skills from this Unit: Performance.

1. Students will list the common constraints of Engineers.
2. Students will prepare a budget, and analysis for their project.
3. Students will document the process, from design to development of their chair project.

ASSESSMENT(S)

Assessment Method Type: Select one or more of the following. Please consider the type(s) of differentiated instruction you will be using in the classroom.

- ____ Pre-test
- ____ Objective assessment - multiple-choice, true- false, etc.
  - __ Quizzes/Tests
  - __ Unit test
- ____ Group project
- X Individual project
- X Self-assessment - May include practice quizzes, games, simulations, checklists, etc.
  - __ Self-check rubrics
  - __ Self-check during writing/planning process
  - _X_ Journal reflections on concepts, personal experiences and impact on one's life
  - __ Reflect on evaluations of work from teachers, business partners, and competition judges
  - __ Academic prompts
  - __ Practice quizzes/tests
- ____ Subjective assessment/Informal observations
  - __ Essay tests
  - __ Observe students working with partners
  - __ Observe students role playing
- X Peer-assessment
  - _X_ Peer editing & commentary of products/projects/presentations using rubrics
  - _X_ Peer editing and/or critiquing
- X Dialogue and Discussion
  - __ Student/teacher conferences
  - __ Partner and small group discussions
  - _X_ Whole group discussions
  - __ Interaction with/feedback from community members/speakers and business partners
- X Constructed Responses
  - __ Chart good reading/writing/listening/speaking habits
  - _X_ Application of skills to real-life situations/scenarios
- ____ Post-test

Assessment(s) Title:

1. Engineering Design Notebook
2. Paper Clip Excel Sheet and Questions from book

Assessment(s) Description/Directions:

1. The main concern for the project is that the students' solutions work and they have stayed within the constraints. The engineering notebook should be analyzed throughout the project to ensure the students are not only completing the project, but also keeping accurate records and documenting their course of action.
2. The students should fill out the excel sheet, which will show a graph for them. The questions from the book should be completed after the activity is complete.

Attachments for Assessment(s): Please list.

- Engineering Design Notebook
- Engineering Design Process
- Engineering Chair Design
- Chair Budget
- Basic Criteria Analysis
- Paper Clip Bend

LEARNING EXPERIENCES

Instructional planning: Include lessons, activities and other learning experiences in this section with a brief description of the activities to ensure student acquisition of the knowledge and skills addressed in the standards. Complete the sequence of instruction for each lesson/task in the unit.

Sequence of Instruction

1. Identify the Standards. Standards should be posted in the classroom for each lesson.

ENGR-FET-1d – Participate in hands-on activities related to multiple engineering and technology pathways.
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2. Review Essential Questions.

1. What are the steps in the design process?
2. What needs to be included in an engineering notebook?
3. How can Excel be used to evaluate solutions?
4. What kind of research and data should be collected?

3. Identify and review the unit vocabulary.

Design

Criteria

Hypothetical

Constraints

Destructive

4. Assessment Activity.

Day 1

- Begin with the hypothetical situation of "Building the Ultimate Roller Coaster." Ask the students to draw sketches on paper, don't put any constraints on their design. You may ask a couple of students to draw them on the board or scan and project onto a screen. Then discuss how realistic it would be to build them. Then discuss real life constraints (ex. Time, money, physics, etc…) that might effect their design and the real world process of how it gets from the drawing board to an actual rollercoaster (ex. computer models, testing, cost analysis, etc…)
- Design Process PowerPoint

Day 2

The ornament box project should be completed as guided practice by each individual student. This allows each student to build an relatively easy project using the design process. The worksheet used may be considered an simplified engineering notebook.

Implementing Step 1 of the Engineering Design Process: Define the problem.

- Explain to students that they will be applying the 10-step engineering design process to solve many of the problems given in the class and that they will record each part of the process for the project that will follow.
- Give students The 10 Steps of Engineering Design hand-out and worksheet.
- Give students the ABC Ornament Company Design Brief handout.
- Read the design brief with the students; call on students to help with parts.
- As a group, have students identify the possible problems while listing them on the board.
- With students' help, refine the list of problems to reduce the list.
- Have students complete the first step on their worksheet.

Day 3

Implementing Step 2 of the Engineering Design Process: Brainstorm, Research, and Generate Ideas

- Solicit input for the definition of brainstorming; define critical thinking and explain how it is used in this part of the process.
- Explain the importance of research and gathering information.
- Explain thumbnail sketching and have each student sketch an idea on their worksheet for Step 2 for their box project.
- Have students share their ideas and allow students to record other students' ideas that they might use.
- Have students examine the collections of boxes for more ideas.
- Define analysis and how students can use it to understand how boxes are designed.
- Draw a cube on the board, then have the students mentally disassemble the cube laying out a 2-dimensional drawing to illustrate how a box might be drawn.

- As a homework assignment, ask students to go home and disassemble as many boxes as possible to generate ideas for their box and how they might lay-out their design. Require that they have three different ideas for Step 2 for their worksheet at the beginning of class the next day.

Day 4

- At the beginning of class, give students time to record/sketch additional box ideas on their worksheets for Step 2.

Implementing Step 3 of the Engineering Design Process: Identify Criteria and Specify Constraints

- Ask students to explain what is meant by criteria; define criteria clearly. What are some other words that may be used instead of criteria? (requirements, specifications, etc.) Example: size
- Based on the definition, with student input, list the criteria of the project on the board.
- Ask what do we mean by constraints? What other words might be used instead of constraint? (limitations, restrictions, etc.) Examples: cost, location
- Similarly, make a list on the board for constraints.
- Examine both lists to clarify understanding.
- Are all of the criteria correctly identified? Are all the constraints correct?
- Using this information, have students complete Step 3 on their worksheet.
- This is a good time to discuss the concepts of engineering: the nature of design, thinking like an engineer, considering human factors, and keeping the customer in mind.

Implementing Step 4 of the Engineering Design Process: Develop and Propose Designs and Choose Among Alternative Solutions

- Explain to students the purpose of this step so that they can adequately choose a solution.
- Encourage the students to keep the box simple as they will have difficulty enough in planning for connections, closure, etc.
- Have students develop small 2-dimensional layouts of their ideas with as much detail as possible so they can choose which of the three solutions might be best. This will help them to analyze and assimilate how to put it together. At this point, their drawings do not have to be precise but rather have enough details to make them think of how the box might take shape as it is folded. They should be thinking of how to connect the sides to each other and which is the top, bottom, front, back, left side, right side, etc.
- Be prepared to offer suggestions and hints to help the students when you notice any errors. Let it be their idea how to correct.
- Have students choose their best idea to use for their box and mark it likewise on their worksheet.

Day 5-6

Implementing Step 5 of the Engineering Design Process: Implement the Proposed Solution (For many students this will take more than one class period.)

- Give the students the following tools and supplies so that they can apply specifications to their design layout: ruler, protractor, compass, pencil, eraser, ¼″ graph paper, and both the clear tape and masking tape as needed.
- Have the ornaments accessible so they can measure.

- After they have finished, give them a pair of scissors and have them cut and fold the box from the graph paper. This will be the time when they will discover that they will have to make corrections. Allow them to add pieces using clear tape to perfect their box.
- Do not allow the students to permanently tape their paper boxes. Masking tape works fairly well without destroying their paper so allow them to use bits of masking tape to secure the edges.
- Instruct students to dismantle their paper boxes to use as a template for their prototype.

Day 7

Implementing Step 6 of the Engineering Design Process: Make a Model or Prototype

- Define model and prototype.
- Explain to students that they will be making a prototype of their design before they make the final box.
- Explain the purposes of making a prototype and make sure that they understand that this is where all mistakes have to be corrected.
- Give students a folder or posterboard, all the tools for the project, and masking tape.
- Instruct them to transfer their pattern over to the folder or the posterboard drawing lightly on the inside of the box to avoid defacing the outside of the box.
- Once the students finish this phase, they will cut the box out and assemble it.

Day 8

Implementing Step 7 of the Engineering Design Process: Evaluate the Solution and the Its Consequences

- Students will evaluate their designs.
- Will the box open and close?
- Will it stay closed?
- Will the ornament fit into the box?
- How will the ornament stay secure?
- Are the corners rigid?
- Have students go through the list of requirements and constraints?
- Does their box meet all of the expectations?
- If not, how can they fix it?
- Allow them to make corrections by adding pieces with clear tape.
- This is also the point that students need to explore how to secure the ornament.

Implementing Step 8 of the Engineering Design Process: Refine the Design

- Give students all the materials and tools for drawing their final design which should include all of the repairs made to the prototype.

Day 9

- Give the students the remaining supplies to finish their final design.

Implementing Step 10 of the Engineering Design Process: Communicate the Processes and Results

- Have students summarize the 10 steps of the engineering design process and communicate their design.
- Instruct students that their plans must be complete and accurate.
- Test the boxes
- Review/summarize

Day 10

The cardboard chair project should be completed by students in groups. They should have a better understanding of the Engineering Design Process after completing the ornament box.

- Engineering Notebook PowerPoint
- Cardboard Chair Project PowerPoint
- Start Cardboard Chair Research

Day 11

- Continue Cardboard Chair Research
- Building of mock-ups

Day 12-13

- Designing chairs and analysis using Basic Criteria Analysis excel spreadsheet.
- Estimation of material used for final solution using Chair Budget excel spreadsheet.

Day 14-15

- Construction of the chairs

Day 16

- Students create posters for marketing their chairs.

Day 17

- Presentation, analysis and testing of the chairs.

Attachments for Learning Experiences: Please list.

Textbook:

Engineering Your Future by Gomez, Oakes, and Leone

Notes & Reflections: May include notes to the teacher, pre-requisite knowledge & skills, suggestions, etc.

The students should not be graded according to how many they got right according to the expert. They should show their research and creativity when filling out the chart though.

CULMINATING PERFORMANCE TASK (Optional)

Culminating Unit Performance Task Title:

Cardboard Chair Project

Culminating Unit Performance Task Description/Directions/Differentiated Instruction:

Students should build a cardboard chair in groups according to the guidelines in the powerpoint.

Attachments for Culminating Performance Task: Please list.

UNIT RESOURCES

Web Resources:

Attachment(s): Supplemental files not listed in assessment, learning experiences, and performance task.

Materials & Equipment:

Cardboard, PowerPoint viewer, textbook

What 21st Century Technology was used in this unit:

X	Slide Show Software		Graphing Software		Audio File(s)
	Interactive Whiteboard	X	Calculator	X	Graphic Organizer
	Student Response System		Desktop Publishing	X	Image File(s)
	Web Design Software		Blog		Video
	Animation Software	X	Wiki		Electronic Game or Puzzle Maker
	Email	X	Website		