GEORGIA | PEACH STATE PATHWAYS

Career, Technical, & Agricultural Education

ENGINEERING & TECHNOLOGY

COURSE: Engineering Concepts (ET-EC)

UNIT: 6. Principles of Structural Design

INTRODUCTION

Annotation:

In this unit students will describe forces that act on bodies at rest, develop mathematical models to explain the variables associated with each force and use this information to solve specific problems in structure related engineering.

Grade(s):

	9th
X	10th
X	11th
X	12th

Time:

15 hours

Author:

Charles J. Kachmar

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-EC-1 – Students will describe the history and characteristics of engineering disciplines.
- ENGR-EC-2 – Students will demonstrate the engineering design process.
- ENGR-EC-3 – Students will solve problems using basic engineering tools and resources.
- ENGR-EC-5a – Use multi-view projection and pictorial drawings to communicate design specifications.
- ENGR-EC-5d – Prepare a proposal for an engineering design project.
- ENGR-EC-5e – Document engineering design processes using an engineering design notebook.
- ENGR-EC-5f – Prepare a report of engineering design activities including a description of analysis, optimization, and selection of a final solution.
- ENGR-EC-5g- Demonstrate oral communication skills in reporting results of an engineering design activity.
- ENGR-STEM-1 – Students will recognize the systems, components, and processes of a technological system.
- ENGR-STEM-2 – Students will identify the impact of engineering and technology within global, economic, environmental, and societal contexts.
- 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-5 – Students will select and demonstrate techniques, skills, tools, and understanding related to energy and power, bio-related, communication, transportation, manufacturing, and construction technologies.
- CTAE-FS-1 – Entrepreneurship: Learners demonstrate understanding of concepts, processes, and behaviors associated with successful entrepreneurial performance.
- CTAE-FS-2 – Academic Foundations: Learners achieve state academic standards at or above grade level.
- 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-5 – Information Technology Applications: Learners use multiple information technology devices to access, organize, process, transmit, and communicate information.
- CTAE-FS-7 – Safety, Health and Environment: Learners employ safety, health and environmental management systems in corporations and comprehend their importance to organizational performance and regulatory compliance.
- CTAE-FS-9 – Ethics and Legal Responsibilities: Learners commit to work ethics, behavior, and legal responsibilities in the workplace.

GPS Academic Standards:

National / Local Standards / Industry / ISTE:

UNDERSTANDINGS & GOALS

Enduring Understandings:

- Students will use math models to provide data for problem solving and decision making.
- Students will use sketching techniques to plan problem solving solutions.
- Students will use Computer Aided Drafting to plan problem solving solutions.
- Students will examine scientific principles essential to structural design.
- Students will examine principles of static systems and their effect on structural systems.
- Students will identify the elements of a simple truss bridge.
- Students will use vectors to predict reaction forces in structures.
- Students will draw free body diagrams to illustrate force setups.

Essential Questions:

- What are the forces that act on bodies at rest?
- How do scientific principles affect engineering design solutions in structural systems?
- How do stress, strain, elasticity, moment, length and material affect deflation?
- How are vectors used to predict reaction in structures?

Knowledge from this Unit: Factual information.

Skills from this Unit: Performance.

ASSESSMENT(S)

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

- ____ Pre-test
- X Objective assessment - multiple-choice, true- false, etc.
  - __ Quizzes/Tests
  - __ Unit test
- ____ Group project
- X Individual project
- ____ Self-assessment - May include practice quizzes, games, simulations, checklists, etc.
  - __ Self-check rubrics
  - __ Self-check during writing/planning process
  - __ 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
- ____ Peer-assessment
  - __ Peer editing & commentary of products/projects/presentations using rubrics
  - __ Peer editing and/or critiquing
- ____ Dialogue and Discussion
  - __ Student/teacher conferences
  - __ Partner and small group discussions
  - __ Whole group discussions
  - __ Interaction with/feedback from community members/speakers and business partners
- ____ Constructed Responses
  - __ Chart good reading/writing/listening/speaking habits
  - __ Application of skills to real-life situations/scenarios
- ____ Post-test

Assessment(s) Title:

Balsa Roof Trusses

Assessment(s) Description/Directions:

Students are given the challenge of designing a model truss that will hold the most force. Use the PowerPoint, CAD, assignment sheets, and web resources to solve this engineering design challenge.

Attachments for Assessment(s): Please list.

- Engineering Disasters PowerPoint
- Engineering Disasters Rubric
- Teton Dam PowerPoint

- Tacoma Narrows PowerPoint
- Walk a Mile in 'Dem Shoes
- Civil Engineering I PowerPoint (USMA WPBB Book – Rossler)
- Stress, Strain, and Elasticity – Excel Spreadsheet
- Elasticity of Balsawood
- Elasticity Data Worksheet
- Deflection of a Material – Excel Spreadsheet
- Cantilever Beam
- Simple Truss Example 1
- Simple Truss Example 2
- String Contest
- Fore- Cantilever Design Challenge
- Civil Engineering II PowerPoint (USMA WPBB Book – Rossler)
- Truss Blank
- Final Truss Challenge

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-EC-2 – Students will demonstrate the engineering design process.
- ENGR-EC-3 – Students will solve problems using basic engineering tools and resources.
- ENGR-EC-4 – Students will demonstrate a whole systems approach to engineering and problem solving.
- ENGR-EC-5a – Use multi-view projection and pictorial drawings to communicate design specifications.
- ENGR-EC-5d – Prepare a proposal for an engineering design project.

  ENGR-EC-5e – Document engineering design processes using an engineering design notebook.

  ENGR-EC-5f – Prepare a report of engineering design activities including a description of analysis, optimization, and selection of a final solution.

  ENGR-EC-5g – Demonstrate oral communication skills in reporting results of an engineering design activity.

- 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-5 – Students will select and demonstrate techniques, skills, tools, and understanding related to energy and power, bio-related, communication, transportation, manufacturing, and construction technologies.
- 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-5 – Information Technology Applications: Learners use multiple information technology devices to access, organize, process, transmit, and communicate information.
- CTAE-FS-6 – Systems: Learners understand a variety of organizational structures and functions.
- CTAE-FS-8 – Leadership and Teamwork: Learners apply leadership and teamwork skills in collaborating with others to accomplish organizational goals and objectives.
- 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.
- SCSh7. Students analyze how scientific knowledge is developed.
- MM3P1. Students will solve problems (using appropriate technology).
- MM3P3. Students will communicate mathematically.

2. Review Essential Questions.

- What are the forces that act on bodies at rest?
- How do scientific principles affect engineering design solutions in structural systems?
- How do stress, strain, elasticity, moment, length and material affect deflation?
- How are vectors used to predict reaction in structures?

3. Identify and review the unit vocabulary.

4. Assessment Activity.

Step 1:

Using the universal systems model, isolate the concept of feedback and discuss the importance of this essential step that is often overlooked. Feedback is the greatest teacher because it necessitates improvement of a system. Assign Engineering Disasters. Have students research a great structural disaster and prepare a presentation to the class. After this is over, share with them the Engineering Disasters PowerPoint. It will talk about some of the key problems faced by structural engineers and architects.

Step 2:

Walk a Mile in 'dem Shoes: Have students design a pair of shoes from limited materials that will meet predetermined design criteria. Using free body diagrams, analyze the chosen model's stride so the shoes can be custom built to offset the impending load.

Step 3:

Using the information that is associated with West Point Bridge Builder (Col. Rossler, PhD) discuss the elements of statics contained in the PowerPoint Civil Engineering I.

Step 4:

Have students complete fishing line experiments on stress = load/ area (hanging 5pound weights off of a piece of fishing line and determining the stress or N/m^2.) *(See String Contest document)*

Step 5:

Have students determine the strain of the same fishing line by measuring the additional length under when stretched out due to the load. Strain = Additional Length/original length.

Step 6:

Using the excel spreadsheet, have students determine their elasticity for the polymer used in the fishing line. Elasticity = Stress / Strain.

Step 7:

Apply the elasticity data to the equation for the deflection of a simple rectangular cantilever. Deflection = $(PL^3)/3EI$. P = Force (N), L = Length (m), E = Elasticity Modulus (pascals), I = Moment of Inertia. Moment of Inertia

for a rectangular cantilever beam is determined by using the equation $I=bh^3/12$. b = base measurement of cross sectional area, h = height of cross sectional area. By using the excel spread sheet provided, students can see mathematically why a diving board is more flexible with a greater base then height and a constructional beam should be greater height than base. They can also predict the deflection in meters of a construction beam.

Step 8:

(Optional) If the technology lab is equipped with AutoDesk Inventor with the Free Element Analysis, students can draw the cantilever in the problem and conduct stress analysis and compare mathematical results with simulator results.

Step 9:

It is difficult to determine the elasticity of balsawood. It is cut from a very soft tree that has the same consistency as a pineapple; the closer your cut to the core, the denser the material is. Therefore, to get a constant elasticity of balsawood is difficult. Provide each student a piece of 1/8" x 1/8" x .75 meters in length. Convert the cross sectional dimensions to meters. Carefully holding one end of the balsa wood as close to the end as possible, hang a 100g weight on the other side. Measure the total deflection. Have students use the equation for deflection to solve for elasticity. $E=(d3I)/PL^3$. Collect the student data and enter into excel. Create a scatter plot to visually compare results of experimentation.

Step 10:

Lecture using Civil Engineering II PowerPoint.

Step 11:

Using WestPoint Bridge Builder, have students study established truss designs and review results of simulation to make them as efficient as possible.

Step 12:

Final Truss Project. (ideally, this design is created using a Computer Aided Drafting software. If Free Element Analysis is available, have students run stress analysis on the 3-D truss design. This will assist in predictive analysis of their design.

Attachments for Learning Experiences: Please list.

- Engineering Disasters PowerPoint
- Engineering Disasters Rubric
- Teton Dam PowerPoint
- Tacoma Narrows PowerPoint
- Walk a Mile in 'Dem Shoes
- Civil Engineering I PowerPoint (USMA WPBB Book – Rossler)
- Stress, Strain, and Elasticity – Excel Spreadsheet
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- Final Truss Challenge

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

CULMINATING PERFORMANCE TASK (Optional)

Culminating Unit Performance Task Title:

Roof Truss Design

Culminating Unit Performance Task Description/Directions/Differentiated

See attached document (Final Truss Challenge)

Attachments for Culminating Performance Task

Final Truss Challenge

UNIT RESOURCES

Web Resources:

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

Materials & Equipment:

What 21st Century Technology was used in this unit:

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