Theme

"If the plan doesn't work, change the plan but never the goal" -anonymous

STEM Innovation Academy Unit 2 Plan

Subject: **Principles of Engineering** Unit Title: **Materials & Structures**	Teacher: **Ms. Mujovic** Duration: **8-10 weeks**

Summary of Unit

Unit 2 provides students with a more concrete understanding of engineering through materials properties and statics. Students begin by learning about beam detection and then forces on truss structures. They learn to identify forces acting on those structures and then gain the ability to calculate internal and external forces acting on those structures.

The students learn about material properties, which lead students to the ability to properly select a material for a given task. Creating new products to meet a given need or want is not the only concern in this area of study. How to reuse/recycle materials for continued and unique uses is also learned.

The primary way of studying materials properties in this unit is through destructive and non-destructive material testing on various materials. Tensile testing is the major destructive test. Students are engaged in how machines perform these tests and use either a classroom machine or a simulation to further their understanding of these processes.

Stage 1 – Desired Results

NGSS and CCSS standards covered in each lesson included in the link below
Standards/Outcomes/PARCC Related items:
https://drive.google.com/open?id=1LQdnvvLkDOGptM-bj4QhP87vdK6h7pzC

Essential Questions/Focus Questions:

Unit 2 lesson 1

2.1 - 1 - Why is it crucial for designers and engineers to construct accurate free body diagrams of the parts and structures that they design?

2.1 - 2 - Why must designers and engineers calculate forces acting on bodies and structures?

2.1 - 3 - When solving truss forces, why is it important to know that the structure is statically determinate?

Unit 2 lesson 2

2.2 - 1 - How does an engineer predict the performance and safety for a selected material?

2.2 - 2 - What are the advantages and disadvantages of utilizing synthetic materials designed by engineers?

2.2 - 3 - What ethical issues pertain to engineers designing synthetic materials?

2.2 - 4 - What did you learn about the significance of selecting materials for product design?

2.2 - 5 - How can an existing product be changed to incorporate different processes to make it less expensive and provide better performance?

2.2 - 6 - How does an engineer decide which manufacturing process to use for a given material?

2.2 - 7 - How do the recycling codes and symbols differ from state to state?

Unit 2 lesson 3

2.3 - 1 - Why is it critical for engineers to document all calculation steps when solving problems?

2.3 - 2 - How is material testing data useful?

2.3 - 3 - Stress-strain curve data points are useful in determining what specific material properties?

Unit 2 lesson 4

2.4 - 1 - What is a design brief? What are design constraints?

2.4 - 2 - Why is a design process so important to follow when creating a solution to a problem?

2.4 - 4 - What does consensus mean, and how do teams use consensus to make decisions?

2.4 - 5 - How do the properties and types of materials affect the solution to a design problem?

Stage 2 – Assessment Evidence

Principles of engineering available in the link below (password required):
https://pltw.read.inkling.com/a/b/e59f07e659484ae6b5c35191f247e5ea/p/64ecc1e21b8d448ca51091073b083d97#51da12b38dca4b8386296b0bee954e4f

Unit Pre-Assessment:

- Centroids - mathematically locate centroid of a rectangle or triangle.
- Draw and annotate free body diagrams
- Calculate force vectors - mathematically calculate force vectors in real world applications
- Calculate moments - mathematically calculate moment (force applied over a given area) in real world applications

- Calculate truss forces - mathematically determine if each member of a truss is experiencing compression or tension.

- Learn about recycling materials and the effects that lack of recycling have on the environment.

- Stress/Strain calculations - mathematically calculate stress (forces per unit area developed in the body against deformation) and strain (ratio of change in dimension to the original dimension) in real world applications

- Tensile Testing - mathematically calculate the tensile (stretch) force a particular material can withstand and apply it to real world applications.

- Unit 2 assessment will cover all concepts covered in this unit.

Presentation:

- Students will solve a materials design problem.

Performance Task(s):

- Students will choose a career field to research and complete a description of that field.

- Centroids - in this activity, students will perform three steps. First, they are asked to mathematically locate the centroid in a rectangle and triangle. Then they cut out a shape of a common beam cross-section from poster board or card stock and go through a procedure to find the centroid of that shape.

- Free Body diagrams - in this activity students practice creating free body diagrams.

- Calculating Force Vectors - in this activity, there will be one guided example and then ask students to complete a similar example.

- Calculating moments - this activity will require students to use bricks or books to calculate moments.

- Step-by-Step Truss System - this activity is designed to guide students through the process of calculating the reaction and member forces within a truss system.

- Calculating Truss Forces - this activity allows students to practice calculating truss forces.

- Structural Design -students will solve an open-ended design problem related to materials and structures centered on effective bridge design. Students will use West Point Bridge Designer software to illustrate their design.

- Product analysis - students will perform simple material tests and calculations on product components to gain a better understanding into why engineers select specific materials for different applications.

- Manufacturing Processes - this activity introduces students to some of the common manufacturing processes for creating products from raw materials.

- Recycling - this project will introduce students to recycling symbols and standards or codes. The students will create product development life cycles for selected products from product analysis activity.

- Stress/Strain Calculations - this activity will introduce students to one of the recommended methods for problem solving.

- Tensile Testing - this activity guides students through calculating and interpreting test data.
- Design Problem: Materials and Structures - students will work in teams to solve a materials design problem.
- Explore West Point Bridge Designer Software - explore and investigate the impact of deck elevation and support configurations related to the "Site Cost" by completing the Deck Elevation, Arch Abutment, Pier, and Cable Anchorages Cost Impact tables.

Authentic Experiences:

- Design a truss online using knowledge of stress/strain and compression/tension forces.

Extensions (Tier I):	Differentiation (Tiers II and III):
• More Design Challenges such as creating a different truss that can carry a heavier load and use different material/number of members from initial design. • Virtual tour of a civil engineering firm that can show the process of creating a real bridge.	• Selective Grouping • Extended Time • Small Group/Individual Instruction for students who are struggling with the same concept.

Stage 3 – Learning Plan

Principle of Engineering: Unit 2 Digital Access (Password Required):
https://pltw.read.inkling.com/a/b/e59f07e659484ae6b5c35191f247e5ea/p/64ecc1e21b8d448ca51091073b083d97

Vocabulary

- Engineer
- Force
- Truss
- Design brief
- Density
- Gravitational force
- Free body diagram
- Moment
- Centroid
- Recycle
- Stress
- Strain
- Manufacturing Process

Expert/Field Experience(s)

- Potential guest speakers: Invite a civil engineer or architect that can come and speak to the students about the process of designing a bridge/building
- Potential field trips: Explore a construction site and/or reach out to a friend who currently works for an architecture firm and arrange students to observe the day to day tasks of an engineer/architect.

Literacy Connections/Research/Resources:

- Discover Engineering Research by diving deep into why certain materials are selected for specific projects.
- Students will be able to create and evaluate their truss design and determine mathematically why their truss is able to hold a particular load or not depending on the type of forces experienced at each joint and member.