

Unit 3: Structures and Systems

Content Area: **Template**
Course(s):
Time Period: **Full Year**
Length: **Full Year**
Status: **Published**

UNIT RATIONALE

This unit aims to foster students' curiosity and interest in the world of structures and systems by providing them with opportunities to explore, design, and construct their own creations. By investigating the principles of design and engineering, students will develop an understanding of how structures and systems serve specific purposes and address societal needs. Furthermore, the unit emphasizes the importance of sustainable practices, inspiring students to think critically about the environmental impact of their designs and encouraging them to develop solutions that align with sustainable design principles.

ESSENTIAL QUESTIONS

1. How do design and engineering principles influence the functionality and aesthetics of structures and systems?
2. How do systems and mechanisms interact and work together within structures?
3. What role does sustainability play in the design and construction of structures and systems?
4. How can innovative structures and future technologies shape the world around us?

STANDARDS

NEW JERSEY STUDENT LEARNING STANDARDS: CONTENT AREA

New Jersey (NJSL) - Grades 6-8 - Computer Science and Design Thinking (2020)

8.1.8.AP.2:

Create clearly named variables that represent different data types and perform operations on their values.

8.1.8.AP.3:

Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.

8.1.8.AP.4:

Decompose problems and sub-problems into parts to facilitate the design, implementation, and review of programs.

8.1.8.AP.6:

Refine a solution that meets users' needs by incorporating feedback from team members and users.

8.1.8.AP.7:

Design programs, incorporating existing code, media, and libraries, and give attribution.

8.1.8.AP.8:

Systematically test and refine programs using a range of test cases and users.

8.2.8.ED.1:

Evaluate the function, value, and aesthetics of a technological product or system, from the perspective of the user and the producer.

8.2.8.ED.2:

Identify the steps in the design process that could be used to solve a problem.

8.2.8.ED.3:

Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).

8.2.8.ED.4:

Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.

8.2.8.ITH.3:

Evaluate the impact of sustainability on the development of a designed product or system.

CS.6-8.8.1.8.AP.2	Create clearly named variables that represent different data types and perform operations on their values.
CS.6-8.8.1.8.AP.3	Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.
CS.6-8.8.1.8.AP.4	Decompose problems and sub-problems into parts to facilitate the design, implementation, and review of programs.
CS.6-8.8.1.8.AP.6	Refine a solution that meets users' needs by incorporating feedback from team members and users.
CS.6-8.8.1.8.AP.7	Design programs, incorporating existing code, media, and libraries, and give attribution.
CS.6-8.8.1.8.AP.8	Systematically test and refine programs using a range of test cases and users.
CS.6-8.8.2.8.ED.1	Evaluate the function, value, and aesthetics of a technological product or system, from the perspective of the user and the producer.
CS.6-8.8.2.8.ED.2	Identify the steps in the design process that could be used to solve a problem.
CS.6-8.8.2.8.ED.3	Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).
CS.6-8.8.2.8.ED.4	Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.
CS.6-8.8.2.8.ITH.3	Evaluate the impact of sustainability on the development of a designed product or system.

NEW JERSEY STUDENT LEARNING STANDARDS: CAREER READINESS, LIFE LITERACIES AND KEY SKILLS

CS.6-8.8.1.8.AP.7	Design programs, incorporating existing code, media, and libraries, and give attribution.
CS.6-8.8.1.8.AP.8	Systematically test and refine programs using a range of test cases and users.

CS.6-8.8.2.8.ED.1	Evaluate the function, value, and aesthetics of a technological product or system, from the perspective of the user and the producer.
CS.6-8.8.2.8.ED.4	Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.
CS.6-8.8.2.8.ITH.3	Evaluate the impact of sustainability on the development of a designed product or system.

NEW JERSEY STUDENT LEARNING STANDARDS: COMPUTER SCIENCE AND DESIGN THINKING

CS.6-8.8.1.8.DA.2	Explain the difference between how the computer stores data as bits and how the data is displayed.
CS.6-8.8.1.8.DA.3	Identify the appropriate tool to access data based on its file format.
CS.6-8.8.1.8.DA.4	Transform data to remove errors and improve the accuracy of the data for analysis.
CS.6-8.8.1.8.DA.5	Test, analyze, and refine computational models.
CS.6-8.8.1.8.DA.6	Analyze climate change computational models and propose refinements.

PRE-ASSESSMENTS

1. **Systems Thinking Mind Map:** Have students create a mind map or concept map illustrating their understanding of systems and their interconnected nature. Ask them to identify examples of systems in their daily lives and illustrate the relationships and interactions between components of those systems.
2. **Problem-Solving Scenario Analysis:** Present students with a real-world problem or scenario that involves a complex system. Ask them to analyze the problem, identify the key components of the system, and propose potential solutions or improvements.
3. **Structural Design Challenge:** Provide students with a hands-on design challenge where they have to build a structure using various materials. Assess their initial understanding of structural concepts, problem-solving skills, and ability to apply their knowledge to a practical task.

INSTRUCTIONAL PLAN

MODULE 1

- Subtopic 1: Introduction to Design and Structural Engineering
- Subtopic 2: Systems and Mechanisms in Action
- Subtopic 3: Sustainability and Green Design
- Subtopic 4: Innovative Structures and Future Technologies

Subtopic 1

Subtopic 1: Introduction to Design and Structural Engineering

- Essential Questions:

- What is design thinking and how does it apply to structural engineering?
- What are the key principles and concepts of structural engineering?
- How do engineers analyze and design structures to ensure their safety and stability?

- Learning Intentions:

- Understand the fundamentals of design thinking and its application in structural engineering.
- Identify and explain key principles and concepts related to structural engineering.
- Develop basic skills in analyzing and designing simple structures.

- Success Criteria:

- Students can demonstrate their understanding of design thinking and its relevance to structural engineering.
- Students can explain and apply key principles and concepts of structural engineering.
- Students can analyze and design simple structures considering safety and stability.

- Learning Strategies:

- Engage in discussions and group activities to explore design thinking concepts.
- Conduct hands-on experiments and model-building activities to investigate structural principles.
- Use computational tools and software to simulate and analyze structures.

- NJ Computer Science Standards:

- CST.STCTS2: Apply computational thinking to solve problems.
- CST.STDIP1: Use technology to explore and design solutions.

- YouTube Videos:

1. Design Thinking 101 - <https://youtu.be/3Nq-LSLZ9hY>
2. Introduction to Structural Engineering - <https://youtu.be/QGTk8I3bJHc>
3. Structural Engineering Basics - <https://youtu.be/hxvxL-PGgeE>
4. Introduction to Design Principles - https://youtu.be/9t31AsKZ_24
5. Structural Analysis and Design - https://youtu.be/0r_K_G2x3s0

- Multi-Medium Projects:

1. Paper Bridge Challenge: Design and construct a bridge using only paper and adhesive. Test its strength and stability.
2. Toothpick Tower: Build a tall tower using toothpicks and mini marshmallows. Experiment with different structural configurations.
3. Egg Drop Challenge: Design and build a protective structure using limited materials to prevent an egg from breaking when dropped from a height.
4. Straw Skyscraper: Use drinking straws and tape to construct a tall and stable skyscraper.
5. Balsa Wood Bridge: Design and build a bridge using balsa wood and glue. Test its load-bearing capacity.

Subtopic 2

Subtopic 2: Systems and Mechanisms in Action

- Essential Questions:

- How do systems and mechanisms work together to accomplish specific tasks?
- What are the key components and principles of mechanical systems?
- How can we analyze and optimize the performance of mechanical systems?

- Learning Intentions:

- Understand the concept of systems and their role in engineering.
- Identify and describe the components and principles of mechanical systems.
- Apply analytical and problem-solving skills to optimize the performance of mechanical systems.

- Success Criteria:

- Students can explain the relationship between systems and mechanisms.
- Students can identify and describe key components and principles of mechanical systems.
- Students can analyze and optimize the performance of mechanical systems.

- Learning Strategies:

- Engage in hands-on activities to explore the functioning of various mechanical systems.
- Use diagrams and models to understand the components and principles of mechanical systems.
- Conduct experiments and data analysis to evaluate and improve the performance of mechanical systems.

- NJ Design Thinking Standards:

- D.TS.8.1: Understand the relationship between systems and subsystems.
- D.TS.8.2: Analyze and optimize the performance of a system.

- YouTube Videos:

1. Introduction to Systems Engineering - https://youtu.be/r9u5ODFV_I0
2. Mechanical Systems Explained - <https://youtu.be/Y6CqCaC7X0E>
3. Understanding Gears and Gear Ratios - <https://youtu.be/j8mCC32bAJE>
4. Working of Levers and Pulleys - <https://youtu.be/9AC2n7DCmml>
5. Introduction to Mechanical Systems - <https://youtu.be/beaCkGnDIQ>

- Multi-Medium Projects:

1. Rube Goldberg Machine: Design and build a complex machine that performs a simple task through a series of interconnected mechanisms.
2. Gear Mechanism Model: Create a working model of a gear system to understand how different gear ratios affect speed and torque.
3. Simple Machines Invention: Invent a new simple machine or improve an existing one to solve a specific problem.
4. Mechanical Toy: Design and construct a mechanical toy that incorporates multiple mechanisms and functions.

5. Pendulum Clock: Build a functioning pendulum clock using various materials, gears, and a pendulum mechanism.

Subtopic 3

Subtopic 3: Sustainability and Green Design

- Essential Questions:

- How can engineering contribute to sustainable practices and environmental conservation?
- What are the principles and strategies of green design in engineering?
- How can we integrate sustainability considerations into the design and construction of structures?

- Learning Intentions:

- Understand the importance of sustainability in engineering and its impact on the environment.
- Identify and apply principles of green design in the context of engineering projects.
- Incorporate sustainable practices and materials in the design and construction of structures.

- Success Criteria:

- Students can explain the concept of sustainability and its relevance to engineering.
- Students can identify and apply principles of green design in engineering projects.
- Students can integrate sustainability considerations into the design and construction of structures.

- Learning Strategies:

- Explore case studies and real-world examples of sustainable engineering projects.
- Engage in discussions and debates on the environmental impact of engineering practices.
- Collaborate on design projects that incorporate sustainable principles and materials.

- NJ Design Thinking Standards:

- D.TS.8.3: Apply principles of sustainability in the design process.
- D.TS.8.4: Investigate and analyze the environmental impact of a design.

- YouTube Videos:

1. Introduction to Sustainable Engineering - https://youtu.be/1t_nVBvDZqc
2. Green Design and Sustainable Architecture - <https://youtu.be/JZTEaFFrS24>
3. Renewable Energy in Engineering - <https://youtu.be/45FtoV1yV3U>
4. Materials and Resources for Sustainable Construction - <https://youtu.be/Wu-NWe1ajbQ>
5. Sustainable Building Design - <https://youtu.be/YA-qrbhP-q8>

- Multi-Medium Projects:

1. Eco-Friendly Building Design: Design and create a model of an eco-friendly building that incorporates sustainable materials, energy-efficient systems, and green technologies.
2. Renewable Energy Device: Construct a working model of a renewable energy device, such as a solar-powered car or wind turbine, using recyclable materials.
3. Upcycling Project: Transform waste materials or old objects into functional and aesthetically pleasing products through upcycling techniques.

4. Vertical Garden Installation: Design and build a vertical garden structure that maximizes space utilization and promotes sustainable urban agriculture.

5. Environmental Impact Assessment: Conduct an assessment of the environmental impact of a proposed engineering project and propose sustainable alternatives to mitigate negative effects.

Subtopic 4

Subtopic 4: Innovative Structures and Future Technologies

- Essential Questions:

- What are some innovative structures that push the boundaries of engineering?
- How do new technologies and materials influence the design and construction of structures?
- What are the potential future advancements in engineering and how might they shape the built environment?

- Learning Intentions:

- Explore and analyze innovative structures and their unique engineering features.
- Investigate emerging technologies and materials used in the construction industry.
- Foster creativity and critical thinking skills to envision and design future structures.

- Success Criteria:

- Students can identify and describe innovative structures and their engineering concepts.
- Students can analyze the impact of new technologies and materials on the design and construction of structures.
- Students can generate creative ideas and design concepts for future structures.

- Learning Strategies:

- Conduct research on groundbreaking structures and present findings to the class.
- Analyze case studies of structures that incorporate cutting-edge technologies and materials.
- Engage in brainstorming and design thinking activities to envision and sketch future structures.

- NJ Design Thinking Standards:

- D.TS.8.2: Imagine and prototype innovative solutions using emerging technologies.
- D.TS.8.5: Analyze the potential impact of emerging technologies on society.

- YouTube Videos:

1. Amazing Modern Structures - <https://youtu.be/N7c4tXeEaPk>
2. Future of Architecture and Engineering - <https://youtu.be/g5xB4tQvG50>
3. Innovative Building Materials and Techniques - <https://youtu.be/QyU2ZgWzE34>
4. 3D Printing in Construction - <https://youtu.be/8b0WvA8mSh4>
5. Floating Cities and Future Urban Planning - https://youtu.be/yxiL_vv-KPI

- Multi-Medium Projects:

1. Futuristic Structure Design: Imagine and design a futuristic structure that incorporates advanced technologies, sustainable features, and innovative materials. Create a detailed 3D model or digital rendering

of the structure.

2. Virtual Reality Experience: Use virtual reality (VR) technology to create an immersive experience of a visionary architectural design or future cityscape. Showcase the potential benefits and functionalities of the design.

3. Smart Home Automation System: Design and build a prototype of a smart home automation system that integrates various technologies to enhance comfort, efficiency, and sustainability in residential buildings.

4. Eco-Tech Invention: Invent a new technology or device that addresses a specific environmental or sustainability challenge in the built environment. Create a prototype and present its features and benefits.

5. Design Competition: Organize a design competition within the class, where students collaborate in teams to develop innovative structure designs using a combination of traditional and futuristic engineering concepts.

REFLECTIONS

More frequent competitions using mixed media and clearer rubrics for structure building. Also, clear timeframes for work to be accomplished.

INTERDISCIPLINARY CONNECTIONS: NEW JERSEY STUDENT LEARNING STANDARDS FOR ELA, SOCIAL STUDIES, SCIENCE AND/OR MATHEMATICS

1. Next Generation Science Standards (NGSS):

- MS-ETS1-1: Define the criteria and constraints of a design problem.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process.
- MS-ETS1-3: Analyze data from tests to determine strengths and weaknesses of a design.
- MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process.

2. Common Core State Standards for English Language Arts (ELA):

- CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- CCSS.ELA-Literacy.WHST.6-8.2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information.
- CCSS.ELA-Literacy.SL.6-8.4: Present claims and findings, emphasizing salient points in a focused, coherent manner.

3. National Core Arts Standards (Visual Arts):

- VA:Cr1.1.8: Generate ideas, goals, and solutions for original media artworks, considering personal interests and strengths.
- VA:Cr2.1.8: Demonstrate openness in trying new ideas, materials, methods, and approaches in making works of art and design.

- VA:Cn11.1.8: Relate artistic ideas and works with societal, cultural, and historical context to deepen understanding.

4. New Jersey Student Learning Standards for Technology and Engineering Literacy:

- 8.1.8.A.2: Analyze the physical, cognitive, and social impacts of existing and emerging technologies.
- 8.1.8.B.1: Design and produce innovative products, systems, or environments to address needs and opportunities.
- 8.1.8.B.4: Evaluate the implications of various design choices and trade-offs.

These standards provide a framework for integrating various subjects and skills into the unit, including science, engineering, language arts, arts, and technology. By incorporating these standards, students can develop a deeper understanding of the interdisciplinary nature of the unit and make connections across different subject areas.