SCHOOL DISTRICT OF THE CHATHAMS

Grand Design Challenge
Grade 8
Marking Period

Course Overview

Students will continually develop and expand upon their understandings of engineering and design by mastering the skills necessary for identifying problems, delineating criteria and constraints for solutions, and framing design briefs. Students will continually apply mathematics, science, and technological understandings to solve contextualized problems framed within the National Academy of Engineering's Grand Challenges of Engineering, as well as problems present in their local communities. Course work provides opportunities for community and global civic engagement and fosters a sense of responsibility and ownership of critical global issues, promoting student choice and autonomy in problem selection and pathways to solutions.

New Jersey Student Learning Standards
The New Jersey Student Learning Standards (NJSLS) can be located at www.nj.gov/education/cccs/2020/.

Engineering Design
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.ED.5: Explain the need for optimization in a design process.
8.2.8.ED.6: Analyze how trade-offs can impact the design of a product.
8.2.8.ED.7: Design a product to address a real-world problem and document the iterative design process, including decisions made as a result of specific constraints and trade-offs (e.g., annotated sketches).

Technology Standards
9.4.8.TL.5: Compare the process and effectiveness of synchronous collaboration and asynchronous collaboration.
9.4.8.TL.6: Collaborate to develop and publish work that provides perspectives on a real-world problem.

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9.4.8.CI.2: Repurpose an existing resource in an innovative way (e.g., 8.2.8.NT.3).
9.4.8.CI.3: Examine challenges that may exist in the adoption of new ideas (e.g., 2.1.8.SSH, 6.1.8.CivicsPD.2).
9.4.8.CI.4: Explore the role of creativity and innovation in career pathways and industries.
9.4.8.CT.2: Develop multiple solutions to a problem and evaluate short- and long-term effects to determine the most plausible option (e.g., MS-ETS1-4, 6.1.8.CivicsDP.1).
9.4.8.CT.3: Compare past problem-solving solutions to local, national, or global issues and analyze the factors that led to a positive or negative outcome.

Career Ready Practices

CRP2. Apply appropriate academic and technical skills.
CRP4. Communicate clearly and effectively and with reason.
CRP6. Demonstrate creativity and innovation
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11. Use technology to enhance productivity.

Interdisciplinary Connections

Science

- MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Units of Study

Unit 1: Grand Accomplishments in Engineering (~4 days)

- How have the challenges presented to engineers progressed and what future problems affect engineers?
- How can an understanding of the challenges presented to engineers allow us to develop problem statements, criteria, and constraints?
- How do criteria/requirements and constraints affect engineers in the world?
- How do engineers identify problems and develop solutions to those problems?

Unit 2: Engineering Within Constraints (~22 days)

- What constitutes a “problem” and how is it different from a question, conflict, or performance task?
- How do engineers and designers identify and develop problem statements?
- What is the difference between a requirement/criteria and a constraint?
- How does one determine or set the criteria and constraints for a problem solving process?
- How does the target audience change how a solution must be engineered?
- How is design influenced by outside forces?

Unit 3: Solving Real-World Grand Design Challenges (~13 days)

- In what ways do engineers identify specific needs within a community?
- How does a community's needs and culture influence design?
- In what ways can engineers improve the lives of the people within their communities?

Revision Date: *December 2021*

Learning Objectives/Discipline Standards of Practice

Learning Objectives

- Evaluate challenges in engineering today.
- Students will determine factors that prevent the solution of a problem.
- Describe how the importance of understanding each grand design challenge is helpful to have a clear understanding of global challenges and problem solving in general.
- Compile research about the progress of attempts to solve a global grand design challenge.
    - Develop a "fact sheet."
    - Create an informational presentation/poster.
- Students will be able to complete "design under constraint" challenges using the engineering design process by utilizing simple tools and physical models.
- Students will be able to use different tools and methods to troubleshoot a design problem.
- Students will be able to compile, arrange, format, and present their documentation.
- Safely utilize the bandsaw, scroll saw, drill press, oscillating spindle sander, combination disc/belt sander, hot wire cutter and/or soldering iron following all directions and proper procedures.
- Students will be able to identify a problem that affects one or more people.
- Students will be able to create a problem statement for a design problem.
- Students will be able to develop and build a project within criteria and constraints to solve a problem.
- Identify a school-wide or local problem, delineate criteria and constraints, and propose and prototype solutions for the problem.
- Students will be able to apply the engineering design process to solve a problem they have identified in their school or local community.
- Students will be able to compile, arrange, format, present and defend information in an engineer's notebook or design portfolio.

Discipline Standards of Practice:

- Computing Systems
    - People interact with a wide variety of computing devices that collect, store, analyze, and act upon information in ways that can affect human capabilities both positively and negatively. The physical components (hardware) and instructions (software) that make up a computing system communicate and process information in digital form.
- Networks and the Internet
    - Computing devices typically do not operate in isolation. Networks connect computing devices to share information and resources and are an increasingly integral part of computing. Networks and communication systems provide greater connectivity in the computing world.
- Impacts of Computing
    - Computing affects many aspects of the world in both positive and negative ways at local, national, and global levels. Individuals and communities influence computing through their behaviors and cultural and social interactions, and, in turn, computing influences new cultural practices.
- Data & Analysis
    - Computing systems exist to process data. The amount of digital data generated in the world is rapidly expanding, so the need to process data effectively is increasingly important. Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.

- Algorithms & Programming
    - An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems.
- Engineering Design
    - People design for enjoyment and to solve problems, extend human capabilities, satisfy needs and wants, and improve the human condition. Engineering Design, a systematic approach to creating solutions to technological problems and finding ways to meet people's needs and desires, allows for the effective and efficient development of products and systems.
- Interaction of Technology and Humans
    - Societies influence technological development. Societies are characterized by common elements such as shared values, differentiated roles, and cultural norms, as well as by entities such as community institutions, organizations, and businesses. Interaction of Technology and Humans concerns the ways society drives the improvement and creation of new technologies, and how technologies both serve and change society.
- Nature of Technology
    - Human population, patterns and movement focus on the size, composition, distribution, and movement of human populations and how they are fundamental and active features on Earth's surface. This includes understanding that the expansion and redistribution of the human population affects patterns of settlement, environmental changes, and resource use. Patterns and movements of population also relate to physical phenomena including climate variability, landforms, and locations of various natural hazards and their effects on population size, composition, and distribution.
- Effects of Technology on the Natural World
    - Many of engineering and technology's impacts on society and the environment are widely regarded as desirable. However, other impacts are regarded as less desirable. Effects of Technology on the Natural World concerns the positive and negative ways that technologies affect the natural world.
- Ethics & Culture
    - Ethics and Culture concerns the profound effects that technologies have on people, how those effects can widen or narrow disparities, and the responsibility that people have for the societal consequences of their technological decisions.

Instructional Resources and Materials
Whole class resources have been identified with an asterisk.

Resources
- NAE Grand Challenges for Engineering
- Grand Achievements of Engineering

Materials
- Access to basic hand tools, woodworking machines, and fabrication equipment
    - Hot Wire Cutter
    - Soldering Iron
    - Drill Press
    - Bandsaw
    - Combination Disc/Belt Sander

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    - Spindle Sander
- Materials for design challenges (foam, wood, wire, acrylic etc.)

Assessment Strategies
Assessment is designed to measure a student's mastery of a course standard and learning objective. Assessment can be used for both instructional purposes (formative assessment) and for evaluative purposes (summative assessment).

The following is a general list of the many forms assessment may take in learning.

- Students will complete approximately four (4) projects between unit 1 and 2.
- When a student completes a project, s/he will complete a critique sheet, reflecting on their work and answer thoughtful questions on their design process.
- A rubric is outlined on the critique sheet, delineating the project parameters and expectations.
- Students present their final projects to their class explaining their project proposal and their solution.

Course Specific Assessments Include:

- Grand Design Challenges Project
- Shadow Box Project
- Scale Room Redesign
- Cell Phone Stand
- Practical Problem Design