SCHOOL DISTRICT OF THE CHATHAMS

3D Engineering Design
Grades 10 - 12
Full Year

Course Overview

The 3D Engineering Design course focuses on the application of the Engineering Design Process and design thinking framework through 3-Dimensional (3D) Computer Aided Drawing/Design (CAD). Students are challenged to develop and design solutions to problems present in our world while developing their ability to create and communicate ideas and designs by taking an idea from concept to product. Students will learn how to use 3D CAD software, such as Fusion360, as well as modeling/animation/rendering software, such as 3D Studio Max, which are both used in the engineering and design industries. This class requires the application of knowledge from various content areas, such as mathematics, design & technology, and science. Furthermore, it provides students with the opportunity to conceive, design, model and create working prototypes for testing. It also develops their ability to express their creative thoughts to others for feedback and critique. Main topics will include 3D design & modeling, assemblies, rendering, rapid prototyping, and portfolio development.

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

Engineering Design
8.2.12.ED.1: Use research to create a product or system that addresses a problem and make modifications based on input from potential consumers.
8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback.
8.2.12.ED.3: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis.
8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience.
8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics).

Nature of Technology
8.2.12.NT.2: Redesign an existing product to improve form or function.

Technology Standards
9.4.12.DC.6: Select information to post online that positively impacts personal image and future college and career opportunities.

21st Century Integration | NJSLS 9
9.3.ST-ET.1Use STEM concepts and processes to solve problems involving design and/or production.
9.3.ST-ET.4 Apply the elements of the design process.

9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
9.3.12.AC-CST.9 Safely use and maintain appropriate tools, machinery, equipment and resources to accomplish construction project goals.
9.3.12.AC-DES.1 Justify design solutions through the use of research documentation and analysis of data.
9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
9.3.12.AC-DES.7Employ appropriate representational media to communicate concepts and project design
9.3.12.AC-DES.8Apply standards, applications and restrictions pertaining to the selection and use of construction materials, components and assemblies in the project design.
9.4.12.CI.1: Demonstrate the ability to reflect, analyze and use creative skills and ideas.
9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.

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
- HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Units of Study

Unit 1: Safety (~3 days)
- Why is it important to comply with the rules, regulations, and procedures in a lab environment?
- Why is it important to pass tool and machine safety exams (both written and hands-on) with a score of 100%?

Unit 2: Engineering, Problem Solving and Design Thinking (~30 days)
- What are the most pressing engineering/technical problems of our time?
- What is an engineer and what does it mean to engage in engineering?
- What are some advantages and disadvantages of an individual problem solving approach versus a design team approach?
- How might we create the best possible solution to a problem?
- Why does an engineer or a designer need to identify criteria and constraints?
- What are some effective ways to generate multiple, potential solutions to a problem?

- How do we know if our solution successfully solves the problem at hand and meets the needs of potential users?

Unit 3: Engineering Drawings Review (~60 days)
- How can we clearly convey a design idea or possible solution to someone unfamiliar with the original problem or design?
- How is engineering drawing similar to and different from artistic drawing?
- What can an isometric view of a shape reveal that an orthographic view cannot?
- How can we depict mechanical parts and mechanical movement?
- What can cause an engineering drawing to be misinterpreted?

Unit 4: Three-Dimensional Modeling (~45 days)
- What is the role of models and prototypes in the design process and would we determine which type of model/prototype is most appropriate for our goals/design?
- What are the essential skills and methods needed to complete an advanced design and assembly of complex engineering designs in 3D CAD programs?
- What essential skills and commands are needed to create animations and short clips depicting assemblies and movements of complex engineering designs in 3D CAD programs?
- How can we make the design and manufacture of a design/product more efficient and less prone to error?
- Using what you know about design and innovation, how can you improve the world around you?

Unit 5: Reverse Engineering (~40 days)
- How are the elements and principles of design used to gain a consumer's attention?
- Why is a design aesthetic value and functional efficiency/structural resilience usually perceived as linked/associated by consumers?
- What are the differences between a product's visual and functional qualities?
- What role does reverse engineering play in product development?
- What is the purpose of a design portfolio and how do you decide what information to include?

Learning Objectives/Discipline Standards of Practice

Learning Objectives:
- Ability to use all machines, tools, and safety equipment in a safe manner following all directions and procedures.
- Communicate through the use of engineering drawings.
- Interpret 3D objects through 2D drawings.
- Utilize CAD software to design solutions to problems.
- Utilize CAD software to develop professional drawings that adhere to engineering principles and design formats.
- Utilize rapid prototyping to create prototypes of CAD designs.
- Analyze a product's visual and functional characteristics.
- Redesign a product to meet the needs of a specific client base.

<u>Discipline Standards of Practice</u>:
- 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
- Safety Resources & Exams
- Computer Aided Design Software (AutoDesk Suite)
- Adobe Creative Cloud Suite

Materials
- Teacher created design briefs and rubrics

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.
- Design Challenges/Projects
- Exams & Hands-On Assessments
- Sketches and Engineering Drawings
- Digital Portfolio