SCHOOL DISTRICT OF THE CHATHAMS

Introduction to Design & Innovation
Grades 9 - 12
Semester

Course Overview

The Introduction to Design & Innovation course provides students with opportunities to apply knowledge and skills through hands-on, problem-solving learning experiences. Students apply the engineering design process and design principles while developing skills in the following areas: hand sketching, engineering and technical drawings, Computer Aided Drawing/Design (CAD), materials processing, and the design and fabrication of working prototypes and models. Students engage in an in-depth study and application of technological processes to solve real-world problems and challenges while learning how to use 2D and 3D CAD software, such as AutoCAD and Fusion360, which is used in the engineering and design industries. Furthermore, the course also develops students' ability to present their designs for testing, feedback and critique.

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.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).
8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor).

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.

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9.3.12.AC.6 Read, interpret and use technical drawings, documents and specifications to plan a project.
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.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.

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.7 Employ appropriate representational media to communicate concepts and project design.
9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM.
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.
9.4.12.CI.1: Demonstrate the ability to reflect, analyze and use creative skills and ideas.
9.4.12.CI.2: Identify career pathways that highlight personal talents, skills and abilities.
9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement and transition.
9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3: Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why solutions may work better than others (e.g., political. economic, cultural).
9.4.12.CT.4: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.5: Participate in online strategy and planning sessions for course-based, school-based or other projects and determine the strategies that contribute to effective outcomes.

Career Ready Practices
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.

Interdisciplinary Connections

Comprehensive Health Health & Physical Education

- 2.3.12.SE.1: Apply a thoughtful decision-making process to evaluate situations and influences that could lead to healthy or unhealthy consequences.
- 2.1.12.SH.3: Demonstrate strategies to prevent, manage, or resolve interpersonal conflicts without harming self or others.

Science

- HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- 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.

Visual and Performing Arts

- 1.2.12prof.Cr1a: Formulate multiple ideas using generative methods to develop artistic goals, and solve problems in media arts creation processes.
- 1.2.12prof.Cr1c: Critique plans, prototypes and production processes considering purposeful and expressive intent.
- 1.2.12prof.Pr5b: Develop and refine creativity and adaptability, such as design thinking and risk taking, in addressing identified challenges and constraints within and through media arts productions.
- 1.5.12prof.Cr2b: Explain how traditional and non-traditional materials may impact human health and the environment and demonstrate safe handling of materials, tools, and equipment.
- 1.5.12acc.Cr2a: Through experimentation, practice, and persistence, demonstrate acquisition of skills and knowledge in a chosen art form.
- 1.5.12 acc.Cr2c: Redesign an object, system, place, or design in response to contemporary issues.
- 1.5.12acc.Cr3a: Engage in constructive critique with peers, then reflect on, re- engage, revise, and refine works of art and design in response to personal artistic vision.
- 1.5.12acc.Pr4a: Analyze, select, and critique personal artwork for a collection or portfolio presentation.
- 1.5.12prof.Cn10a: Document the process of developing ideas from early stages to fully elaborated ideas.

Units of Study

Unit 1: Safety (~15 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: Modeling/Manufacturing, Technology & Design (~24 days)

- What is technology and design and what role do they play in the engineering design process?
- How can we create the best possible solution to a problem?
- What does one need to know in order to design a solution to a given problem?
- How is a 3D Printer used in the prototyping field?
- How can an engineer use tools such as 3D Printers and laser cutters to develop an idea?

Unit 3: Engineering Drawings & Computer Aided Drafting/Design (CAD) (~12 days)

- What are the various ways in which ideas or thoughts can be conveyed to others?
- 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?
- How does CAD assist with the modeling, manufacturing, and prototyping industry?
- How can assembly models (exploded and/or animated) of a proposed design be used in the design and problem solving process, as well as beyond the design and problem solving process?
- How does a designer or engineer decide what to include in a set of working drawings, what views are needed, and other additional information that may be important?

Unit 4: Problem-Solving Design Challenges (~24 days)

- How might we create the best possible solution to a problem?
- What does one need to know in order to design the solution to a problem?
- How do I apply knowledge of various tools/machines, materials, systems, and the engineering design process in the development of a solution and design?
- What role do models and prototypes play in the design and problem solving process?
- How do I use this feedback or data to revise my design?

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 and sketching.
- Develop 2D drawings.
- Properly place dimensions for orthographic views.
- Draw and design objects in isometric and oblique views.
- Use section planes and hatch patterns when drawing auxiliary views from isometric and orthographic views.
- Utilize CAD software to design solutions to problems.
- Utilize CAD software to develop professional drawings that adhere to engineering principles and design formats.
- Analyze a product's visual and functional characteristics.
- Develop an understanding of resources, processes, and products and their relationship within the technological environment.
- Develop a student's creative problem solving techniques to solve real world problems.
- Use educational technology as a bridge to an interdisciplinary approach to learning.
- Develop communication skills by identifying and solving problems as well as presenting documented solutions.

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

- *Safer Makerspaces, Fab Labs, and STEM Labs* by Kenneth Roy & Tyler Love
- AutoDesk Suite (Computer Aided Design Software)
- Adobe Creative Cloud Suite
- G-Suite for Education (Google Docs, Sheets, Slides, etc.)

Materials

- Cantilever Handout
- Bridge Design Handout

Revision Date: *November 2021*

- Bridge Drawing Sheet Example
- Bridge Weight/Load Ratio Handout
- Band Saw Safety handout and Exam
- Drill Press Safety handout and Exam

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.

- Tests
- Design Projects
    - Design & Rationale
    - Sketches and Engineering Drawings
    - Rubrics
- Digital Portfolio
- Peer Feedback
- Self-Reflection
- Reflective Exit Tickets/Slips
- Bridge Building Software design challenge
- Bridge Building Construction Plans
- Bridge Build/assembly/test phase
- CAD shape development assignment
- CAD assembly assignment
- CO2 car design AutoCAD Assessment
- CO2 car design build/assembly/test phase

Course Specific Assessments Include:

- Safety demonstrations & assessments