

COURSE TITLE

Design and Innovation

LENGTH

One Semester

DEPARTMENT

STEM Department

SCHOOL

Rutherford High School

DATE

September 10, 2018

Design and Innovation

I. Introduction/Overview/Philosophy

Design and Innovation is a semester course. In this class engineering scope, content, and professional practices are presented through practical applications. Students in engineering teams apply technology, science, and mathematics concepts and skills to solve engineering design problems and innovate designs. Students research, develop, test, and analyze engineering designs using criteria such as design effectiveness, public safety, human factors, and ethics. This course is an essential experience for students who are interested in technology, innovation, design, and engineering. The course is taught in the new state- of-the-art Rutherford High School STEM LAB.

II. Objectives

Course Outline:

1. Introduction to Engineering
 - a. Fundamentals of STEM
 - b. Design, Research, & Development
 - c. Universal Design
 - d. Impact of Product Design & Development
 - e. Prototype & Manufacturing
2. Design Fundamentals
 - a. Complex System Thinking
 - b. System Criteria & Constraints
3. Technology & Society
 - a. Trade-offs & Transfer
 - b. Environmental Impact

Student Outcomes:

After successfully completing this course, the student will:

- Use knowledge of science and technology, together with strategies of design, to solve practical problems.
- Construct complex systems with layers of controls to operate particular parts of the system and to control other controls.
- Develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
- Work safely and accurately with a variety of tools, machines, and materials.
- Communicate the observation, processes, and results of the entire process and final solution.
- Identify the transportation utilized within a given system such as manufacturing, construction, communication, health and safety, or agricultural.
- Use systems in the design and development of technology
- Operate systems so that they function in the way they were designed
- Design a troubleshooting diagram and manual for another user to maintain the safe and proper operation of a system or product.
- Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.
- Diagnose a system that is malfunctioning and distinguish tools, materials, machines, and knowledge to

repair it.

- Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.

New Jersey Student Learning Standards

CAREER READY PRACTICES

CRP1 Act as a responsible and contributing citizen and employee.

Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

CRP2 Apply appropriate academic and technical skills.

Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation

CRP4 Communicate clearly and effectively and with reason.

Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.

CRP5. Consider the environmental, social and economic impacts of decisions.

Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.

CRP6. Demonstrate creativity and innovation.

Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

CRP7. Employ valid and reliable research strategies.

Career-ready individuals are discerning in accepting and using new information to make decisions, change practices or inform strategies. They use reliable research process to search for new information. They evaluate

the validity of sources when considering the use and adoption of external information or practices in their workplace situation.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem; they thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

CRP9. Model integrity, ethical leadership and effective management.

Career-ready individuals consistently act in ways that align personal and community-held ideals and principles while employing strategies to positively influence others in the workplace. They have a clear understanding of integrity and act on this understanding in every decision. They use a variety of means to positively impact the directions and actions of a team or organization, and they apply insights into human behavior to change others' action, attitudes and/or beliefs. They recognize the near-term and long-term effects that management's actions and attitudes can have on productivity, morals and organizational culture.

CRP10. Plan education and career paths aligned to personal goals.

Career-ready individuals take personal ownership of their own education and career goals, and they regularly act on a plan to attain these goals. They understand their own career interests, preferences, goals, and requirements. They have perspective regarding the pathways available to them and the time, effort, experience and other requirements to pursue each, including a path of entrepreneurship. They recognize the value of each step in the education and experiential process, and they recognize that nearly all career paths require ongoing education and experience. They seek counselors, mentors, and other experts to assist in the planning and execution of career and personal goals.

CRP11. Use technology to enhance productivity.

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.

CRP12. Work productively in teams while using cultural global competence.

Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

TECHNOLOGY

Standard 8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.

Strand A. Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations.

8.1.12.A.1- Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources.

8.1.12.A.3- Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue.

8.1.12.A.5- Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Strand B. Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology.

8.1.12.B.2- Apply previous content knowledge by creating and piloting a digital learning game or tutorial.

Strand C. Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.

8.1.12.C.1- Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.

Strand D. Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.

8.1.12.D.1- Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.

8.1.12.D.2- Evaluate consequences of unauthorized electronic access (e.g., hacking) and disclosure, and on dissemination of personal information.

8.1.12.D.3- Compare and contrast policies on filtering and censorship both locally and globally.

8.1.12.D.4- Research and understand the positive and negative impact of one's digital footprint.

8.1.12.D.5- Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs.

Strand E: Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information.

8.1.12.E.1- Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.

8.1.12.E.2- Research and evaluate the impact on society of the unethical use of digital tools and present your research to peers.

Strand F: Critical thinking, problem solving, and decision making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

8.1.12.F.1- Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

Standard 8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming:

All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.

Strand A. The Nature of Technology: Creativity and Innovation Technology systems impact every aspect of the world in which we live.

8.2.12.A.1- Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.

8.2.12.A.2- Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.

8.2.12.A.3- Research and present information on an existing technological product that has been repurposed for a different function.

Strand B. Technology and Society: Knowledge and understanding of human, cultural and societal values are fundamental when designing technological systems and products in the global society.

8.2.12.B.1- Research and analyze the impact of the design constraints (specifications and limits) for a product or technology driven by a cultural, social, economic or political need and publish for review.

8.2.12.B.4- Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants.

8.2.12.B.5- Research the historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product, and present the competing viewpoints to peers for review.

Strand C. Design: The design process is a systematic approach to solving problems.

8.2.12.C.2- Analyze a product and how it has changed or might change over time to meet human needs and wants.

8.2.12.C.6- Research an existing product, reverse engineer and redesign it to improve form and function.

8.2.12.C.7- Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.

Strand D. Abilities for a Technological World: The designed world is the product of a design process that provides the means to convert resources into products and systems.

8.2.12.D.1- Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.

8.2.12.D.2- Write a feasibility study of a product to include: economic, market, technical, financial, and management factors, and provide recommendations for implementation.

8.2.12.D.3- Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system.

8.2.12.D.4- Assess the impacts of emerging technologies on developing countries.

8.2.12.D.5- Explain how material processing impacts the quality of engineered and fabricated products.

8.2.12.D.6- Synthesize data, analyze trends and draw conclusions regarding the effect of a technology on the individual, society, or the environment and publish conclusions.

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9.2 Career Awareness, Exploration, and Preparation

Strand C: Career Preparation

9.2.12.C.1 Review career goals and determine steps necessary for attainment.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

COMPANION STANDARDS FOR SCIENCE AND TECHNICAL SUBJECTS

RST.11-12.1. Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

WHST.11-12.6. Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

III. Proficiency Levels

Design and Innovation is a semester elective appropriate for students that have completed Technological Foundations.

IV. Methods of Assessment

Student Assessment

Students will be assessed using a variety of methods, including but not limited to homework, projects, and journals.

Curriculum/Teacher Assessment

The teacher will provide the subject area supervisor with suggestions for changes on an ongoing basis.

V. Grouping

This is an elective course for students that have completed Technological Foundations.

VI. Articulation/Scope & Sequence/Time Frame

Course length is one semester.

VII. Resources

Texts/Supplemental Reading/References

1. Gradwell, John B., Welch, Malcolm, and Martin., Eugene. Technology: Shaping Our World. The Goodheart-Willcox Company, Inc, 2008.
2. LaPorte, James., and Sander, Mark., Engineering & Design Applications. McGraw Hill/Glencoe
3. Wright, R. Thomas, Brown, Ryan A., Exploring Design, Technology, & Engineering. The Goodheart-Willcox Company, Inc, 2012.

VIII. Suggested Activities

Appropriate activities are found on the curriculum map.

IX. Methodologies

The following methods of instruction are suggested: lecture, group projects, demonstration, hands-on applications, and class presentations.

X. Interdisciplinary Connections

The primary focus of this course is reinforce concepts taught in the classroom to the real world. Connections will be made to social studies, mathematics, and science.

XI. Differentiating Instruction for Students with Special Needs: Students with Disabilities, Students at Risk, English Language Learners, and Gifted & Talented Students

Differentiating instruction is a flexible process that includes the planning and design of instruction, how that instruction is delivered, and how student progress is measured. Teachers recognize that students can learn in multiple ways as they celebrate students' prior knowledge. By providing appropriately challenging learning, teachers can maximize success for all students.

Differentiating in this course includes but is not limited to:

Differentiation for Support (ELL, Special Education, Students at Risk)

- Peer mentoring on problems
- Differentiated teacher feedback on assignments
- Modeling out problems on whiteboard
- Visual aids as we project problems on whiteboard
- Study guides
- Tiered assignments
- Scaffolding of materials and assignments
- Re-teaching and review
- Guided note taking
- Exemplars of varied performance levels
- Multi-media approach to accommodating various learning styles

Differentiation for Enrichment

- Supplemental reading material for independent study
- Flexible grouping
- Tiered assignments
- Topic selection by interest
- Enhanced expectations for independent study
- Elevated questioning techniques using Webb's Depth of Knowledge matrix

XII. Professional Development

The teacher will continue to improve expertise through participation in a variety of professional development opportunities.

XII. Curriculum Map/Pacing Guide

| Unit Topic | Time Allocated | Differentiating Instruction for Students with Disabilities, Students at Risk, English Language Learners, & Gifted & Talented Students | Standards | Assessments |
|---|----------------|--|--|--|
| Introduction to Engineering <ul style="list-style-type: none"> ● Fundamentals of STEM ● Design, Research, & Development ● Universal Design ● Impact of Product Design & Development ● Prototype & Manufacturing | 7 weeks | <i>For Support:</i> Modified project assessment <i>For Enhancement:</i> Real-world problems | 8.1.12.A.1,3,5 8.1.12.B.2 8.1.12.C.1 8.1.12.D 8.1.12.E.1&2 8.1.12.F.1 8.2.12.A.1 - 3 8.2.12.B.1,4,5 8.2.12.C.2,6,7 8.2.12.D.1-6 9.2.12.C.1,3 CRP1,2,4,7,8,10,12 RST.11-12.1,3 WHST.11-12.6,8,10 | <i>Formative Assessment:</i> Study of an impact of a product in the society. Group work on creating a universal design <i>Summative Assessment</i> Prototype design & manufacturing of an object |
| Design Fundamentals <ul style="list-style-type: none"> ● Complex System Thinking ● System Criteria & Constraints | 8 weeks | <i>For Support:</i> Modification of student projects/product. Teacher modeling. <i>For Enhancement:</i> Student-driven project | 8.1.12.A.1,3,5 8.1.12.B.2 8.1.12.C.1 8.1.12.D 8.1.12.E.1&2 8.1.12.F.1 8.2.12.A.1 - 3 8.2.12.B.1,4,5 8.2.12.C.2,6,7 8.2.12.D.1-6 8.2.12.E.1,2,3 9.2.12.C.1,3 CRP1,2,4,7,8,10,12 | <i>Formative Assessment:</i> Homework on the differences between criteria & constraints <i>Summative Assessment</i> Test on System thinking. Create a system as it relates to engineering |

| Unit Topic | Time Allocated | Differentiating Instruction for Students with Disabilities, Students at Risk, English Language Learners, & Gifted & Talented Students | Standards | Assessments |
|---|----------------|---|--|--|
| | | | RST.11-12.1,3 WHST.11-12.6,8,10 | |
| Technology & Society <ul style="list-style-type: none"> • Trade-offs & Transfer • Environmental Impact | 5 weeks | <i>For Support:</i> Allow error Modified assessment <i>For Enhancement:</i> Provide extension activities | 8.1.12.A.1,3,5 8.1.12.B.2 8.1.12.C.1 8.1.12.D 8.1.12.E.1&2 8.1.12.F.1 8.2.12.A.1 -3 8.2.12.B.1 -5 8.2.12.C.2,6,7 8.2.12.D.2-6 8.2.12.E.1,2,3 9.2.12.C.1,3 CRP1,2,4,7,8,10,12 RST.11-12.1,3 WHST.11-12.6,8,10 | <i>Formative Assessment:</i> Research on technology transfer. <i>Summative Assessment</i> Quiz on technology transfer. Benchmark Assessment by creating a solution to environmental problem. |