COURSE TITLE

Engineering Design

LENGTH

Full Year

DEPARTMENT

STEM Department

SCHOOL

Rutherford High School

DATE

Fall 2018

Initial BOE Approval Date (Born on): 8/22/2016

Engineering Design

I. Introduction/Overview/Philosophy

This course focuses on how engineers apply their creativity, resourcefulness, mathematical, scientific and technical knowledge and skills in the creation or refinement of technological products/systems. A key approach will be the employment of a sophisticated, sequential and iterative design and development process to solve authentic engineering tasks/problems.

Students will be challenged to participate as members of engineering teams within a typical business organization. Independent and group work will be reflective of authentic engineering projects found in the designed world. Student performance within this structure will be assessed in numerous and diverse ways. It is important to note that measurement of student performance will be reflective of actual professional engineering evaluative processes currently used in this career field. Major 'topics' or 'chapters' will be included to organize instruction of appropriate standards and benchmarks and reflect contemporary engineering industry practices:

- Principles of Design
- Engineering Resources
- Engineering Design Process
- Project Management

II. Objectives

Course Outline:

1. Fundamentals of Engineering Design
    a. Human Factor
    b. Environmental Factors
    c. Industrial Factors
    d. Market Factors
2. Elements of Design
    a. Design Improvement
    b. Trade-offs (Robot Design)
    c. Core Technologies (Building & Programming)
3. Structural Design
    a. Technology Transfer
    b. Patent Process
    c. Problem solving method
    d. Material Science
4. Project Management
    a. Principle of Project Management
    b. Quality Assurance
    c. Project Planning

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.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.
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.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.
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.3- Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
8.2.12.C.5- Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
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.

21ST CENTURY LIFE AND CAREERS

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 Level

Engineering Design is full year elective course appropriate for students that have completed Technological Foundations, Design & Innovation, and Advanced Design Applications.

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 a high school elective course offered to students that have completed both Technological Foundations, Design & Innovation, and Advanced Design Applications.

VI. Articulation/Scope & Sequence/Time Frame

Course length is one year.

VII. Resources

Texts/Supplemental Reading/References

Resources include but are not limited to:

1. Engineering by Design Curriculum
2. Instructor supplied resource materials (Instructional handouts, drawings, etc)
3. Internet
4. Supplemental reading
5. Equipment/supplies as ordered
6. Household materials

VIII. Suggested Activities

Appropriate activities are listed in 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 to 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
Fundamentals of Engineering Design ● Human Factor ● Environmental Factors ● Industrial Factors ● Market Factors	10 weeks	*For Support:* Modified assessments. Rephrase questions, directions, & explanations. Pairing Students. Student-driven projects *For Enhancement:* Real-world problems and scenarios Collect, record, & analyze the measurements for all members in the class.	8.1.12.A.5 8.1.12.B.2 8.1.12.C.1 8.1.12.D.1 8.1.12.E.1,2 8.1.12.F.1 8.2.12.A.1,2,3 8.2.12.B.4 8.2.12.C.2,3,5 8.2.12.D CRP1,2,4,7,8,10,12 9.2.12.C.1,3 RST.11-12.1, 3 WHST.11-12.6,8,10	*Formative Assessment:* Group & cooperative work Classwork *Summative Assessment* Quiz: Briefly constructed response on factors affecting Engineering Design. Powerpoint Presentation. Test: Market & profitability analysis of a product.
Elements of Design ● Design Improvement ● Trade-offs (Robot Design) ● Core Technologies (Building & Programming)	10 weeks	*For Support:* Visual learning Student-driven projects *For Enhancement:* Provide extension activities	8.1.12.A.5 8.1.12.B.2 8.1.12.C.1 8.1.12.D.1,3 8.1.12.E.1,2 8.1.12.F.1 8.2.12.A.1,2,3 8.2.12.B.4 8.2.12.C 8.2.12.D 8.2.12.F CRP1,2,4,7,8,10,12 9.2.12.C.1,3 RST.11-12.1, 3 WHST.11-12.6,8,10	*Formative Assessment:* Journal entry: Critical components to each of the designs researched *Summative Assessment* Interactive post content quiz on “Trending products” -Project Evaluation Benchmark Assessment

Unit Topic	Time Allocated	Differentiating Instruction for Students with Disabilities, Students at Risk, English Language Learners, & Gifted & Talented Students	Standards	Assessments
Structural Design • Technology Transfer • Patent Process • Problem solving method • Material Science	10 weeks	*For Support:* Modification of student products Pairing Students *For Enhancement:* Inquiry-based instruction	8.1.12.A.5 8.1.12.B.2 8.1.12.C.1 8.1.12.D.1,3 8.1.12.E. 8.1.12.F.1 8.2.12.A.1,2,3 8.2.12.B.4 8.2.12.C 8.2.12.D 8.2.12.F CRP1,2,4,7,8,10,12 9.2.12.C.1,3 RST.11-12.1, 3 WHST.11-12.6,8,10	*Formative Assessment:* Self-assessment of work performed *Summative Assessment* Benchmark Assessment Quiz on materials composition
Project Management • Principle of PM • Quality Assurance • Project Planning	10 weeks	*For Support:* Modified assessments. Rephrase questions, directions, & explanations. *For Enhancement:* Independent study Real-world problems and scenarios	8.1.12.A.5 8.1.12.B.2 8.1.12.C.1 8.1.12.D.1,3 8.1.12.E.1,2 8.1.12.F.1 8.2.12.A.1,2,3 8.2.12.B.4 8.2.12.C 8.2.12.D 8.2.12.F CRP1,2,4,7,8,10,12 9.2.12.C.1,3 RST.11-12.1, 3 WHST.11-12.6,8,10	*Formative Assessment:* Self-assessment of work performed *Summative Assessment* Benchmark Assessment Unit Test on Quality control