

Glen Ridge Public Schools –Visual & Performing Arts Curriculum



Course Title: Fundamentals of Engineering

Subject: Visual and Performing Arts

Grade Level: 10-12

Duration: Full year

Prerequisite: None

Elective or Required: Elective

Computer Science, Engineering, and Technology Mission Statement:

Since computational thinking and problem solving are integral parts of our lives and 21st century learning, students must be actively involved in their Computer Science, Engineering, and Technology (CSET) education. The CSET curricula will emphasize thinking skills through a balance of computation, intuition, common sense, logic, design, analysis, and technology. Students will use a combination of technology and critical thinking to solve real-world problems. To achieve these goals, students will be taught a standards-based curriculum that is aligned with the New Jersey Curriculum Standards.

Course Description:

This course is designed to excite students about engineering and give them the head start they need in today's competitive workplace. Engineering offers some of the most rewarding career opportunities possible. This course will engage student interest in these exciting career opportunities by giving them a hands-on activates in each of the major engineering topics and allow them to use real-world equipment and software such as Autodesk AutoCAD, Inventor, Revit and other CAD software.

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FUNDAMENTALS OF ENGINEERING TABLE OF CONTENTS

UNIT	TITLE	Timeline
1	Introduction to Engineering Design	3 Weeks
2	Design Process & Mechanical Systems	5 Weeks
3	Electrical Engineering	3 Weeks
4	Civil Engineering	5 Weeks
5	Mechanical Engineering	5 Weeks
6	Manufacturing Engineering	5 Weeks
7	Aerospace Engineering	9 Weeks

Course Name

Fundamentals of Engineering

Topic/Unit:

Introduction to Engineering Design

Approximate # Of Weeks: 2-3 Weeks

Essential Questions:

- Why should you study engineering?
- How do engineers impact political, economic and cultural parts of our lives?
- How is the engineering design process used to create solutions to problems?
- How do criteria and constraints help to shape solutions?
- How can you design a product that has both form and function?

Upon completion of this unit students will be able to:

- Create a digital notebook to reflect you career aspirations in Engineering. (8.1.12.A.1), (NJSLSA.W6), & (W.11-12.6)
- Understand the method of retrieving information through the public network and have a positive approach to copyright and original design. (8.1.12.D.1)
- Explain different fields of engineering and the professional duties of the specific engineer. (9.1.12.A.3)
- Describe the education and license necessary to become an engineer. (9.1.12.A.4) & (6.1.12.C.14.d)
- Research a technology that has evolved over time and predict the future changes for this technology. (8.2.12.B.4) & (8.2.12.C.2)
- Create a presentation that describes one field of engineering. (W.11-12.4)
- Explain the steps and process of the engineering design process. (9.3.ST-ET.4)
- Design and create an original product following the engineering process. (8.2.12.D.1)
- Use CAD software to design an original prototype. (M.G-MG.A.3)
- Design and create an original device that has both function and form. (9.3.12.AR-VIS.3)

Interdisciplinary Standards

Math

- **M.G-MG.A.3:** Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).★

English Language Arts

- **NJSLSA.W6:** Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
- **W.11-12.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- **W.11-12.6:** Use technology, including the Internet, to produce, share, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Social Studies

- **6.1.12.C.14.d:** Relate the changing manufacturing, service, science, and technology industries and educational opportunities to the economy and social dynamics in New Jersey

Technology

- **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.D.1:** Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.
- **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.C.2:** Analyze a product and how it has changed or might change over time to meet human needs and wants.
- **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.

Personal Financial Literacy

- **9.1.12.A.3:** Analyze the relationship between various careers and personal earning goals.
- **9.1.12.A.4:** Identify a career goal and develop a plan and timetable for achieving it, including educational/training requirements, costs, and possible debt.

Career and Technical Education

- **9.3.ST-ET.4:** Apply the elements of the design process.
- **9.3.12.AR-VIS.3:** Analyze and create two and three-dimensional visual art forms using various media.

Activities:

- Students will use the Internet and other computer software to research and create a presentation that shows the past present and future projects a specific engineering field has worked on, are working on and may encounter in the future.
- Students will use a 3D modeling program to design and create a three-dimensional representation of a technology.
- Students will use CAD to design create alternative designs for a new product.
- Students will create digital notebook that will start with an Introduction to Engineering section for the engineering class.

STEAM Activities:

- 3D Poster: Students will design and create a three-dimensional poster for the field of engineering of their choice. Posters will include a description of the field including degree requirements and licenses, starting and average salary and typical responsibilities. One famous engineer in the field. And a past present and future prediction of a technology in the field. The posters must be three-dimensional or include a three-dimensional object.
- Cell Phone Stand design: Students will use modeling materials to design for a cell phone stand. The device must improve a basic paper folded stand and include 2 new functions and improve 3 different forms (ascetics and ergonomics of the device. The will apply the design process, use tools and scale to create a real life size object.

Enrichment Activities:

- Students will research topics of engineering societies, student organizations, and competitions to develop an appreciation of the field.
- Samples of engineering presentations will be displayed.
- Samples prototypes students have designed.
- Samples of product packing students have designed.
- Presentation of one field of engineer. Include:
 - a. A description of the responsibilities of the specific type of engineer.
 - b. The type of degree required.
 - c. Length of education or license needed for that field.
 - e. Starting salary and average salary for an engineer in the field.
- Product design: Design an original product prototype using the engineering design process.

Methods of Assessments/Evaluation:

- Students will be assessed on their ability to research and design an informational display.
- Quizzes on careers in Engineering.

- Students will present their finished presentations to the class to teach their specific field of engineering.
- Students will write a one-paragraph reflection paper describing how their design will improve the paper cell phone. They will explain how their design adds two functions and justify their ascetic and ergonomic improvements. They will create a final digital presentation to “sell” their new design.

Resources:

- Textbooks: *Engineering Fundamentals Design, Principles, and Careers*
 - Chapters 1,2, 3 & 16
- Computers with AutoCAD and Inventor installed
- Handouts
- PowerPoint
- CAD or design software
- Poster boards
- Scissors
- Cardboard
- Cardstock
- Photo paper
- Rulers
- X-acto knives
- Tape/glue
- Plotter/Printers
- 3D printer
- TV/VCR/DVD
- Projector and screen
- Calculator
- Rulers

Online Resources

- Mr. Shohen’s page: <http://www.glenridge.org/Page/3608>
- Design process:
<http://www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml>
- Paper Cell phone Stand:
 - <https://www.youtube.com/watch?v=7F4EN2IFP24>
 - <http://www.cnet.com/news/six-free-diy-smartphone-stands/>

Course Name

Fundamentals of Engineering

Topic/Unit:

Design Process & Mechanical Systems

Approximate # Of Weeks: 4-5 Weeks

Essential Questions:

- Who Creates design problems?
- When is the engineering design process complete?
- Why is communicating the solution so important?
- How does rapid prototyping improve the design world?
- What is the purpose of a final report after a project is completed and tested?
- How does mechanical advantage play a major role in increasing a force?

Upon completion of this unit students will be able to:

- Identify steps of the design process including researching a problem, designing, building, testing and communicating the solution. (8.2.12.D.1) & (9.3.ST-ET.4)
- Research mechanical systems found in catapults, trebuchets and ballista. (8.2.12.B.4), (NJSLSA.R1) & (6.2.12.C.3.d)
- Brainstorm numerous solutions to a technical problem, select a final option and create a drawing of the design (8.2.12.C.5) & (HS-ETS1-2)
- Explain the concepts of energy motion and mechanical advantage. (9.3.ST-ET.1)
- Identify how simple machines are used in mechanical systems. (8.2.12.C.4) & (9.3.ST-SM.2)
- Use CAD software to design an original prototype or part for a mechanical system. (M.G-MG.A.3)
- Design and create a mechanical device that has both function and form. (9.3.12.AR-VIS.3)
- Create a digital presentation that documents your progress through the design process. (NJSLSA.W6) & (W.11-12.4)

Interdisciplinary Standards

Math

- **M.G-MG.A.3:** Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*

Social Studies

- **6.2.12.C.3.d:** Determine how, and the extent to which, scientific and technological changes, transportation, and new forms of energy brought about massive social, economic, and cultural changes.

English Language Arts

- **NJSLSA.R1:** Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
- **NJSLSA.W6:** Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
- **W.11-12.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience

Science

- **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.

Technology

- **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.C.4:** Explain and identify interdependent systems and their functions.
- **8.2.12.C.5:** Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- **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.

Career and Technical Education

- **9.3.ST-ET.1:** Use 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-SM.2:** Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
- **9.3.12.AR-VIS.3:** Analyze and create two and three-dimensional visual art forms using various media.

Activities:

- Students will use the Internet and other computer software to research and create a design to solve a technical problem.

- Students will use a 3D modeling program to design and create a three-dimensional representation of a technology.
- Students will use CAD to design create alternative designs for a new product.
- Students will create digital notebook that will start with an Introduction to Engineering section for the engineering class.

STEAM Activities:

- Hoops: Students will work as a team to design and construct a self propelled Catapult to carry and launch as many Ping-Pong balls into a hoop in 3 minutes. The energy sources shall consist of any elastic storage device (rubber bands, bungee cords, leaf springs, etc.). Only a mechanical device may provide energy to either the movement of the apparatus or the propulsion of the ping-pong ball.
- Patent Application: Each team is required to research a design, brainstorm ideas, select the best one and create a final technical drawing of the device with a materials list and notations.

Enrichment Activities:

- Students will research historical catapults and other mechanical systems to aid them in their design of a new technology.
- Students will research topics of mechanical advantage and simple machines and describe principals of technical power.
- Students can design 3D printed parts to enhance their prototypes.
- Samples prototypes students have designed.
- Presentation following the steps of the design process.

Methods of Assessments/Evaluation:

- Performance-based assessment design, craftsmanship, creativity and competition results.
- Quizzes on Engineering design process and mechanical advantage.
- Students will create a digital reflection report describing how their design worked and can be improved. They will explain how their design functioned properly and ways that it didn't function consistently. They will create a final digital presentation including 3D designs, pictures and video of their design.

Resources:

- Textbooks: *Engineering Fundamentals Design, Principles, and Careers*
 - Chapters 4, 5, 6 & parts of 10.
- Computers with AutoCAD and Inventor installed
- Handouts

- PowerPoint
- CAD or design software
- Poster boards
- Scissors
- Cardboard
- Cardstock
- Photo paper
- Rulers
- X-acto knives
- Tape/glue
- Plotter/Printers
- 3D printer
- TV/VCR/DVD
- Projector and screen
- Calculator
- Rulers

Online Resources

- Mr. Shohen's page: <http://www.glenridge.org/Page/3608>
- Catapults and trebuchets:
- <https://www.youtube.com/watch?v=egZhg7v4NRs>
 - <https://sites.google.com/site/physicsofcatapults/home/how-a-catapult-works-the-basics>
 - <http://science.howstuffworks.com/transport/engines-equipment/question127.htm>

Course Name

Fundamentals of Engineering

Topic/Unit:

Electrical Engineering

Approximate # Of Weeks: 2-3 Weeks

Essential Questions:

- What would your life be like without electricity?
- How have electricity and electrical components shaped the world you live in?
- How has the harnessing of electricity affected the last 100 years of inventions?
- If matter cannot be created nor destroyed, what happens to electricity that is used?
- Why is the relationship among voltage, current, and resistance so important to understanding electrical systems?
- How can reducing electrical consumption affect the world?
- Can alternative energy systems eventually produce enough power to supply the world's needs?
- How will electricity be produced when all fossil fuel is consumed?

Upon completion of this unit students will be able to:

- Identify and draw various electronic components and schematic symbols. (8.2.12.C.4)
- Understand how electrons move on the atomic level and common sources of electrical energy, their limitations, theory of transfer of energy and electron movement. (RI.11-12.4), (6.2.12.C.3.d) & (HS-PS2-6)
- Design and build circuits and devices that use schematics plans. (9.3.ST-SM.2)
- Draw electrical schematics for small circuits using CAD software. (8.2.12.C.5)
- Calculate ohms law from a schematic. Understand and apply the relationship among voltage, current, and resistance. Select the proper Ohm's law formula from a chart. (M.A-CED.A.4)
- Use a digital multi meter on an energized electrical circuit. (9.3.ST-ET.3)
- Create a product that uses series and/or parallel circuits using electrical components and wires. (8.2.12.D.1)
- Identify, design and build devices that transfer energy from motion into electrical energy. (HS-PS3-3)
- Use programming language to aid in the creation of an electronic device. (8.2.12.E.3)
- Apply safe shop practices when working with electricity. (9.3.ST.3)

- Design and create electronic devices that have both function and form. (9.3.12.AR-VIS.3)
- Create a digital presentation that documents your progress through the design process. (NJSLSA.W6) & (W.11-12.4)

Interdisciplinary Standards

Math

- **M.A-CED.A.4:** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law $V = IR$ to highlight resistance R .*

Social Studies

- **6.2.12.C.3.d:** Determine how, and the extent to which, scientific and technological changes, transportation, and new forms of energy brought about massive social, economic, and cultural changes.

English Language Arts

- **W.11-12.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- **NJSLSA.W6:** Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
- **RI.11-12.4:** Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms over the course of a text (e.g., how Madison defines faction in Federalist No. 10).

Science

- **HS-PS3-3:** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- **HS-PS2-6:** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials

Technology

- **8.2.12.C.5:** Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- **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.E.3:** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).

Career and Technical Education

- **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.3:** Apply processes and concepts for the use of technological tools in STEM.
- **9.3.ST-SM.2:** Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
- **9.3.12.AR-VIS.3:** Analyze and create two and three-dimensional visual art forms using various media.

Activities:

- Conduct class discussions after each reading assignment.
- Students will design and build electronic systems to perform a specific task.
- Construction projects in class that uses electrical systems to solve problems.
- Solve practical problems using Ohm's Law and other assignments relating to electrical engineering.
- Use various electrical measuring devices and record their results.
- Students will use AutoCAD to draw basic electronic schematics.
- Alternative energy systems can be created for use with architectural models.
- Electronic components can be designed and incorporated into 3D printed models to add light, add sound or to create motion.
- Students will create an Electrical Engineering section for the engineering class digital notebook.

STEAM Activities:

- **Flashing LEDs:** Students will design and build an ornament that includes a flashing LED circuit. They will identify and solder components draw schematics and develop an understanding for switches, resistors, LEDs, voltage, current and resistance.
- **Electrical Product Design:** Students can design an electrical device that uses an electronic circuit. Examples of this could be a robotic arm or conveyor belt. Students can design and build a transportation vehicle that incorporates a motor and gears. Other products could use speakers and LEDs to amplify a MP3 Player.
- **Arduino:** Students will have the opportunity to learn how to build and program numerous electronic projects without soldering and consuming materials. Arduino boards will give students the opportunity to use a programming language to solve problems or accomplish tasks. Students

will be engaged in building designing and programming projects including traffic lights, flashlights and other electronic devices.

Enrichment Activities:

- Alternative energy: Students can design an alternative energy electrical system for a residential home or commercial building. They can use solar cells, or design and print parts for wind or water turbines.
- STEAM Game: Students will design and create an electronic product or game using the skills learned from the unit. The game should be designed to teach young players about a specific topic related to STEAM.

Methods of Assessments/Evaluation:

- Performance-based assessment on electrical devices' ability to solve problems.
- Practical tests in the following areas:
 1. Reading schematics
 2. Quality of soldering
 3. Practical mounting of parts
 4. Operation
 5. Product design and functioning
- Lab worksheets.
- CAD drawings.

Resources:

- Handouts of procedures and labs.
- Electricity Textbook. *Electricity 10th Edition*
- Textbooks: *Engineering Fundamentals Design, Principles, and Careers*
 - Chapter 8
- Computers with AutoCAD and Inventor installed
- Plotter/Printers
- TV/VCR/DVD
- Projector and screen
- Calculator
- Calipers and Micrometers
- Digital Millimeters
- Electrical components

Online Resources

- Mr. Shohen's page: <http://www.glenridge.org/Page/3608>
- Ohm's Law and basic components:
 - https://www.youtube.com/watch?v=_jX3dezzMg
 - https://www.youtube.com/watch?v=_jX3dezzMg
 - <https://www.youtube.com/watch?v=8gvJzrjwjdS>

- <https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab>
- Arduino: <https://www.arduino.cc/>

Course Name

Fundamentals of Engineering

Topic/Unit:

Civil Engineering

Approximate # Of Weeks: 4-5 Weeks

Essential Questions:

- How do Civil Engineers affect the landscape?
- How are structures engineered to be stable and safe and to withstand various loads and forces?
- How has GPS survey equipment, Google Earth and laser transits impacted CAD programs and the job of surveyors?
- In what ways have technical developments allowed for structures to be built from new building materials?
- What would towns and cities look like if no one had property lines?
- How can topography maps help when designing a structure?
- How do Engineers use structural analysis and static and dynamic loads when designing structures?

Upon completion of this unit students will be able to:

- Describe structural forces, loads and components. (HS-PS2-3)
- Identify types of bridges and their basic components. (8.2.12.B.4)
- Understand the internal structure of a tower. (8.2.12.C.4)
- Apply mathematical problems associated with Civil/Survey Engineering. (M.G-MG.A.3) & (9.3.ST-ET.5)
- Use common terms and recognize design concerns associated with Civil/Survey Engineering. (HS-ETS1-2) & (9.3.ST-SM.2)
- Use computer simulations to model the impact of weight applied to a structure. (HS-ETS1-4)
- Plan, design and build structures that are efficient in terms of strengths to weight. (8.2.12.C.5) & (8.2.12.D.1)
- Explain the responsibilities of a Civil Engineer/Surveyor by researching a survey site and talking with civil or survey engineers. (9.3.ST.5)
- Design and create structures that have both function and form. (9.3.12.AR-VIS.3)
- Create a digital presentation that documents your progress through the design process. (NJSLSA.W6) & (W.11-12.4)

Interdisciplinary Standards

Math

- **M.G-MG.A.3:** Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).★

English Language Arts

- **NJSLSA.W6:** Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
- **W.11-12.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Science

- **HS-PS2-3:** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision
- **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-ETS1-4:** 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

Technology

- **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.C.5:** Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- **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.

Career and Technical Education

- **9.3.ST.5:** Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
- **9.3.ST-ET.5:** Apply the knowledge learned in STEM to solve problems.
- **9.3.ST-SM.2:** Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
- **9.3.12.AR-VIS.3:** Analyze and create two and three-dimensional visual art forms using various media.

Activities:

- Students will use structural analysis software to design buildings, bridges and structures to withstand various loads and forces.
- Students will discuss issues in the Civil Engineering/Survey field.
- Students will test structures and analyze their efficiencies.
- Students will use CAD software to create drawings and to plot a specific scale factor.
- Use Autodesk Revit to create a topographical surface with contours.
- Use Google earth to import simulated terrain from the global positioning satellites.
- Students will create a Civil Engineering section for the engineering class digital notebook.
- Research and document a survey site. New construction of a bridge, tower.

STEAM Activity:

- Bridges: Students will design virtual bridges to gain an understanding of construction materials, reducing material sizes and cost. Next they will design a three-dimensional truss bridge in a modeling program and apply structural analysis software to determine deflection caused by loads and forces. They will create a final design to be 3D printed and test the real life model for its efficiency.
- Towers: Students will use CAD software to design a tower. They will build a model using coffee sirs and glue. Final designs will be tested for its strength to weight efficiency.

Enrichment Activities:

- Invite a surveyor to come into class and set up a transit and a GPS demonstration.
- Real life survey plans may be shown to display items commonly seen on a survey drawing.
- A civil engineer or surveyor may speak to the class about their career.
- Students may visit a college engineering program.
- Students may visit the site of a new construction to see how survey equipment works in the field.

Methods of Assessments/Evaluation:

- Performance-based assessment on Civil/Survey standards as used in industry
- Students building and strength testing analysis.
- Creation of Civil/Survey engineering drawings.
- Tests– Civil Engineering/Survey terms and math problems.

Resources:

- Textbooks: *Engineering Fundamentals Design, Principles, and Careers*
 - Chapter 9
- Computers with AutoCAD, Inventor, Rivet, and WestPoint Bridge designer installed
- Plotter/Printers
- 3D Printer
- TV/VCR/DVD
- Projector and screen
- Calculator
- Ruler

Online Resources:

- Mr. Shohen's page: <http://www.glenridge.org/Page/3608>
- WestPoint Bridge designer: <https://bridgecontest.org/>
- Google Earth: <https://www.google.com/earth/>
- PBS building big: <http://www.pbs.org/wgbh/buildingbig/>
- <https://www.youtube.com/watch?v=EYRYtTMcYZM>
- https://www.youtube.com/watch?v=IXyG68_caV4
- <https://www.youtube.com/watch?v=j-zczJXSxnw>

Course Name

Fundamentals of Engineering

Topic/Unit:

Mechanical Engineering

Approximate # Of Weeks: 4-5 Weeks

Essential Questions:

- How is mechanical engineering applied to improve a working product?
- How is mechanical advantage used in manufacturing products that apply force, work, and power?
- What can you discover when analyzing why a system or a failed part?
- How do engineers apply mathematical calculations when designing a mechanical system?
- What causes a working product to malfunction?
- How engineers create technology to be more sustainable in the future?
- Why are precise measurements critical to drawing and creating accurate parts?

Upon completion of this unit students will be able to:

- Research mechanical systems and explain concepts of energy, motion and simple machines. (NJSLSA.R1) & (9.3.ST-SM.2)
- Calculate gear ratios for mechanical advantage and understand gearing for speed vs. gearing for power. (8.2.12.C.4) & (9.3.ST-ET.1)
- Apply mathematical problems associated with mechanical engineering including work, pressure, power, torque, and efficiency. (9.3.ST-ET.5)
- Use common measuring devices found in the mechanical engineering field. (8.2.12.C.5) & (HS-ETS1-2)
- Draw 3D solid models to design an original prototype or parts for a mechanical system. (M.G-GMD.B.4)
- Demonstrate geometric knowledge and skills required to produce a mechanical motion through an assembly working drawing. (M.G-MG.A.3)
- Develop and deliver a presentations using CAD software to engage and inform audiences. (9.3.ST.1)
- Design and apply the engineering problem-solving loop in order to fabricate a solution to a problem. (8.2.12.D.1) & (9.3.ST-ET.4)
- Design and build devices that transfer energy from electrical energy to mechanical motion. (HS-PS3-3)
- Design devices that use electricity and magnetism to produce motion. (HS-PS3-5)
- Use programming language to aid in the creation of a mechanical system. (8.2.12.E.3)
- Design and create mechanical powered devices that have both function and form. (9.3.12.AR-VIS.3)

- Create a digital presentation that documents your progress through the design process. (NJSLSA.W6) & (W.11-12.4)

Interdisciplinary Standards

Math

- **M.G-GMD.B.4:** Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
- **M.G-MG.A.3:** Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

English Language Arts

- **NJSLSA.R1:** Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
- **NJSLSA.W6:** Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
- **W.11-12.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Science

- **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-PS3-3:** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*
- **HS-PS3-5:** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction

Technology

- **8.2.12.C.4:** Explain and identify interdependent systems and their functions.
- **8.2.12.C.5:** Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- **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.E.3:** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).

Career and Technical Education

- **9.3.ST.1:** Apply engineering skills in a project that requires project management, process control and quality assurance.
- **9.3.ST-ET.1:** Use 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.ST-SM.2:** Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
- **9.3.12.AR-VIS.3:** Analyze and create two and three-dimensional visual art forms using various media.

Activities:

- Students will measure, and draw mechanical device using design and 3D modeling techniques.
- The class will solve mathematical problems related to mechanical engineering, mechanical advantage, gear ratios, work, pressure, power, torque, and efficiency.
- Produce projects that use mechanical devices through the use of research via the Internet and computer simulations.
- Students will create designs to solve a technical problem.
- Students will use a 3D modeling program to design and create a three-dimensional representation of mechanical devices.
- Students will create a Mechanical Engineering section for the engineering class digital notebook.

STEAM Activities:

- **Magnetic Levitation:** A Maglev train takes advantage of the simple magnetic principle that states opposite poles attract and similar poles repel. This allows a Maglev train to virtually float on a cushion of air. Students will design a device that uses two simple machines to deliver logs to a sawmill (pencils to a bin). Next students will use an electrified track and a DC motor to create a magnetic levitation vehicle that travels for speed.
- **3D printed Mini Car:** Students will use modeling software and the 3D printer to design and build a mini train for rail transportation. Then design for tethered rail transportation. Attempts will be made to move the most amount of business people to the platform.
- **Autonomous high way:** Students will use microprocessors (Arduino board) to design build and program vehicles that will traverse a track without crashing into other vehicles.

Enrichment Activities:

- Students will research topics of mechanical advantage, simple machines and gear ratios for speed and power.
- Students can design 3D printed parts to enhance their prototypes.
- Samples prototypes and video from student designs.
- Presentation following the steps of the design process.
- A mechanical engineer can visit the school; students can visit an engineering facility and an engineering college.
- The class will discuss in a meeting format how problems are solved and which students' work is commendable and where others could use improvement.

Methods of Assessments/Evaluation:

- Performance-based assessment on mechanical systems' ability to solve problems.
- Assessment on the creation of a projects using the following areas:
 1. Problem Defining
 2. Idea Generating
 3. Solution Creation
 4. Testing/Analysis
 5. Final Solution or Output
 6. Design Improvement
- Tests – Mechanical engineering terms and math problems.
- Peer evaluation of assembly drawings and mechanical parts created from the 3D printer.

Resources:

- Textbooks: *Engineering Fundamentals Design, Principles, and Careers*
 - Chapter 10
- Computers with AutoCAD and Inventor installed
- Plotter/Printers
- TV/VCR/DVD
- Projector and screen
- Calculator
- Calipers and Micrometers

Online Resources:

- Mr. Shohen's page: <http://www.glenridge.org/Page/3608>
- Arduino: <https://www.arduino.cc/>
- Gear Ratio: https://www.youtube.com/watch?v=D_i3PJYtuY

Course Name

Fundamentals of Engineering

Topic/Unit:

Manufacturing Engineering

Approximate # Of Weeks: 4-5 Weeks

Essential Questions:

- How do you design a part for manufacturability?
- How do prototypes shape the design of a final product?
- How can improving a tool or a machine effect the creation of a product?
- How does the creation of more sophisticated technology affect the job market?
- In what ways can Computer Numerical Control (CNC) machines improve the technical world?
- How do the limitations of equipment affect the manufacturing of parts?

Upon completion of this unit students will be able to:

- Investigate the roles and responsibilities of manufacturing engineers and industrial designers. (8.2.12.D.5), (9.3.MN.1) & (NJSLSA.R1)
- Design and draw 3D solid models for rapid prototyping. (8.2.12.C.5) & (HS-ETS1-2)
- Design and build mechanical systems to solve problems. (8.2.12.C.4)
- Use CNC (Computer Numerical Control) equipment in the creation of a designed project. (8.2.12.C.3) & (8.2.12.D.3)
- Apply mathematical problems associated with fabrication. (9.3.MN.6) & (M.G-GMD.B.4)
- Use common measuring devices found in the manufacturing industry. (9.3.ST.1)
- Use programming language to aid in the creation of product. (8.2.12.E.3)
- Design and apply the engineering problem-solving loop in order to fabricate a solution to a problem. (9.3.ST.6) & (9.3.ST-ET.4)
- Design and create an original device that has both function and form. (8.2.12.D.1) & (9.3.12.AR-VIS.3)
- Create a digital presentation that documents your progress through the design process. (NJSLSA.W6) & (W.11-12.4)

Interdisciplinary Standards:

Math

- **M.G-GMD.B.4:** Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.

English Language Arts

- **NJSLSA.R1:** Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
- **NJSLSA.W6:** Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
- **W.11-12.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Science

- **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.

Technology

- **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.4:** Explain and identify interdependent systems and their functions.
- **8.2.12.C.5:** Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- **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.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.E.3:** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).

Career and Technical Education

- **9.3.MN.1:** Evaluate the nature and scope of the Manufacturing Career Cluster and the role of manufacturing in society and in the economy.
- **9.3.MN.6:** Demonstrate workplace knowledge and skills common to manufacturing.
- **9.3.ST.1:** Apply engineering skills in a project that requires project management, process control and quality assurance.
- **9.3.ST.6:** Demonstrate technical skills needed in a chosen STEM field.
- **9.3.ST-ET.4:** Apply the elements of the design process.

- **9.3.12.AR-VIS.3:** Analyze and create two and three-dimensional visual art forms using various media.

Activities:

- Students will design and create 3D solid models for rapid prototyping.
- Students will develop drawings for a CNC (Computer Numerical Control) project.
- The class will discuss in a meeting format how problems are solved and which students' work is commendable and where others could use improvement.
- The class will solve mathematical problems related to construction concerns and details.
- Students will complete various metalworking operations using hand tools and machines.
- Students will create an Industrial Manufacturing section for the engineering class digital notebook.

STEAM Activities:

- Product design: Design a prototype for efficient manufacturing. Students will research methods of producing the product using classroom CNC (Computer Numerical Control) equipment.
- Tiny CNC drawing robot: Students will print out parts in the 3D printer and program with Arduino to create their own mini three-axis CNC pen machine.

Enrichment Activities:

- Students will measure and draw common parts of mechanical systems using parametric software.
- As part of a team the students will create a new part for mass production that uses CNC equipment.
- A prototype of the part can be printed using the school's 3D printer.
- Have a machinist, metallurgist, machine operator or an engineer visit the school; visit a college or a commercial metalworking site.
- Students can recreate parts from a textbook or use real life parts. Each drawing should be dimensioned using proper dimensioning rules.
- Drawings should allow students to become familiar with design parts for manufacturability.

Methods of Assessments/Evaluation:

- Performance-based assessment on mechanical systems' ability to solve problems.
- Assessment on the creation of a projects using the following areas:
 7. Problem Defining

8. Idea Generating
 9. Solution Creation
 10. Testing/Analysis
 11. Final Solution or Output
 12. Design Improvement
- Tests – Manufacturing terms and math problems.
 - Peer evaluation of assembly drawings and mechanical parts created from the 3D printer.

Resources:

- Textbooks: *Engineering Fundamentals Design, Principles, and Careers*
 - Chapter 14
- Computers with AutoCAD and Inventor installed
- Plotter/Printers
- TV/VCR/DVD
- Projector and screen
- Calculator
- Calipers and Micrometers

Online Resources:

- Mr. Shohen's page: <http://www.glenridge.org/Page/3608>
- Arduino: <https://www.arduino.cc/>
- CNC Plotter bot:
<http://plotterbot.com/2013/11/how-to-build-a-tiny-cnc-drawing-robot/>
- Inventables: Projects: <https://www.inventables.com/projects>

Course Name

Fundamentals of Engineering

Topic/Unit:

Aerospace Engineering

Approximate # Of Weeks: 8-9 Weeks

Essential Questions:

- How does Newton's three laws of motion have a tremendous impact on aerospace engineering?
- Why does the study of fluid dynamics and aerodynamics rely on the scientific understanding of conservation of mass, momentum and energy?
- Why are the four forces of flight (lift, thrust, drag, and gravity) so important when designing aerodynamic objects for flight and speed?
- Is spacecraft design different from fixed wing design?

Upon completion of this unit students will be able to:

- Investigate the roles and responsibilities of aerospace engineers and explain the history of flight. (6.2.12.C.3.d),(8.2.12.B.4) & (NJLSA.R1)
- Explain Newton's laws of motion as it pertains to flight and transportation. (RI.11-12.7) & (HS-PS2-1)
- Design and build aerodynamic objects to reduce drag, and produce lift. (8.2.12.C.4) & (HS-ETS1-2)
- Explain Bernoulli theory of lift for a fixed wing aircraft. (9.3.ST-SM.2)
- Calculate speed of a dragster and compare it with to others. (M.F-LE.A.1.b)
- Calculate the apex height of a rocket in flight. (M.G-SRT.D.11)
- Design and draw 3D virtual models computer simulations. (HS-ETS1-4)
- (8.2.12.C.5) & (HS-ETS1-2)
- Design and apply the engineering problem-solving loop in order to fabricate a solution to a problem. (9.3.ST.6) & (9.3.ST-ET.4)
- Design and create aerodynamic devices that have both function and form. (8.2.12.D.1) & (9.3.12.AR-VIS.3)
- Create a digital presentation that documents your progress through the design process. (NJLSA.W6) & (W.11-12.4)

Interdisciplinary Standards:

Math

- **M.G-SRT.D.11:** (+) Understand and apply the Law of Sines and the Law of Cosines to find unknown measurements in right and non-right triangles (e.g., surveying problems, resultant forces).
- **M.F-LE.A.1.b:** Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

English Language Arts

- **NJSLSA.R1:** Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
- **NJSLSA.W6:** Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
- **RI.11-12.7:** Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
- **W.11-12.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Social Studies

- **6.2.12.C.3.d:** Determine how, and the extent to which, scientific and technological changes, transportation, and new forms of energy brought about massive social, economic, and cultural changes

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-ETS1-2:** 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-ETS1-4:** 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

Technology

- **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.C.4:** Explain and identify interdependent systems and their functions.
- **8.2.12.C.5:** Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- **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.

Career and Technical Education

- **9.3.ST.6:** Demonstrate technical skills needed in a chosen STEM field.
- **9.3.ST-ET.4:** Apply the elements of the design process.
- **9.3.ST-SM.2:** Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
- **9.3.12.AR-VIS.3:** Analyze and create two and three-dimensional visual art forms using various media.

Activities:

- Students will develop drawing plans for aerodynamic objects.
- Students will use analysis software to design planes, dragsters and rockets.
- Students will discuss issues in the Aerodynamic Engineering field.
- Students will test designs and analyze their efficiencies based on time, speed and distance.
- Use Autodesk Inventor to create virtual models.
- Research and document projects and suggest methods of improvements.
- Students will create an Aerospace Engineering section for the engineering class digital notebook.

STEAM Activities:

- **Planes:** Students will build, fly, and adjust (trim) a model to make long endurance flights inside a contained airspace. The delta will be used for the in class project. Next design an original self-propelled plan that achieves the longest flight time. Evaluation is based on the duration of flight. A bonus of ten (10) seconds is added to the flight time per flight if the airplane successfully lands on its wheels and comes to a rest on its wheels. (Based on the TSA Flight Endurance Challenge)
- **Dragsters:** Students will design and construct an aerodynamic shaped CO₂ powered dragster from a wood blank that will race down a guide wire and be clock for its max speed. It will also be raced against other students' cars to determine the fast car. (Based on the TSA Dragster design)
- **Rockets:** Students will build and test rockets to determine the highest flight. They will apply a trigonometry formula to find the height of the flight (opposite) based on the distance away on the ground (adjacent) and angle of the theta.

Enrichment Activities:

- Students will measure and draw common parts of aeronautic systems using parametric software.
- Students may participate in state competitions (TSA) for CO₂ dragster design and Flight Endurance.
- A prototype of the dragster can be printed using the school's 3D printer.

- Have an aeronautic engineer visit the school; visit a college or a Aerospace Engineering program.

Methods of Assessments/Evaluation:

- Performance-based assessment on aerodynamic models' ability to solve problems.
- Assessment on the creation of a projects using the following areas:
 1. Problem Defining
 2. Idea Generating
 3. Solution Creation
 4. Testing/Analysis
 5. Final Solution or Output
 6. Design Improvement
- Tests – Aerodynamic terms and math problems.
- Peer evaluation of drawings and projects and project performance.

Resources:

- Textbooks: *Engineering Fundamentals Design, Principles, and Careers*
 - o Chapter 13
- Computers with AutoCAD and Inventor installed
- Plotter/Printers
- TV/VCR/DVD
- Projector and screen
- Calculator
- Calipers and Micrometers
- Balsa wood and other supplies

Online Resources:

- Mr. Shohen's page: <http://www.glenridge.org/Page/3608>
- Flight:
- <http://www.tsaweb.org/sites/default/files/HS%20Flight%20Endurance.pdf>
 - <https://www.youtube.com/watch?v=khvvaXsIEVY>
- Dragsters:
- <http://www.umasd.org/cms/lib7/PA01000379/Centricity/Domain/474/212%20Dragster%20Design.pdf>
 - <https://www.youtube.com/watch?v=sJMjBmy7pIU>
 - <https://www.youtube.com/watch?v=8Pgx9qM1W6A>
- Rockets:
- <https://www.grc.nasa.gov/www/k-12/rocket/rktparts.html>
 - <http://www.jamesyawn.net/modelrocket/intro/index.html>
 - https://www.youtube.com/watch?v=w8_fHEkgkNg
 - <http://quest.arc.nasa.gov/aero/virtual/demo/aeronautics/youDecide/kiteMeasure2Trig.html>