PTLW Principles of Engineering (POE) ACP
Curriculum Map

Adapted from:
Understanding By Design

Reviewed by:
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Adopted:
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Vernon School District
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Course Description

The PTLW Principles of Engineering (POE) ACP course of engineering exposes students to some of the major concepts they'll encounter in a post secondary engineering course of study. Students have an opportunity to investigate engineering and high-tech careers and to develop skills and understanding of course concepts. Students employ engineering and scientific concepts in the solution of engineering design problems. They develop problem-solving skills and apply their knowledge of research and design to create solutions to various challenges. Students also learn how to document their work and communicate their solutions to peers and members of the professional community.
Prerequisite: > 80% Average Introduction to Engineering Design & successful completion of Algebra I and/or Geometry.
Based upon the following list of proficiencies, each student must demonstrate a minimum competency level of 65%. Competencies will be measured by way of an evaluation program consisting of; completion of projects, tests and quizzes, class participation, as well as class attendance in accordance with the schools attendance policy.

New Jersey Student Learning Standards covered throughout the course

In conjunction with the New Jersey Student Learning Standards, students enrolled in the Biology Honors courses will demonstrate the ability to:

TECHNOLOGY EDUCATION, ENGINEERING AND DESIGN STANDARDS

Computer Science

- 8.1.12.CS.2: Model interactions between application software, system software, and hardware.
- 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.
- 8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.

Design Thinking

- 8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback.
- 8.2.12.ED.3: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis.
- 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience.

- 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics).
- 8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor).
- 8.2.12.ITH.1: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design constraints.
- 8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.
- 8.2.12.ITH.3: Analyze the impact that globalization, social media, and access to open source technologies has had on innovation and on a society's economy, politics, and culture.
- 8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product.
- 8.2.12.NT.2: Redesign an existing product to improve form or function.
- 8.2.12.ETW.1: Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation, and maintenance of a chosen product.
- 8.2.12.ETW.2: Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment.
- 8.2.12.ETW.3: Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.
- • 8.2.12.EC.1: Analyze controversial technological issues and determine the degree to which individuals, businesses, and governments have an ethical role in decisions that are made.
- 8.2.12.EC.2: Assess the positive and negative impacts of emerging technologies on developing countries and evaluate how individuals, non-profit organizations, and governments have responded.
- 8.2.12.EC.3: Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience.
- 8.2.12.ETW.4: Research 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.

9.1 – Financial Literacy

- 9.1.12.EG.3: Explain how individuals and businesses influence government policies.

9.2 – Career Awareness

- 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.

9.3 – Career & Technical Education (CTE) Content Area: 21st Century Life and Careers

- 9.3.12.AC-DES.1 Justify design solutions through the use of research documentation and analysis of data.

- 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
- 9.3.12.AC-DES.3 Describe the requirements of the integral systems that impact the design of buildings.
- 9.3.12.AC-DES.4 Apply building codes, laws and rules in the project design.
- 9.3.12.AC-DES.5 Identify the diversity of needs, values and social patterns in project design, including accessibility standards.
- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.12.AC-DES.7 Employ appropriate representational media to communicate concepts and project design.
- 9.3.12.AC-DES.8 Apply standards, applications and restrictions pertaining to the selection and use of construction materials, components and assemblies in the project design.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
- 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.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.2 Display and communicate STEM information.
- 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
- 9.3.ST-ET.6 Apply the knowledge learned in the study of STEM to provide solutions to human and societal problems in an ethical and legal manner.
- 9.3.ST-SM.1 Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
- 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.ST-SM.3 Analyze the impact that science and mathematics has on society.
- 9.3.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

Life Literacies and Key Skills

- 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
- 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).

INTERDISCIPLINARY MATH

- N-Q.A.1: "Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays."
- N-Q.A.2: "Define appropriate quantities for the purpose of descriptive modeling."
- HS.N-Q.A.1-3: Use units to understand and solve multi-step real-world problems, including choosing appropriate levels of accuracy.
- HS.G-MG.A.1-3: Apply geometric concepts in modeling situations (e.g., using measurement in design, physics, and engineering problems).
- HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

INTERDISCIPLINARY 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-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.
- HS-PS3-4: Investigate energy transfers (often involves temperature, force, and motion measurements).
- HS-ETS1-3: Evaluate solutions to a real-world problem using data, which often involves measurement.

INTERDISCIPLINARY LANGUAGE ARTS

- W.IW.9–10.2.E Establish and maintain a style and tone appropriate to the audience and purpose (e.g., formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.
- SL.PI.9–10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience.
- SL.UM.9–10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest.

ACP Grading Criteria
• Major Grades - 70% • Minor Grades - 30%

Course Resources
Core Text: ● **Digital LMS Provided by Project Lead the Way; www.pltw.org** **Technologies:** ● **Project Lead the Way Learning Management System** ● **CAD Software** ● **VEX Robotics Hardware and Programming Software** ● **Arduino Electronics and Programming Hardware and Software** ● **Vernier Graphical Analysis Software** ● **Google Sheets/Microsoft Excel** ● **3D Printer Slicing Software** **Supplemental Materials:** ● **Schoology Learning Management System**

Scope and Sequence- Topical Outline		
Unit	Title	Time
1	Mechanical Design	45 Days
2	Application of Robotics	45 Days
3	Energy in Action	45 Days
4	Designing Infrastructure and Developing Sustainability DEI Activity - Lending a Helping Hand	45 Days

The timeline is only an approximation. The inclusion of a classroom project in any one of the above units would extend the time allotment.

Subject Area: Engineering Level: Engineering (IED) CP	
Unit	**1**
Timeframe	45 Days
Established Goals	1. **Understand and Apply Mechanical Advantage** ○ Quantify the mechanical advantage (MA) of simple and compound machines. ○ Use MA to evaluate the efficiency of mechanical systems in solving real-world problems. 2. **Demonstrate Knowledge of Simple Machines** ○ Identify, describe, and analyze the six types of simple machines. ○ Investigate and calculate work, energy, and power in systems involving simple machines. ○ Apply knowledge of simple machines to maximize force and efficiency in design challenges (e.g., pulley systems, gear trains, robot pull challenge). 3. **Quantify and Analyze Energy, Work, and Power** ○ Define and calculate energy, work, and power using proper units and formulas. ○ Interpret how energy transformations occur in mechanical systems. ○ Evaluate system efficiency and use energy calculations to improve mechanical designs. 4. **Explore and Utilize Mechanisms** ○ Understand and demonstrate the four types of motion: linear, rotary, reciprocating, and oscillating. ○ Analyze how mechanical systems convert one type of motion into another. ○ Design and build mechanisms (e.g., latch mechanisms) to manipulate motion and solve design problems. 5. **Design and Build Functional Mechanical Systems** ○ Apply principles of simple machines and motion conversion to design a machine that performs a specific function. ○ Collaborate to develop complex, multi-step mechanical systems in a team-based motion conversion challenge. 6. **Solve Real-World Engineering Problems** ○ Identify a real-world agricultural problem and propose a mechanical solution. ○ Use the engineering design process to brainstorm, prototype, test, and refine a compound machine to solve the identified problem. ○ Communicate a proposed solution effectively through a formal presentation to a panel of

	"investors." 7. **Apply Project Management and Professional Skills** ○ Utilize teamwork, time management, and communication strategies during hands-on projects. ○ Conduct a professional interview to explore mechanical engineering or related careers. ○ Develop professional presentation and persuasive communication skills in project pitches.
NJSLS	**Technology Integration: Computer Science and Design Thinking** ● 8.1.12.CS.2: Model interactions between application software, system software, and hardware. ● 8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback. ● 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **21st Century Skills Integration: Career Readiness, Life Literacies, and Key Skills** ● 9.1.12.EG.3: Explain how individuals and businesses influence government policies. ● 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs. ● 9.3.12.AC-DES.1 Justify design solutions through the use of research documentation and analysis of data. ● 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues. ● 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field. ● 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production. ● 9.3.ST-ET.2 Display and communicate STEM information. ● 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM. ● 9.3.ST-ET.4 Apply the elements of the design process. ● 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems. ● 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects. ● 9.3.12.AC-DES.7 Employ appropriate representational media to communicate concepts and project design. ● 9.3.ST-SM.2 Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

	• 9.3.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data. • 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). • 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). • 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
Essential Questions	• How do engineers quantify the mechanical advantage of a system? • How do engineers apply their knowledge of simple machines to solve problems? • How do engineers quantify energy, work, and power? • How do engineers apply their knowledge of energy, work, and power to solve problems? • How are mechanisms used to convert one type of motion to another? • How do engineers manipulate motion to solve design problems? • How can you apply your understanding of machines and mechanisms to solve an authentic problem?
Content Knowledge	*Students will learn:* • Students will learn how to define and calculate mechanical advantage. • Students will learn how to identify and analyze simple and compound machines. • Students will learn how to calculate work, energy, and power in mechanical systems. • Students will learn how to evaluate the efficiency of mechanical systems. • Students will learn how to analyze the relationship between force, distance, and mechanical advantage. • Students will learn how to identify and differentiate the four types of motion. • Students will learn how to convert one type of motion to another using mechanical mechanisms.Students will learn how to design and build mechanisms that manipulate motion. • Students will learn how to use gears and gear ratios to affect speed and torque. • Students will learn how to design pulley systems to maximize mechanical advantage. • Students will learn how to apply Newton's laws to analyze forces in mechanical systems. • Students will learn how to collect and analyze data using force and acceleration sensors. • Students will learn how to solve design problems using knowledge of simple machines and motion. • Students will learn how to use the engineering design process to solve a real-world agricultural problem. • Students will learn how to collaborate on team-based engineering challenges. • Students will learn how to pitch engineering solutions in a formal presentation. • Students will learn how to conduct a professional interview in the field of engineering.

Skills	*Students will be able to:* • Students will be able to calculate mechanical advantage, work, energy, and power. • Students will be able to identify and analyze simple and compound machines. • Students will be able to evaluate the efficiency of mechanical systems. • Students will be able to design and build pulley systems and gear trains. • Students will be able to distinguish between and apply the four types of motion. • Students will be able to design mechanisms that convert one type of motion to another. • Students will be able to construct and test mechanical systems to solve real-world problems. • Students will be able to use force and acceleration sensors to gather and interpret data. • Students will be able to apply Newton's laws in analyzing mechanical systems. • Students will be able to work collaboratively in a team to complete engineering challenges. • Students will be able to follow the engineering design process from problem identification to solution. • Students will be able to develop, refine, and present a compound machine solution to an agricultural problem. • Students will be able to communicate engineering ideas effectively in written and oral formats. • Students will be able to manage time, roles, and responsibilities within a team project. • Students will be able to conduct a professional interview to explore engineering careers.
Benchmark Assessments	• Pre-test data collected in this unit, post assessment given during unit 2 is documented in the unit 2 "Benchmark Assessments" row.
Formative Assessments	• Observation of hands on projects • Over-easy engineering problem solving activity • What's simple about a combine worksheet • Mechanical system efficiency practice questions • Top Gear Design Activity Sketches • Top Gear MA calculations • Tug of War design process logbook setup • Agricultural solutions brainstorming
Summative Assessments	• Compound machine design (physical product) • Compound machine design (engineering logbook) • Door locking mechanism design and logbook • VEX rover final design • Tug of War engineering logbook • Fix Fran's Farm Agricultural Solution

Alternative Assessments	• Simple machine digital portfolio • Mechanism function video explanation • Peer-reviewed motion conversion sketch • Virtual pulley system simulation with analysis • Interactive quiz using a learning platform (e.g., Kahoot, Quizizz)
Instructional Materials (Core)	• Project Lead the Way LMS Student Units 1.1, 1.2, 1.3, 1.4. • PLTW Introduction to Engineering Learning Management System and Curriculum Unit 1.1, 1.2, 1.3, 1.4 (Teacher) • CAD Software (Fusion360/OnShape) • Fabrication equipment (3D Printers and Laser Cutter) • Fabrication materials (printer filament, foam core, cardboard, plywood) • Vernier Graphical Analysis Software • Measuring Tools (Calipers and Rulers) • VEX Robotics Structural Components and Electronics
Instructional Materials (Supplemental)	• Variety of instructional online videos on Mechanical Advantage • Video on how to break down large problems into small problems, related to engineering and the design process, for example.
Learning Activities	• Over-Easy Engineering problem-solving activity • What's Simple About a Combine worksheet • Top Gear Design Activity • Pulley system simulation and optimization • Gear train exploration and speed/torque analysis • VEX Rover build and testing • Door locking mechanism design and build • Motion conversion challenge (collaborative machine segments) • Tug of War design activity • Agricultural Solutions design problem • Compound machine design and prototype • Engineering logbook documentation activities • Peer critique of design sketches or prototypes

Interdisciplinary Connections	**<u>Cross curricular Activity</u>**<u>: Compound Mechanism Design</u> The interdisciplinary connection between **Unit 1: Mechanical Design** of *Principles of Engineering* and a **physics course** lies primarily in the application of core physics principles to real-world engineering problems. Key connections include: ● **Forces and Motion:** Concepts such as Newton's Laws, friction, acceleration, and net force are foundational to analyzing how mechanical systems function. ● **Work, Energy, and Power:** Calculating work done by machines, energy transformations, and power output directly aligns with physics topics. ● **Simple Machines:** Physics explores the mechanical advantage and efficiency of levers, pulleys, and inclined planes, which are applied in engineering design. ● **Kinematics and Dynamics:** Understanding linear and rotational motion supports the design and analysis of mechanisms and moving parts. ● **Systems of Forces and Equilibrium:** Balancing forces and moments in mechanisms relates to statics and dynamics content in physics. ● **Data Collection and Analysis:** Using tools like force sensors and motion detectors ties into experimental physics methods and lab practices. This unit effectively bridges theoretical physics with practical, hands-on engineering design. **INTERDISCIPLINARY MATH** ● N-Q.A.1: "Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays." ● HS.N-Q.A.1-3: Use units to understand and solve multi-step real-world problems, including choosing appropriate levels of accuracy. ● HS.G-MG.A.1-3: Apply geometric concepts in modeling situations (e.g., using measurement in design, physics, and engineering problems).

	• HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **INTERDISCIPLINARY 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-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. • HS-PS3-4: Investigate energy transfers (often involves temperature, force, and motion measurements). • HS-ETS1-3: Evaluate solutions to a real-world problem using data, which often involves measurement. **INTERDISCIPLINARY LANGUAGE ARTS** • W.IW.9–10.2.E Establish and maintain a style and tone appropriate to the audience and purpose (e.g., formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing. • SL.PI.9–10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. • SL.UM.9–10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest.

Subject Area: Engineering Level: Engineering (IED) CP	
Unit	**2**
Timeframe	45 Days

Established Goals	**Established Goals for Unit 2: Application of Robotics** 1. **Understand the Characteristics and Functions of Robots** ○ Define the essential components and characteristics of a robot. ○ Distinguish between robots and other mechanical or programmable devices. ○ Explore the history and future of robotics through research and prediction. 2. **Develop Effective Programming Practices** ○ Write clear, efficient, and organized code using industry-standard conventions. ○ Apply conditional logic and loops to control robotic behavior. ○ Debug, test, and refine code to ensure functionality. 3. **Integrate and Apply Sensors in Engineering Solutions** ○ Identify and use various sensors (e.g., bumper switch, limit switch, potentiometer, optical sensor, distance sensor). ○ Differentiate between open-loop and closed-loop systems. ○ Program robots to respond to sensor input to solve specific tasks. 4. **Explore and Apply Artificial Intelligence in Robotics** ○ Understand basic concepts of artificial intelligence and machine learning. ○ Train and implement supervised machine learning models in robotic systems. ○ Design and program AI-enabled robots to perform human-assistive tasks. 5. **Evaluate Ethical Implications of AI and Robotics** ○ Investigate ethical issues related to artificial intelligence and automation. ○ Analyze real-world scenarios and determine responsible courses of action. ○ Consider the societal impacts of AI in engineering solutions. 6. **Apply Mechanical and Programming Knowledge to Solve Complex Problems** ○ Use the engineering design process to develop robotics-based solutions. ○ Integrate mechanical components and programming to create functional robotic systems.

	○ Collaborate in teams to build and refine a robot capable of completing complex tasks. 7. **Design and Perform a Coordinated Robotic System** ○ Design and build a robotic musical instrument using principles of mechanical and electrical systems. ○ Program robots to perform in coordination with other systems to play music. ○ Research global instruments and apply cultural understanding in design. 8. **Strengthen Career Readiness and Technical Communication** ○ Continue exploring careers in robotics, AI, and engineering. ○ Practice communication, collaboration, and project management skills. ○ Present solutions and design decisions effectively to peers and stakeholders.
NJSLS	● 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change. ● 8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers. ● 8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback ● 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). ● 8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor). ● 8.2.12.EC.3: Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience. ● 9.1.12.EG.3: Explain how individuals and businesses influence government policies. ● 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs. ● 9.3.12.AC‐DES.1 Justify design solutions through the use of research documentation and analysis of data. ● 9.3.12.AC‐DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.

	• 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects. • 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data. • 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy. • 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.6 Demonstrate technical skills needed in a chosen STEM field. • 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production. • 9.3.ST-ET.2 Display and communicate STEM information. • 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM. • 9.3.ST-ET.4 Apply the elements of the design process. • 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems. • 9.3.ST-SM.1 Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities. • 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.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data. • 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). • 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). • 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
Essential Questions	• What characteristics define a robot? • What practices do programmers use to write effective code? • How do engineers use sensors to solve design problems? • What is artificial intelligence, and how do engineers use it to solve problems? • What are some of the ethical implications of artificial intelligence? • How can you apply your understanding of mechanics and programming to solve a design problem?

Content Knowledge	*Students will learn:* ● Students will learn the essential components and characteristics of a robot. ● Students will learn how to distinguish between robots and other mechanical or programmable devices. ● Students will learn the history and future of robotics through research and prediction. ● Students will learn to write clear, efficient, and organized code using industry-standard conventions. ● Students will learn to apply conditional logic and loops to control robotic behavior. ● Students will learn how to debug, test, and refine code to ensure functionality. ● Students will learn to identify and use various sensors (e.g., bumper switch, limit switch, potentiometer, optical sensor, distance sensor). ● Students will learn to differentiate between open-loop and closed-loop systems. ● Students will learn to program robots to respond to sensor input to solve specific tasks. ● Students will learn the basic concepts of artificial intelligence and machine learning. ● Students will learn to train and implement supervised machine learning models in robotic systems. ● Students will learn to design and program AI-enabled robots to perform human-assistive tasks. ● Students will learn to investigate ethical issues related to artificial intelligence and automation. ● Students will learn to analyze real-world scenarios and determine responsible courses of action. ● Students will learn to consider the societal impacts of AI in engineering solutions. ● Students will learn to use the engineering design process to develop robotics-based solutions. ● Students will learn to integrate mechanical components and programming to create functional robotic systems. ● Students will learn to collaborate in teams to build and refine a robot capable of completing complex tasks. ● Students will learn to design and build a robotic musical instrument using principles of mechanical and electrical systems. ● Students will learn to program robots to perform in coordination with other systems to play music. ● Students will learn to research global instruments and apply cultural understanding in design. ● Students will learn to explore careers in robotics, AI, and engineering. ● Students will learn to practice communication, collaboration, and project management skills. ● Students will learn to present solutions and design decisions effectively to peers and stakeholders.
Skills	*Students will be able to:* ● Students will be able to define the essential components and characteristics of a robot. ● Students will be able to distinguish between robots and other mechanical or programmable devices. ● Students will be able to research the history and predict the future of robotics. ● Students will be able to write clear, efficient, and organized code using industry-standard conventions.

	• Students will be able to apply conditional logic and loops to control robotic behavior. • Students will be able to debug, test, and refine code to ensure functionality. • Students will be able to identify and use various sensors (e.g., bumper switch, limit switch, potentiometer, optical sensor, distance sensor). • Students will be able to differentiate between open-loop and closed-loop systems. • Students will be able to program robots to respond to sensor input to solve specific tasks. • Students will be able to understand basic concepts of artificial intelligence and machine learning. • Students will be able to train and implement supervised machine learning models in robotic systems. • Students will be able to design and program AI-enabled robots to perform human-assistive tasks. • Students will be able to investigate ethical issues related to artificial intelligence and automation. • Students will be able to analyze real-world scenarios and determine responsible courses of action. • Students will be able to consider the societal impacts of AI in engineering solutions. • Students will be able to use the engineering design process to develop robotics-based solutions. • Students will be able to integrate mechanical components and programming to create functional robotic systems. • Students will be able to collaborate in teams to build and refine a robot capable of completing complex tasks. • Students will be able to design and build a robotic musical instrument using principles of mechanical and electrical systems. • Students will be able to program robots to perform in coordination with other systems to play music. • Students will be able to research global instruments and apply cultural understanding in design. • Students will be able to explore careers in robotics, AI, and engineering. • Students will be able to practice communication, collaboration, and project management skills. • Students will be able to present solutions and design decisions effectively to peers and stakeholders.
Benchmark Assessments	**This benchmark assessment is for the first two units:** • Multiple assessments throughout Quarter 1 and 2 to determine knowledge of mechanisms, mechanical advantage, power, force, programming and design and CAD skills. • At the end of Quarter 2, students will complete a project/assessment in which they utilize VEX robotics structural and electronics components, as well as consumable and recyclable materials to create a robot that plays music. This assessment will determine their abilities in problem solving, following the design process, sketching, drawing, CADing and 3D printing and creating mechanisms that can move and strike an object to create sound, determining appropriate force calculations and programming the musical robot to play a specific song.

Formative Assessments	● VEX Robotics Component Identification Quiz ● Robot vs. Mechanical Device Comparison Worksheet ● Code Debugging Challenge ● Conditional Logic and Loop Programming Exercise ● Sensor Integration Practical Lab ● Human-Assistive Robot Design Proposal ● Engineering Design Process Reflection Journal ● Robot Design and Programming Checkpoint ● Group Robotics Project Progress Presentation ● Robotic Musical Instrument Prototype Evaluation ● Collaborative Programming Task (Pair or Group Coding) ● Career Exploration in Robotics Reflection Paper ● Technical Communication and Project Management Peer Review ● Final Project Design and Presentation Feedback
Summative Assessments	● Robotics History and Future Research Presentation ● Robotic Rover Engineering Logbook ● Python programming test ● Ethics in artificial Intelligence Presentation ● Final Project - Robotic Instrument as indicated in benchmark assessment
Alternative Assessments	● Robotic System Design Challenge ● AI Integration Simulation ● Robotics Concept Blog ● Interactive Robotics Ethics Panel ● Robot Performance Showcase
Instructional Materials (Core)	● Project Lead the Way LMS Student Units 2.1, 2.2, 2.3, 2.4. ● PLTW Introduction to Engineering Learning Management System and Curriculum Unit 2.1, 2.2, 2.3, 2.4 (Teacher) ● CAD Software (Fusion360/OnShape) ● Fabrication equipment (3D Printers and Laser Cutter) ● Fabrication materials (printer filament, foam core, cardboard, plywood) ● Measuring Tools (Calipers and Rulers) ● VEX Robotics structural and electronics components ● VEX Robotics programming software

Instructional Materials (Supplemental)	• Variety of instructional online videos on Mechanical Advantage • VEX Robotics videos and instructional support pages. VEX Build Help
Learning Activities	• VEX Robotics Component Exploration • Robot vs. Mechanical Device Comparison • Code Debugging Workshop • Conditional Logic and Loop Coding Exercise • Sensor Integration Lab • Human-Assistive Robot Design • Engineering Design Process Reflection • Robot Design and Programming Checkpoint • Group Robotics Project Progress Presentation • Robotic Musical Instrument Prototype • Collaborative Coding Session • Career Exploration in Robotics • Technical Communication Workshop • Final Project Design Feedback • Robotics History and Future Research Presentation • Robotic Rover Engineering Logbook • Python Programming Test • Ethics in AI Presentation • Final Project - Robotic Instrument Presentation
Interdisciplinary Connections	**Cross curricular Activity**: Robotic Instrument The interdisciplinary connection between the summative benchmark assessment and activity, **Robotic Instrument,** lies in the application of core physics principles to real-world engineering problems. Key connections include: • **Forces and Motion:** Concepts such as Newton's Laws, friction, acceleration, and net force are foundational to analyzing how mechanical systems function. • **Work, Energy, and Power:** Calculating work done by machines, energy transformations, and power output directly aligns with physics topics.

	Simple Machines: Physics explores the mechanical advantage and efficiency of levers, pulleys, and inclined planes, which are applied in engineering design. **Kinematics and Dynamics:** Understanding linear and rotational motion supports the design and analysis of mechanisms and moving parts. **Systems of Forces and Equilibrium:** Balancing forces and moments in mechanisms relates to statics and dynamics content in physics. **Data Collection and Analysis:** Using tools like force sensors and motion detectors ties into experimental physics methods and lab practices. This unit effectively bridges theoretical physics with practical, hands-on engineering design. **INTERDISCIPLINARY MATH** - N-Q.A.1: "Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays." - HS.N-Q.A.1-3: Use units to understand and solve multi-step real-world problems, including choosing appropriate levels of accuracy. - HS.G-MG.A.1-3: Apply geometric concepts in modeling situations (e.g., using measurement in design, physics, and engineering problems). - HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **INTERDISCIPLINARY 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-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. - HS-PS3-4: Investigate energy transfers (often involves temperature, force, and motion measurements). - HS-ETS1-3: Evaluate solutions to a real-world problem using data, which often involves measurement.

	INTERDISCIPLINARY LANGUAGE ARTS ● W.IW.9–10.2.E Establish and maintain a style and tone appropriate to the audience and purpose (e.g., formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing. ● SL.PI.9–10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. ● SL.UM.9–10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest.

Subject Area: Engineering Level: Engineering (IED) CP	
Unit	**3**
Timeframe	45 Days
Established Goals	● Understand the principles and applications of electrical circuits. ● Apply mathematical concepts to model and analyze fluid power systems. ● Analyze and apply kinematic equations to real-world engineering problems. ● Integrate knowledge of circuits, fluid power, and motion to solve complex design challenges. ● Develop engineering problem-solving and critical thinking skills through hands-on activities.
NJSLS	● 8.1.12.CS.2: Model interactions between application software, system software, and hardware. ● 8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers. ● 8.2.12.ED.3: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis. •

	● 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. ● 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). ● 8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor). ● 8.2.12.ITH.1: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design constraints. ● 8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation. ● 8.2.12.ITH.3: Analyze the impact that globalization, social media, and access to open source technologies has had on innovation and on a society’s economy, politics, and culture. ● 8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product. ● 8.2.12.NT.2: Redesign an existing product to improve form or function. ● 8.2.12.ETW.1: Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation, and maintenance of a chosen product. ● 8.2.12.ETW.2: Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment. ● 8.2.12.ETW.3: Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution. ● • 8.2.12.EC.1: Analyze controversial technological issues and determine the degree to which individuals, businesses, and governments have an ethical role in decisions that are made. ● 8.2.12.EC.2: Assess the positive and negative impacts of emerging technologies on developing countries and evaluate how individuals, non-profit organizations, and governments have responded. ● 8.2.12.EC.3: Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience. ● 8.2.12.ETW.4: Research 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. ● 9.1.12.EG.3: Explain how individuals and businesses influence government policies.

	• 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs. • 9.3.12.AC-DES.1 Justify design solutions through the use of research documentation and analysis of data. • 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues. • 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data. • 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces. • 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy. • 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.6 Demonstrate technical skills needed in a chosen STEM field. • 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production. • 9.3.ST-ET.2 Display and communicate STEM information. • 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM. • 9.3.ST-ET.4 Apply the elements of the design process. • 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems. • 9.3.ST-ET.6 Apply the knowledge learned in the study of STEM to provide solutions to human and societal problems in an ethical and legal manner. • 9.3.ST-SM.1 Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities. • 9.3.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data. • 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). • 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). • 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
Essential Questions	• How can electrical circuits be modeled and applied in real-world systems? • What mathematical principles govern fluid power systems? • How does motion affect the design of mechanical systems? • How can multiple energy systems be integrated into a single solution?

	• What are the financial considerations when pursuing a postsecondary education in engineering?
Content Knowledge	*Students will learn:* • Students will learn the components and configurations of electrical circuits. • Students will learn to derive and apply Ohm's Law and Kirchhoff's Laws. • Students will learn the differences between series and parallel circuits. • Students will learn the properties and mathematical models of hydraulic and pneumatic systems. • Students will learn to derive and use equations for projectile motion. • Students will learn to collect and analyze experimental data. • Students will learn how to integrate circuits, fluid power, and motion in a system.
Skills	*Students will be able to:* • Students will be able to build and model electrical circuits using breadboards and simulations. • Students will be able to derive and apply Ohm's Law and Kirchhoff's Laws. • Students will be able to calculate pressure, force, and area in fluid power systems. • Students will be able to design and build a working hydraulic system. • Students will be able to measure gravitational acceleration and model projectile motion. • Students will be able to apply kinematic equations to real-world scenarios. • Students will be able to design and build a mechanical system that integrates multiple energy forms.
Benchmark Assessments	• This benchmark assessment begins by collecting pre-test data at the beginning of Unit 3, the post assessment is a final project. **Final Benchmark Project (Culminating Assessment for Units 3 & 4)** **Project Title: Future-Ready Community Redesign Project** **Overview:** Students act as engineering consultants tasked with redesigning a real community building or facility. Their solution must integrate electrical circuits, fluid power systems, structural elements, renewable energy, and transportation infrastructure, while considering environmental and accessibility standards. **Required Elements:**

	Automated Entrance System Includes an electrical circuit that powers LEDs or sound indicators when activated. Incorporates a fluid-powered door or lift system. Must be safe, efficient, and meet client needs. **Building Power Supply Redesign** Propose a renewable energy system (e.g., solar, hydro, wind). Use energy calculations to determine sufficiency of power generation. Provide life cycle and environmental trade-off analysis. **Structural Analysis** Select or design a structural component. Include force diagrams, material properties, and cost analysis. CAD model of the design using appropriate simulation tools. **Transportation Access Point** Redesign an intersection or access point. Include critical lane volume calculations and optimization strategies. Justify design based on traffic density and user accessibility (including ADA compliance). **Presentation & Communication** Students must present their full solution in a formal design review. Include visuals: CAD models, spreadsheets, energy diagrams, maps. Defend their engineering choices using math, science, and research-based evidence. **Assessment Criteria** Technical Accuracy (Math, Science, Engineering Principles) Innovation and Sustainability of Design Feasibility and Cost Analysis Teamwork and Collaboration Communication and Presentation Skills Documentation and Justification
Formative Assessments	● Ohm's Law Derivation Activity ● Breadboarding Practice Circuits ● Fluid Power Mathematics Problem Set ● Projectile Motion Calculation Practice

	• Simulation-Based Circuit Configuration Exercises • Kinematic Data Collection and Analysis Lab
Summative Assessments	• Final Safe Design (Lesson 3.1) • Working Hydraulic System Design (Lesson 3.2) • Zipline Design Challenge (Lesson 3.3) • Automated Golfer Unit 3 Capstone Project
Alternative Assessments	• Oral explanation of circuit design • Sketches and annotations of fluid power systems • Video documentation of design process and testing • Peer review and critique of project designs • Engineering journal reflections
Instructional Materials (Core)	• Project Lead the Way LMS Student Units 3.1, 3.2, 3.3 • PLTW Introduction to Engineering Learning Management System and Curriculum Unit 3.1, 3.2, 3.3 (Teacher) • CAD Software (Fusion360/OnShape) • Fabrication equipment (3D Printers and Laser Cutter) • Fabrication materials (printer filament, foam core, cardboard, plywood) • Measuring Tools (Calipers and Rulers) • VEX Robotics structural and electronics components • VEX Robotics programming software • Fabrication materials (printer filament, foam core, cardboard, plywood) • Measuring Tools (Calipers and Rulers)
Instructional Materials (Supplemental)	• Project Lead the Way Lead Teacher Brian Bobbit STEM Adventures YouTube Channel (CAD and 3D printing tutorials) • OnShape Learning Center CAD Tutorials
Learning Activities	• Hands-on breadboarding and circuit simulations • Ohm's and Kirchhoff's Laws derivation from collected data • Fluid power design and building activity • Experimental measurement of gravity • Zipline construction and projectile landing prediction

	● Integration of mechanical, electrical, and fluid systems in a golf challenge
Interdisciplinary Connections	**Cross curricular Activity**: Fluid Power Design and Building Activity In this lesson, students will engage in a hands-on engineering project in which they design, prototype, and test a fluid-powered robotic arm capable of picking up and moving a ping pong ball. Working in teams, students will apply the engineering design process to conceptualize their robotic arms, create 3D CAD models of their mechanisms and end effectors, and fabricate components using 3D printing and laser cutting. To power their designs, students will use syringes or fluid power pumps to simulate hydraulic actuation. They will calculate the mechanical advantage of their designs using principles of fluid mechanics and leverage this knowledge to optimize force transmission and movement. Throughout the project, students will maintain an engineering log to document their sketches, calculations, testing results, design iterations, and reflections. This project emphasizes real-world problem-solving, encourages collaboration, and integrates core concepts from physics, mathematics, and English Language Arts. Interdisciplinary Connections **Physics:** ● Understanding hydraulic pressure and force transmission using Pascal's Law ● Investigating the relationship between pressure, force, and area ● Exploring work, power, and mechanical advantage in simple machines ● Applying Newton's laws to predict and analyze motion of robotic arms **INTERDISCIPLINARY SCIENCE STANDARDS** ● 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. ● HS-PS3-4: Investigate energy transfers (often involves temperature, force, and motion measurements). ● HS-ETS1-3: Evaluate solutions to a real-world problem using data, which often involves measurement.

	Mathematics: ● Calculating mechanical advantage and pressure-area relationships ● Applying algebra and ratios to optimize fluid system performance ● Estimating force requirements and actuator sizes ● Using geometric reasoning and measurement in CAD modeling **INTERDISCIPLINARY MATH STANDARDS** ● N-Q.A.1: "Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays." ● HS.N-Q.A.1-3: Use units to understand and solve multi-step real-world problems, including choosing appropriate levels of accuracy. ● HS.G-MG.A.1-3: Apply geometric concepts in modeling situations (e.g., using measurement in design, physics, and engineering problems). ● HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **English Language Arts (ELA):** ● Maintaining an organized and technical engineering logbook ● Writing detailed design justifications and procedural documentation ● Presenting project findings through a formal presentation or demonstration ● Using technical vocabulary and clear explanations in both written and oral communication **INTERDISCIPLINARY LANGUAGE ARTS STANDARDS** ● W.IW.9–10.2.E Establish and maintain a style and tone appropriate to the audience and purpose (e.g., formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing. ● SL.PI.9–10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. ● SL.UM.9–10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest.

Subject Area: Engineering Level: Engineering (IED) CP	
Unit	**4**
Timeframe	45 Days
Established Goals	● Understand static systems and apply structural analysis methods. ● Analyze and evaluate renewable energy sources for sustainability. ● Use mathematical models and data to optimize transportation systems. ● Design infrastructure solutions that integrate sustainability and structural integrity. ● Apply project management, teamwork, and communication skills in engineering contexts. ● Explore future career impacts related to artificial intelligence.
NJSLS	● 8.1.12.CS.2: Model interactions between application software, system software, and hardware. ● 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change. ● 8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers. ● 8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback. ● 8.2.12.ED.3: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis. ● 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. ● 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). ● 8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor). ● 8.2.12.ITH.1: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design constraints. ● 8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.

	• 8.2.12.ITH.3: Analyze the impact that globalization, social media, and access to open source technologies has had on innovation and on a society's economy, politics, and culture. • 8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product. • 8.2.12.NT.2: Redesign an existing product to improve form or function. • 8.2.12.ETW.1: Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation, and maintenance of a chosen product. • 8.2.12.ETW.2: Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment. • 8.2.12.ETW.3: Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution. • • 8.2.12.EC.1: Analyze controversial technological issues and determine the degree to which individuals, businesses, and governments have an ethical role in decisions that are made. • 8.2.12.EC.2: Assess the positive and negative impacts of emerging technologies on developing countries and evaluate how individuals, non-profit organizations, and governments have responded. • 8.2.12.EC.3: Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience. • 8.2.12.ETW.4: Research 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. • 9.1.12.EG.3: Explain how individuals and businesses influence government policies. • 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs. • 9.3.12.AC-DES.1 Justify design solutions through the use of research documentation and analysis of data. • 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues. • 9.3.12.AC-DES.3 Describe the requirements of the integral systems that impact the design of buildings. • 9.3.12.AC-DES.4 Apply building codes, laws and rules in the project design. • 9.3.12.AC-DES.5 Identify the diversity of needs, values and social patterns in project design, including accessibility standards. • 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.

	• 9.3.12.AC-DES.7 Employ appropriate representational media to communicate concepts and project design. • 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production. • 9.3.ST-ET.2 Display and communicate STEM information. • 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM. • 9.3.ST-ET.4 Apply the elements of the design process. • 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems. • 9.3.ST-ET.6 Apply the knowledge learned in the study of STEM to provide solutions to human and societal problems in an ethical and legal manner. • 9.3.ST-SM.1 Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities. • 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.ST-SM.3 Analyze the impact that science and mathematics has on society. • 9.3.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data. • 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). • 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). • 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
Essential Questions	• How do structural systems support loads and remain stable? • What role do renewable energy sources play in sustainable design? • How can mathematics improve transportation systems? • How do engineers make design decisions that balance cost, efficiency, and environmental impact? • In what ways will artificial intelligence shape the future of engineering careers?
Content Knowledge	*Students will learn:*

	• Students will learn how to create and analyze free body diagrams and force vectors. • Students will learn how to calculate moments, internal forces, and stresses. • Students will learn the principles of renewable and nonrenewable energy sources. • Students will learn how to perform life cycle analyses and evaluate environmental trade-offs. • Students will learn to calculate traffic density, flow rate, and critical lane volume. • Students will learn to model and optimize intersections and road designs. • Students will learn how to integrate multiple engineering disciplines into a single project.
Skills	*Students will be able to:* • Students will be able to design and test static structures using mathematical analysis. • Students will be able to use CAD software to model and evaluate structures. • Students will be able to research and evaluate the sustainability of energy sources. • Students will be able to design and test a hydroelectric device. • Students will be able to collect and analyze transportation data using spreadsheets. • Students will be able to redesign intersections using mathematical modeling tools. • Students will be able to work collaboratively to develop and present infrastructure redesign proposals.
Benchmark Assessments	• This benchmark assessment begins by collecting pre-test data at the beginning of Unit 3, the post assessment is a final project. **Final Benchmark Project (Culminating Assessment for Units 3 & 4)** **Project Title: Future-Ready Community Redesign Project** **Overview:** Students act as engineering consultants tasked with redesigning a real community building or facility. Their solution must integrate electrical circuits, fluid power systems, structural elements, renewable energy, and transportation infrastructure, while considering environmental and accessibility standards. **Required Elements:** **Automated Entrance System** Includes an electrical circuit that powers LEDs or sound indicators when activated. Incorporates a fluid-powered door or lift system. Must be safe, efficient, and meet client needs. **Building Power Supply Redesign** Propose a renewable energy system (e.g., solar, hydro, wind).

	Use energy calculations to determine sufficiency of power generation. Provide life cycle and environmental trade-off analysis. **Structural Analysis** Select or design a structural component. Include force diagrams, material properties, and cost analysis. CAD model of the design using appropriate simulation tools. **Transportation Access Point** Redesign an intersection or access point. Include critical lane volume calculations and optimization strategies. Justify design based on traffic density and user accessibility (including ADA compliance). **Presentation & Communication** Students must present their full solution in a formal design review. Include visuals: CAD models, spreadsheets, energy diagrams, maps. Defend their engineering choices using math, science, and research-based evidence. **Assessment Criteria** **Technical Accuracy (Math, Science, Engineering Principles)** **Innovation and Sustainability of Design** **Feasibility and Cost Analysis** **Teamwork and Collaboration** **Communication and Presentation Skills** **Documentation and Justification**
Formative Assessments	• Cantilever Beam Lab Report • Free Body Diagram Practice Problems • Renewable Energy Debate Preparation Sheet • Traffic Flow Spreadsheet Activity • Intersection Design Peer Review • CAD Beam Deflection Simulation • Bridge Truss Cost Optimization Worksheet
Summative Assessments	• Statics and Structural Analysis Quiz • Renewable Energy Device Design Report • Transportation System Design Presentation • Unit 4 Infrastructure Redesign Project Submission

Alternative Assessments	• Reflective Journal on Sustainability Practices • Video Presentation of Intersection Redesign • Portfolio of Engineering Sketches and Calculations • AI Career Impact Infographic • Self-Assessment Rubric on Team Collaboration and Communication
Instructional Materials (Core)	• Project Lead the Way LMS Student Units 4.1, 4.2, 4.3, 4.4 • PLTW Introduction to Engineering Learning Management System and Curriculum Unit 4.1, 4.2, 4.3, 4.4 (Teacher) • CAD Software (Fusion360/OnShape) • Fabrication equipment (3D Printers and Laser Cutter) • Fabrication materials (printer filament, foam core, cardboard, plywood) • Measuring Tools (Calipers and Rulers) • Fabrication materials (printer filament, foam core, cardboard, plywood) • Measuring Tools (Calipers and Rulers)
Instructional Materials (Supplemental)	• OnShape Learning Center CAD Tutorials • Video tutorials on beam deflection in OnShape • PLTW Formula Sheet • YouTube Engineering is Everywhere • National Society of Professional Engineers (NSPE) Career Exploration
Learning Activities	• Build and test a cantilever beam structure • Model beam deflection in CAD software • Conduct stress-strain lab with material testing • Design and test a hydroelectric generator • Analyze intersection data with traffic models • Redesign a building for sustainable energy integration • Conduct life cycle analysis on selected materials • Collaborate on a capstone infrastructure redesign project
Interdisciplinary Connections	In the **Transportation System Design Presentation**, students work collaboratively to analyze and redesign a transportation system to meet specific client needs, including accessibility for individuals with different abilities. Using collected traffic data, mathematical models, and engineering design principles, students propose improvements to traffic flow, capacity, and safety at a chosen intersection or roadway. The final product is a professional presentation that includes

	design rationale, mathematical calculations, proposed layout revisions, and visual aids such as maps or traffic simulations. **Presentation components include:** ● Traffic flow analysis using collected and modeled data. ● Mathematical justification for changes in speed limits, lane configurations, or traffic control devices. ● CAD drawings or hand-drawn diagrams of the improved intersection or roadway. ● Evaluation of the environmental and social impact of the redesign. ● Consideration of accessibility for users with physical or cognitive disabilities. ● Oral and visual communication of findings in a professional engineering context. **Interdisciplinary Connections:** **Mathematics:** ● Application of **statistics** to analyze traffic volume and flow rate data. ● Use of **algebraic models** to calculate speed, density, and capacity. ● **Optimization techniques** to determine the most efficient lane configurations. ● Use of **spreadsheets** and **formulas** to evaluate traffic metrics and propose improvements. **Science:** ● Application of **Newtonian mechanics** in understanding vehicle motion and safe stopping distances. ● **Environmental science** concepts to assess pollution impact and benefits of traffic efficiency. ● Exploration of **systems thinking** as it relates to interconnected transportation, environmental, and social systems. **ELA (English Language Arts):** ● **Technical writing** for the formal engineering report and presentation script. ● **Research and synthesis** of transportation guidelines, accessibility standards, and client needs.

	● **Oral communication and presentation skills** for effectively delivering the proposal to a simulated audience of stakeholders. ● Use of **visual rhetoric** (charts, diagrams, CAD drawings) to enhance clarity and persuasion.

Diversity, Equity and Inclusion (DEI) Activity	**Lend a Helping Hand** **Head, Shoulders, Knees, and Toes Design Activity Summary** In this design activity, students will develop a solution to assist individuals with disabilities in driving or using a vehicle. The activity simulates how physical limitations can impact the ability to perform basic tasks required for safe driving, such as walking to the car, using pedals, turning the steering wheel, and checking mirrors. Students are introduced to three clients with unique transportation needs: ● Jill: Needs a vehicle to accommodate the special needs of her twins. Client #1- Non-verbal girls with a rare DNA mutation: a condition with breathing support, feeding tube and wheelchairs for mobility and posture support. ● Susmitha: Needs to drive without her right arm. Client#2 - Indian American woman, army medic who is a left arm amputee. ● Siera: Needs to drive using only her upper body. ● Client #3 - Woman who was crushed by a hay bale while working on the Penn State Horse Farm, has limited movement and sensation from the belly button down. Students will follow the Design Process to create a solution for one of these clients. Key steps include: ● Research: Investigating existing solutions and technologies that may assist the client. ● Brainstorming Solutions: Generating ideas and narrowing down the best option using a Decision Matrix. ● Concept Sketching: Communicating ideas visually to refine the design. ● Collaboration and Feedback: Working with a partner and sharing concept sketches with another group for constructive feedback. ● Iterating the Design: Revising the design based on feedback and finalizing the solution with technical drawings or CAD models. Deliverables: Depending on the design, deliverables may include CAD models or physical prototypes. Students will also reflect on how solving real-world challenges for clients with disabilities changes their perspective on engineering and empathy. The final task includes researching organizations that pair engineers with communities to solve problems and identifying opportunities that align with their interests.

Additional Information

21st Century Skills Integration: Career Readiness, Life Literacies, and Key Skills	• 9.1.12.EG.3: Explain how individuals and businesses influence government policies. • 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs. • 9.3.12.AC-DES.1 Justify design solutions through the use of research documentation and analysis of data. • 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues. • 9.3.12.AC-DES.3 Describe the requirements of the integral systems that impact the design of buildings. • 9.3.12.AC-DES.4 Apply building codes, laws and rules in the project design. • 9.3.12.AC-DES.5 Identify the diversity of needs, values and social patterns in project design, including accessibility standards. • 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects. • 9.3.12.AC-DES.7 Employ appropriate representational media to communicate concepts and project design. • 9.3.12.AC-DES.8 Apply standards, applications and restrictions pertaining to the selection and use of construction materials, components and assemblies in the project design. • 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance. • 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data. • 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces. • 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy. • 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.6 Demonstrate technical skills needed in a chosen STEM field.

	9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production. 9.3.ST-ET.2 Display and communicate STEM information. 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM. 9.3.ST-ET.4 Apply the elements of the design process. 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems. 9.3.ST-ET.6 Apply the knowledge learned in the study of STEM to provide solutions to human and societal problems in an ethical and legal manner. 9.3.ST-SM.1 Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities. 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.ST-SM.3 Analyze the impact that science and mathematics has on society. 9.3.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data. 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
Use of Technology	- Students in the classroom are one-to-one with Windows PCs, Google Suite Productivity Software, a variety of CAD software packages, 3D printers, CNC laser engraver/cutters - All students are one-to-one with Chromebooks for day-to-day use in the classroom and at home, CAD software can be used online and are compatible with Chromebooks. - All classrooms have access to an interactive BenQ or Promethean Board with speaker system so lessons can include video, sound, and interactive lessons for all learners
Technology Integration: Computer Science & Design Thinking	8.1.12.CS.2: Model interactions between application software, system software, and hardware. 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change. 8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers. 8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback. •

	● 8.2.12.ED.3: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis. • ● 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. ● 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). ● 8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor). ● 8.2.12.ITH.1: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design constraints. ● 8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation. ● 8.2.12.ITH.3: Analyze the impact that globalization, social media, and access to open source technologies has had on innovation and on a society's economy, politics, and culture. ● 8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product. ● 8.2.12.NT.2: Redesign an existing product to improve form or function. ● 8.2.12.ETW.1: Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation, and maintenance of a chosen product. ● 8.2.12.ETW.2: Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment. ● 8.2.12.ETW.3: Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution. ● • 8.2.12.EC.1: Analyze controversial technological issues and determine the degree to which individuals, businesses, and governments have an ethical role in decisions that are made. ● 8.2.12.EC.2: Assess the positive and negative impacts of emerging technologies on developing countries and evaluate how individuals, non-profit organizations, and governments have responded.

	• 8.2.12.EC.3: Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience. • 8.2.12.ETW.4: Research 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.
Career Education with Diversity, Equity and Inclusion	• Career Clusters Interest Survey • Engineer • Inventor • Amputee Engineer • Mary G. Ross: The first Native American female engineer, Ross worked at Lockheed Missiles and Space Company, contributing to projects such as the Agena rocket and concepts for missions to Venus and Mars. • Alice H. Parker: An African American inventor, Parker patented a central heating system using natural gas in 1919, revolutionizing home heating. • Dr. Temple Grandin (Autistic Engineer): Background: Dr. Temple Grandin is a world-renowned animal behavior expert and a professor of animal science at Colorado State University. Diagnosed with autism at a young age, she has revolutionized the livestock industry with her designs for humane livestock handling facilities. Grandin has also been an advocate for neurodiversity and has written several books on autism, sharing her experience as an engineer with a different neurological perspective. • Hugh Herr (Amputee Engineer): Background: Hugh Herr is an engineer and biomechatronics expert, currently the director of the Biomechatronics Group at the MIT Media Lab. He is a double amputee, having lost both of his legs below the knee in a climbing accident. Herr has since dedicated his life to developing prosthetic limbs that allow individuals with limb loss to walk, run, and climb again.
Special Ed Accommodations and Modifications	• Accommodations will be dictated by the general makeup of the class. • Special Education modifications will be implemented as per the Individualized Education Programs of the students in the class. • Please click here for an overview of the variety of accommodations set in place. **Class Specific Modifications and Accommodations** • Multi-modal visual aides • Chunking and scaffolded assignments • Checklists/simplified instructions and rubrics • Providing model examples • Modification of CAD interface

	● Alternative input devices for PC use ● Alternative/differentiated assessments ● Reduced workload/shortening of long term projects ● Clearly defined group roles for group projects ● Simplification of complex/technical vocabulary terminology ● CAD instead of hand drawing/use of graph paper and pre-labeled drawings.
504 Accommodations and Modifications	● Special Education modifications will be implemented as per the Individualized Education Programs of the students in the class. ● Please [click here]() for an overview of the variety of accommodations set in place. ● Accommodations will be dictated by the general makeup of the class. **Class Specific Modifications and Accommodations** ● Multi-modal visual aides ● Chunking and scaffolded assignments ● Checklists/simplified instructions and rubrics ● Providing model examples ● Modification of CAD interface ● Alternative input devices for PC use ● Alternative/differentiated assessments ● Reduced workload/shortening of long term projects ● Clearly defined group roles for group projects ● Simplification of complex/technical vocabulary terminology ● CAD instead of hand drawing/use of graph paper and pre-labeled drawings. ● modeling ● Text to Speech (to listen to text) ● Speech to text (speak to type) ● Reduce Unnecessary stimuli ● Preferential Seating ● Adjust development environment to cater to student needs (text highlighting, suggestion text, etc…) POSSIBLE CONTENT ADJUSTMENTS - based on pre-assessment and benchmark assessment data ● Extended time ● Modification of complexity of design projects ● Chunking of assignments ● Alternative drawing methods for CAD or access to pre-drawn templates ● Borrowing of measurement tools for practice at home
Multilingual Learners (MLL)	● Coordinate activities with ESL teacher to accommodate individual learning needs ● Provide appropriate leveled texts ● Students complete the ACCESS 2.0 t

Accommodations and Modifications	• Utilizing AI and translation software to modify assignments.
Gate Accommodations and Modifications	• Inclusive Identification process that depicts the child as a whole in order to provide the best learning environment possible for each student. Click here for Identification Profile Sample • Tiered Services utilizing NAGC K-12 Programming standards to ensure individual needs are being met. Click here for services map. • Formative Assessment utilized in order to promote acceleration, curriculum compacting, grouping, and asynchronous learning where appropriate. • Dynamic Model for Gifted Program Improvement is utilized in order to verify that our program is employing not only up to date methods, but also effective ones. • Teacher training in Gifted Education. • Compacting curriculum based on pre assessments and skill reviews **Content Specific Changes can Include:** • Increasing the difficulty of individual projects. • Students generating additional drawings. • Students utilizing more advance constraint and measuring techniques in CAD software • Having students redesign 3D printed parts to reduce mass. • Reduction in complexity of math problems
At Risk for School Failure	• Credit Retrieval Programs • Apex - virtual • Viking Success Academy • Counseling interventions • Parent meetings • Student meetings • Individual and Group counseling
MTSS/RTI Alignment	The VTSD Response to Intervention and MTSS Manual and the NJTSS Early Reading Screening Guidelines outline the policies and procedures that 'exist to ensure a coordinated system for planning, delivering, measurement, and modification of intervention and referral services implemented in each school by a multidisciplinary team to address the learning, behavioral, and health needs of all students. (N.J.A.C. 6A:16-8)' This requirement is fulfilled through the district New Jersey Tiered System of Support (NJTSS) Early Reading grant initiative and our Multi-Tiered Systems of Support (MTSS) Response to Intervention plan which includes a. A continuum of supports and interventions available in each school to support learning, behavior, and health needs; b. Action plans for interventions based on student data and desired outcomes; c. Professional development for multidisciplinary teams and staff who provide interventions; and d. Review and assessment of effectiveness of interventions (e.g., progress monitoring).