Middle Township High School

Principles of Engineering

Curriculum

Middle Township Public Schools

216 S. Main Street

Cape May Court House, NJ 08210

Born on and approved August 2023

Principles of Engineering

Course Description

Principles of Engineering (POE) is a foundation course of the high school engineering pathway. This survey course exposes students to some of the major concepts that they will encounter in a postsecondary engineering course of study. Through problems that engage and challenge, students explore a broad range of engineering topics, including mechanisms, the strength of materials and structures, automation, and kinematics. The course applies and concurrently develops secondary level knowledge and skills in mathematics, science, and technology. Students have the opportunity to develop skills and understanding of course concepts through activity-, project-, and problem-based (APB) learning. By solving rigorous and relevant design problems using engineering and science concepts within a collaborative learning environment, APB learning challenges students to continually hone their interpersonal skills, creative abilities, and problem solving skills. Students will also learn how to document their work and communicate their solutions to their peers and members of the professional community. It also allows students to develop strategies to enable and direct their own learning, which is the ultimate goal of education.

Pacing Guide

Unit Titles	Time Frame
Unit One - Energy and Power	**September - November**
Unit Two - Materials and Structures	**December - February**
Unit Three - Control Systems	**February - May**
Unit Four - Statistics and Kinematics	**May - June**

Course Resources and Materials

- www.pltw.org
- PLTW Engineering Notebook
- Chromebook
- 3D Printer & Materials
- Vernier Sensors
- Graphical Analysis 4 application
- Tinkercad
- VEX IQ IED Kit
- VEX V5 system
- VEXcode V5 software
- ROBOTC software
- Miscellaneous materials

Unit 1 – Energy and Power

Timeframe: September - November

Unit 1 Overview

The goal of Unit 1 is to introduce students to mechanisms, energy sources, and alternative energy applications. Students will gain an understanding of mechanisms through the application of theory-based calculations accompanied by lab experimentation. They will also learn that as energy and power are transferred and transformed, losses to friction in the system will occur. Students will understand that such losses affect the overall efficiency of the system. They will have an opportunity to investigate thermal energy and alternative energy applications. Students will explore and gain experiences relating to solar hydrogen systems and thermal energy transfer through materials. The unit concludes with students working in teams to solve a design problem that focuses on energy and power. They will use the knowledge and understanding built through the previous learning events to create a solution to the problem. It is important for students to understand that an acceptable solution is one that fits the criteria and constraints of the design brief.

Essential Questions

- What are some strategies that can be used to make everyday mechanisms more efficient?
- What is a situation in which an engineer would want to include a mechanism with a mechanical advantage greater than one? What is the advantage in this case?
- How could designing a solution to a mechanical problem without regard to efficiency be problematic?
- How is a specific energy production source considered to be “clean” and in what ways may it not be so “clean”?
- How might innovation of current technology involved with energy production provide energy more efficiently?
- What is one possible way that “lost” energy of a specific energy production source might be collected in your home or school and transformed for a usable purpose?
- What are the advantages and disadvantages of wiring a house with either series or parallel circuits?
- In what innovative ways could the efficiency of electricity production using solar cells be maximized throughout the day?
- What advancements in technology and infrastructure need to take place to make the usage of hydrogen fuel cells more common?
- What are some materials in your home that prevent energy transfer from inside your home to the outside environment? Which of the three forms of energy transfer are they attempting to limit?
- How does a design team come to know what problem to solve?

Essential Learning Outcomes

- Students will construct and test simple machines using VEX® components and other available lab equipment such as Vernier® Go Direct® Force and Acceleration Sensor

and GA4.

- Students will explain mechanisms through the application of theory-based calculations accompanied by lab experimentation.
- Students will demonstrate solving equations relating to simple machines, specifically the lever, wheel and axle, and pulley.
- Students will learn how energy and power are converted and how inefficiencies occur in the system.
- Students will virtually construct circuits and obtain measurements for different properties related to the circuits.
- Students will measure loss in a system that converts electrical into mechanical motion to lift a weight.
- Students will learn how energy and power are converted and how inefficiencies occur in the system.
- Students will determine the voltage and current production resulting from the use of solar cell and fuel cell systems.
- Students will calculate the wattage produced by both energy sources and use the calculated wattage to determine electrical energy production effectiveness related to mechanical transportation.
- Students will design, construct, and test a renewable insulation material to achieve high thermal resistance properties and values.
- Students will investigate thermal energy and alternative energy applications.
- Students will design and create a simulated renewable electrical energy generation and distribution system.
- Students will investigate circuit wiring to use generated voltages and energy transmission to consumers.
- Students will investigate LEDs to determine operating conditions, such as voltage and resistance values.

8.2 Design Thinking Standards Addressed

- 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.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.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.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.ETW.3: Identify a complex, global environmental or climate change issue, develop a systematic 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.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.

Assessments (Diagnostic, Formative, Summative, Benchmark, Alternative)

- PLTW Activities
- Projects
- Performance Tasks
- Entrance & Exit Tickets
- Self-Assessments
- Multimedia Presentations
- Lesson Quizzes
- Topic Assessments
- Benchmark Assessments
- End of Course Assessments

Integration of Career Readiness, Life Literacies, and Key Skills

- 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
- 9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement, and transition.
- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.
- 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
- 9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections

- *NJSLS ELA Companion Standards*
    - RST.9-10.2. Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
    - RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

- WHST.9-10.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- WHST.9-10.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

➢ *NJSLS Mathematics Standards*

- HSN.RN.A.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents.
- HSN.VM.A.1 Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).
- HSN.VM.A.2 Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.
- HSN.VM.A.3 Solve problems involving velocity and other quantities that can be represented by vectors.
- HSN.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.
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
- HSA.SSE.A.1.A Interpret parts of an expression, such as terms, factors, and coefficients.
- HSA.SSE.A.1.B Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret $P(1+r)^n$ as the product of P and a factor not depending on P.
- HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.
- HSA.CED.A.3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.
- HSA.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.
- HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
- HSA.REI.B.4 Solve quadratic equations in one variable.

- HSF.LE.A.1.B Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.
- HSF.TF.B.7 Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.
- HSG.SRT.C.6 Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.
- HSG.SRT.C.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.
- HSG.GMD.A.3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.
- HSG.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.
- HSG.MG.A.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
- HSG.MG.A.2 Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
- HSG.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).
- HSS.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).
- HSS.ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
- HSS.ID.A.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

➢ *NJSLS Science Standards*

- 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-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
- HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.
- HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
- HS-ETS1-1 Analyze a major global challenge to specify qualitative and

quantitative criteria and constraints for solutions that account for societal needs and wants.
    - HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
    - HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
    - HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Unit 2 - Material and Structures

Timeframe: December - February

Unit 2 Overview

The goal of Unit 2 is for students to have a more concrete understanding of engineering through materials properties and statics. Students begin by learning about beam deflection and then forces on truss structures. They learn to identify forces acting on those structures and then gain the ability to calculate internal and external forces acting on those structures. The students learn about material properties, which lead students to the ability to properly select a material for a given task. Creating new products to meet a given need or want is not the only concern in this area of study. How to reuse/recycle materials for continued and unique uses is also learned. The primary way of studying materials properties in this unit is through destructive and non-destructive material testing on various materials. Tensile testing is the major destructive test. Students are engaged in how machines perform these tests and use either a classroom machine or a simulation to further their understanding of these processes. This unit concludes with a design problem whereby students, working in teams, follow the design process to solve a design problem.

Essential Questions

- ➢ Why is it crucial for designers and engineers to construct accurate free body diagrams of the parts and structures that they design?
- ➢ Why must designers and engineers calculate forces acting on bodies and structures?
- ➢ When solving truss forces, why is it important to know that the structure is statically determinate?
- ➢ How does an engineer predict the performance and safety for a selected material?
- ➢ What are the advantages and disadvantages of utilizing synthetic materials designed by engineers?
- ➢ How can an existing product be changed to incorporate different processes to make it less expensive and provide better performance?
- ➢ How does an engineer decide which manufacturing process to use for a given material?

- Why is it critical for engineers to document all calculation steps when solving problems?
- How is material testing data useful?
- Stress-strain curve data points are useful in determining what specific material properties?
- What is a design brief? What are design constraints?
- Why is a design process so important to follow when creating a solution to a problem?
- What is a decision matrix and why is it used?

Essential Learning Outcomes

- Students will learn how to identify and calculate forces acting on a body when it is in static equilibrium.
- Students will calculate internal and external forces of a truss.
- Students will investigate the basic categories and properties of materials.
- Students will discover how products are made and how they are recycled once they are no longer useful.
- Students will perform simple material tests and calculations on product components to gain a better understanding of why engineers select specific materials for different applications.
- Students will recreate the product components using 3D modeling software.
- Students will create a computer-generated illustration outlining the product component and its material properties.
- Students will create product development life cycles for the selected products.
- Students will investigate the two major categories of material testing, known as destructive testing and nondestructive testing.
- Students will solve a materials design problem by developing a solution that fits the constraints and specifications of the design brief.

8.2 Design Thinking Standards Addressed

- 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.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.ETW.1: Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation, and maintenance of a chosen product.

Assessments (Diagnostic, Formative, Summative, Benchmark, Alternative)

- PLTW Activities
- Projects
- Performance Tasks
- Entrance & Exit Tickets
- Self-Assessments
- Multimedia Presentations
- Lesson Quizzes
- Topic Assessments
- Benchmark Assessments
- End of Course Assessments

Integration of Career Readiness, Life Literacies, and Key Skills

- 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
- 9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement, and transition.
- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.
- 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
- 9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections

- *NJSLS ELA Companion Standards*
  - RST.9-10.1. Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
  - RST.9-10.2. Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
  - RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

- RST.9-10.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
- RST.9-10.10. By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.
- WHST.9-10.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- WHST.9-10.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- WHST.9-10.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- WHST.9-10.9. Draw evidence from informational texts to support analysis, reflection, and research.
- WHST.9-10.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

➢ *NJSLS Mathematics Standards*

- HSN.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.
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
- HSA.SSE.A.1.A Interpret parts of an expression, such as terms, factors, and coefficients.
- HSA.SSE.A.1.B Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret $P(1+r)^n$ as the product of P and a factor not depending on P.

- HSG.GMD.A.3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.
- HSG.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.
- HSG.MG.A.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
- HSG.MG.A.2 Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).

➢ *NJSLS Science Standards*

- HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
- HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
- HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Unit 3 – Control Systems

Timeframe: February - May

Unit 3 Overview

The goal of Unit 3 is for students to recognize the abundance of and infinite variety of computer use in our daily lives. Students learn to control mechanical systems by recognizing computer outputs and gaining an understanding of how to write code to control them. They additionally experiment with various input devices and learn how they can adapt computer code to control computer outputs. Furthermore students gain an understanding of fluid power, both hydraulic and pneumatic. They begin to recognize the power and control advantages of fluid power. The unit concludes with students working in teams to solve a design problem that focuses on using control systems. They will integrate their prior knowledge, skills, and understandings from Unit 1: Simple Machines, Unit 2: Material Properties, and this unit. Students will decide what input devices to use, how to code their

use, and the various output devices necessary to create a solution to the problem.

Essential Questions

- What are the advantages and disadvantages of using programmable logic to control machines versus monitoring and adjusting processes manually?
- What are some everyday, seemingly simple devices that contain microprocessors, and what function do the devices serve?
- What questions must designers ask when solving problems to decide between digital or analog systems and between open or closed loop systems?
- What impact does fluid power have on our everyday lives?
- What are similarities and differences of mechanical advantage in simple machines and hydraulic systems?
- Why are Pascal's Law, the perfect gas laws, Bernoulli's Principle, and other similar rules important to engineers and designers of fluid power systems?

Essential Learning Outcomes

- Students will learn how to control mechanical processes using computer software and hardware.
- Students will build a testbed with the exception of installing the Servo Motor, Ultrasonic Sensor, and Light Sensor.
- Students will develop their own programs and use a programming technique to efficiently test code by temporarily commenting out a line that may be used again later.
- Students will explore both pneumatic and hydraulic power by learning the basic components of each system and how they are designed to manipulate work and power.
- Students will observe and explain how fluid power devices work.
- Students will solve a design problem that focuses on control systems.

8.1 Computer Science Standards Addressed

- 8.1.12.AP.1: Design algorithms to solve computational problems using a combination of original and existing algorithms.

8.2 Design Thinking Standards Addressed

- 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.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.

Assessments (Diagnostic, Formative, Summative, Benchmark, Alternative)

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Integration of Career Readiness, Life Literacies, and Key Skills

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- 9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections

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  - RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
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  - WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
  - WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
  - WHST.9-10.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
- *NJSLS Mathematics Standards*
  - HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive

modeling.

- *NJSLS Science Standards*
  - 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-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
  - HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
  - HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Unit 4 – Statistics and Kinematics

Timeframe: May - June

Unit 4 Overview

In Unit 4, students are engaged in learning to use statistics to evaluate an experiment. Later they begin a study of dynamics, specifically kinematics, and apply statistical skills to study freefall motion. Students use theoretical and experimental data as a basis for learning statistical analysis. By collecting, organizing, and interpreting the data, students build the skills needed to understand data results. They further use these new skills and knowledge to design a vehicle that will propel itself. Later, students will address the problem of designing a machine to accurately launch an object a specified distance. Examining projectile motion is at the core of this design problem.

Essential Questions

- Why is it crucial for designers and engineers to use statistics throughout the design process?
- Why is process control a necessary statistical process for ensuring product success?
- Why is theory-based data interpretation valuable in decision making?
- Why is experiment-based data interpretation valuable in decision making?
- What are the relationships between distance, displacement, speed, velocity, and acceleration?
- Why is it important to understand and be able to control the motion of a projectile?

Essential Learning Outcomes

- Students will learn the processes of gathering, organizing, interpreting, and formulating an understanding of data.
- Students will interpret data they collect, create a graphical data representation, and explain the data trend.
- Students will create a vehicle to learn important aspects of motion and freefall.
- Students will investigate kinematics concepts involved in projectile motion.

- Students will explore the concepts of distance, displacement, speed, velocity, and acceleration.
- Students will improve upon an existing design by designing their own tests and deciding what data to gather to improve their devices.

8.1 Computer Science Standards Addressed

- 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 Design Thinking Standards Addressed

- 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.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.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.2: Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment.
- 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.

Assessments (Diagnostic, Formative, Summative, Benchmark, Alternative)

- PLTW Activities
- Projects
- Performance Tasks
- Entrance & Exit Tickets
- Self-Assessments
- Multimedia Presentations
- Lesson Quizzes
- Topic Assessments
- Benchmark Assessments
- End of Course Assessments

Integration of Career Readiness, Life Literacies, and Key Skills

- 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
- 9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement, and transition.
- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.

- 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions
- 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
- 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
- 9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections

- *NJSLS ELA Companion Standards*
  - RST.9-10.2. Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
  - RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
  - WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
  - WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
  - WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
  - WHST.9-10.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
  - WHST.9-10.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
  - WHST.9-10.9. Draw evidence from informational texts to support analysis, reflection, and research.
  - WHST.9-10.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
- *NJSLS Mathematics Standards*
  - HSN.RN.A.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents.
  - HSN.VM.A.1 Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use

appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).

- HSN.VM.A.2 Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.
- HSN.VM.A.3 Solve problems involving velocity and other quantities that can be represented by vectors.
- HSN.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.
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
- HSA.SSE.A.1.A Interpret parts of an expression, such as terms, factors, and coefficients.
- HSA.SSE.A.1.B Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret $P(1+r)^n$ as the product of P and a factor not depending on P.
- HSA.CED.A.3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.
- HSA.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.
- HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
- HSA.REI.B.4 Solve quadratic equations in one variable.
- HSF.TF.B.7 Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.
- HSG.SRT.C.6 Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.
- HSG.SRT.C.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.
- HSG.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).
- HSS.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).
- HSS.ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard

deviation) of two or more different data sets.
    - HSS.ID.A.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
    - HSS.MD.B.7 Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).
- *NJSLS Science Standards*
    - 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-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
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Integrated Accommodations and Modifications

- **Special Education Students**
    - Ongoing Interventions, strategic Interventions and Intensive Interventions that are teacher and/or technologically driven within the curriculum and targeted to standards in need of support.
    - Provide graphic organizers for additional support or encourage students to create digital multimedia to showcase knowledge.
    - Extended time for revisions or opportunity to identify and develop areas of personal interest
- **English Language Learners**
    - Bilingual language glossary for literacy and vocabulary prior to and during each lesson.
    - English Language Learner support embedded into each lesson for use during the instructional part of the lesson (rephrasing, models, photos,etc.)
    - Targeted support strategies that focus on key areas of language development: listening, speaking, reading, and writing for students at different proficiency levels.
    - Technology supported assignments aligned with standards in students' native language.
- **Skills Fragile Students**
    - Teacher led reteach to build understanding which encompass guided reteaching activities for teachers to utilize when students need a better understanding of lesson topics.
    - Readiness assessment individualized study plan generated based on a students' score on the topic readiness assessment. Allows students to gain additional support in standards that should have been mastered in a previous grade.
    - Adaptive practice and homework utilizing recommended resources
    - Encourage students to make transformations - use a common task or item in a different way
    - Provide graphic organizers for additional support or encourage students to create digital multimedia to showcase knowledge.

- Extended time for revisions or opportunity to identify and develop areas of personal interest

➢ **504 Students**

- Video tutorials for each lesson with units for students to access as needed.
- Literacy and vocabulary activities that provide scaffolded support for students to build vocabulary
- Encourage creative expression and thinking by allowing students to choose how to approach a problem or assignment.
- Provide graphic organizers for additional support or encourage students to create digital multimedia to showcase knowledge.
- Extended time for revisions or opportunity to identify and develop areas of personal interest

➢ **Gifted & Talented Students**

- Enrichment activities for teachers to utilize when learners are advanced within the given standard/topic.
- Encourage students to explore concepts in depth and encourage independent studies or investigations.
- Modeling or independent student led research