Principles of Engineering

Grades 10-12

Unit 1

Subject	**Grade**	**Unit**	**Suggested Timeline**
Principles of Engineering	10-12	1 – Energy and Power	10 weeks

Grade Level Summary

We live in a powered world. Both simple and complex mechanisms are used to make our work easier. Understanding how power is distributed and why mechanisms decrease the amount of energy required to do work allows us to improve existing mechanical systems and create new ones. In this unit students will learn the theory behind mechanical advantage, energy distribution, and heat flow. Students will also complete activities in which they will see the theory at work, and will solve problems associated with work, energy, and thermodynamics.

Grade Level Units

Unit 1 – Energy and Power
Unit 2 – Materials and Structures
Unit 3 – Control Systems
Unit 4 – Statistics and Kinematics

Unit Title

Energy and Power

Unit Overview

Throughout the first unit, students will complete a research project outside of class. They will research a discipline of engineering and complete a presentation for the class. Students will begin the unit by investigating the six simple machines and how each of them can be used to create a mechanical advantage. Simple machines will be combined to create complex machines where students will predict theoretical mechanical advantage, and will then measure the actual mechanical advantage for comparison and analysis. Energy will be explored including various energy sources, distribution systems, and relationships between current, voltage, resistance and work. Students will also investigate the efficiency of mechanical systems including the electrical motors powering them. Focus will then shift to the effects of work and heat transfer within systems. Finally the unit concludes with a project in which students will design, model, and construct their own scaled power distribution system.

Unit Essential Questions

1-1. Why is it important to begin considering career paths during high school?
1-2. What career opportunities are available to match your specific interests?
1-3. What are some current applications of simple machines, gears, pulleys, and sprockets?
1-4. What are some strategies that can be used to make everyday mechanisms more efficient?
1-5. What are the trade-offs of mechanical advantage related to design?
1-6. Why must efficiency be calculated and understood during the design process?
2-1. What sources of energy are available for use? What are the benefits and drawbacks regarding efficiency, usefulness, and the environment?
2-2. What emerging technologies are or may be on the horizon that will provide energy more efficiently.
2-3. What are the different energy sources that are used to deliver energy to your community?
2-4. What are some examples in your community of individuals or businesses harnessing their own energy?
2-5. Where and how is the electricity that reaches your home produced?

Key Understandings

1-1. Engineers and engineering technologists apply math, science, and discipline specific skills to solve problems.
1-2. Engineers and engineering technologists apply math, science, and discipline specific skills to solve problems.
1-3. Technical communication can be accomplished in oral, written, and visual forms and must be organized in a clear and concise manner.
1-4. Most mechanisms are composed of gears, sprockets, pulley systems, and simple machines.
1-5. Mechanisms are used to redirect energy within a system by manipulating force, speed, and distance.
1-6. Mechanical advantage ratios mathematically evaluate input work versus output work of mechanisms.
2-1. Energy source classifications include nonrenewable, renewable, and inexhaustible.
2-2. Energy source processes include harnessing, storing, transporting, and converting.
2-3. Energy often needs to be converted from one form to another to meet the needs of a given system.
2-4. An understanding of work, energy, and power is required to determine system efficiency.

2-6. What efficient uses of energy and power can you identify at home, school, or work? 2-7. What is the relationship between resistance, current, and voltage within an electrical system? 2-8. What are the distinguishing characteristics between series and parallel circuits? 2-9. How do you calculate the efficiency of an electrical mechanical system? 3-1. What limitations affect electricity production using solar cells? 3-2. What limitations affect electricity production using hydrogen fuel cells? 3-3. How can system configuration affect voltage and current? 3-4. How does thermodynamics relate to energy and power? 3-5. What are some everyday examples of the First and Second Laws of Thermodynamics? 4-1. What is a design brief and what are design constraints? 4-2. Why is a design process so important to follow when creating a solution to a problem? 4-3. What is a decision matrix and why is it used? 4-4. What does consensus mean, and how do teams use consensus to make decisions?	2-5. An understanding of the basics of electricity requires the understanding of the three fundamental concepts of voltage, current, and resistance. 2-6. The atomic structure of a material determines whether it is a conductor, an insulator, or a semiconductor. 3-1. Energy management is focused on efficient and accessible energy use. 3-2. System energy requirements must be understood in order to select the proper energy source. 3-3. Energy systems can include multiple energy sources that can be combined to convert energy into useful forms. 3-4. Hydrogen fuel cells created electricity and heat through an electrochemical process that converts hydrogen and oxygen into water. 3-5. Solar cells convert light energy into electricity by using photons to create electron flow. 3-6. Thermodynamics is the study of the effects of work, thermal energy, and energy on a system. 3-7. Thermal energy can transfer via convection, conduction, or radiation. 3-8. Material conductivity, resistance, and energy transfer can be calculated. 4-1. Design problems can be solved by individuals or teams. 4-2. Engineers use a design process to create solutions to existing problems. 4-3. Design briefs are used to identify the problem specifications and to establish project constraints. 4-4. Teamwork requires constant communication to achieve the desired goal. 4-5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

Focus Standards Addressed in the Unit	
3.4.10.C1	Apply the components of the technological design process.
CC.2.1.HS.F.4	Use units as a way to understand problems and to guide the solution of multi-step problems.
CC.2.1.HS.F.5	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CC.2.2.HS.C.5	Construct and compare linear, quadratic, and exponential models to solve problems.
3.2.P.B4	Develop qualitative and quantitative understanding of current, voltage, resistance, and the connections among them.
3.4.12.E3	Compare and contrast energy and power systems as they relate to pollution, renewable and non-renewable resources, and conservation.
3.2.P.B3	Analyze the factors that influence convection, conduction, and radiation between objects or regions that are at different temperatures.
3.4.10.E3	Compare and contrast the major forms of energy: thermal, radiant, electrical, mechanical, chemical, nuclear and others.
CC.1.4.9-10.W	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.

CC.1.5.9-10.D	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning; ensure that the presentation is appropriate to purpose, audience, and task.
CC.1.3.11-12.J	Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Important Standards Addressed in the Unit	
CC.2.2.HS.D.1	Interpret the structure of expressions to represent a quantity in terms of its context.
CC.2.2.HS.D.7	Create and graph equations or inequalities to describe numbers or relationships.
CC.2.2.HS.D.10	Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically.
CC.2.1.HS.F.3	Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.
CC.2.3.HS.A.14	Apply geometric concepts to model and solve real world problems.
CC.1.5.9-10.G	Demonstrate command of the conventions of standard English when speaking based on Grades 9–10 level and content.

Misconceptions	**Proper Conceptions**
1. Engineering is a profession in which only math and science skills are important.	1. While strong math and science skills are important for success in the engineering profession, an ability to communicate coherently and correctly is equally important. Through their engineering research project, students will discover all of the skills required to practice engineering.
2. I know what I'm doing; I don't need to show my work.	2. Documenting your work is an important part of engineering so that you can: reference your work for error analysis and correction, allow others to follow and duplicate or modify your work, and provide a detailed historical reference of your solution process. You may know what you are doing, but you have to assume that the person reviewing your work does not.
3. Machines with a mechanical advantage of less than 1 are of no use.	3. Machines with a mechanical advantage of less than one are often used. Simple examples include a broom and a fishing rod where an increased rotational speed is gained at the expense of a reduced mechanical advantage. Each problem will define the type of mechanism needed to solve it.
4. The characteristics of an electrical load vary with the power transmitted through it.	4. The magnitude of an electrical load's resistance to the flow of electricity is constant. The current flowing through a given load directly varies with the voltage drop across that load.
5. Heat energy freely flows either way between hot and cold. That's why it suddenly feels so cold when I open the door in the winter or so hot when I open the oven door.	5. Heat energy naturally flows from hot to cold. Only if external work is done on a system will heat flow from cold to hot.

Concepts	**Competencies**	**Vocabulary**	
• Mechanisms • Energy • Thermodynamics	• Describe ways that mechanisms transmit input forces to magnified output forces	ABET Actual Mechanical Advantage Belt	Active Solar Energy Collection Alternative Energy

	• Model how various forms of energy are harnessed and used to do work • Apply the laws of thermodynamics to predict how a system is affected by changes in the surrounding environment	Career Chain Effort Force Efficiency Friction Fulcrum Gear Ideal Mechanical Advantage Idler Gear Inclined Plane Lever Mechanism Moment Pitch Pulley Resistance Force Screw Simple Machine Sprocket Static Equilibrium Technical Communication Torque Wedge Wheel and Axle Alternative Energy Ampere Biomass Current Electrical Energy Electricity Electromagnetic Induction Efficiency Energy Energy Conversion Environmental Protection Agency Fossil Fuel Generator Geothermal Energy Gravitational Energy Induction Inexhaustible Energy Kinetic Energy Nonrenewable Energy Ohm Ohm’s Law Parallel Circuit Potential Energy Power Converter Power Grid Renewable Energy Resistance Work Turbine Power	Ampere Conduction Convection Current Electrical Energy Electricity Electromagnetic Energy Electrolysis Energy Entropy First Law of Thermodynamics Fuel Cell Stack Heat Kelvin Line of Best Fit Ohm Ohm’s Law Passive Solar Energy Collection Product Development Lifecycle Radiation Renewable Energy Resistance R-value Second Law of Thermodynamics Temperature Thermal Equilibrium Thermodynamic System Thermodynamics U-value Volt Voltage Zeroth Law of Thermodynamics Accuracy Assembly Brainstorming Component Consensus Constraint Decision Matrix Design Brief Design Modification Design Process Design Statement Designer Open-Ended Pictorial Sketch Problem Statement Purpose Sketch Solid Modeling Target Consumer Team

		Rotor Series Circuit Volt Voltage	

Assessments

Design Challenges – Students will be given a problem through a design brief for which they will develop a solution in teams within one class period.

Homework – Occasional homework assignments will be given to reinforce classroom concepts. Homework will be graded for completeness (including level of documentation of work) and will be used to formatively assess if additional instruction is needed.

Engineering Notebook Checks – Students will maintain a formal engineering notebook to document their work throughout the course. Periodic checks will assess proper notebook format and content. Certain projects will be completely contained within the engineering notebook and will be assessed according to the rubric provided for that project.

Vocabulary Quizzes – Understanding and using technical language is an important component of this course. Students will be expected to acquire and use new terms. Periodic quizzes within each unit will assess their ability to identify new vocabulary.

Oral Presentations – Students will report project solutions via oral presentations to the class. Content and presentation style will be assessed according to a standard rubric for each project.

Unit Tests / Unit Projects – Each unit will include a summative written test or project. Projects may be assessed through a presentation, engineering notebook review, electronic submission, or a combination of one or more of these. Rubrics and design briefs will be provided with each project to clearly communicate the content and performance expectations for that project.

Suggested Strategies to Support Design of Coherent Instruction

Charlotte Danielson's Framework for Teaching: Domain 3 Instruction

Lesson 1.1 - Mechanisms

Throughout the discussion of mechanisms, continuously stress the everyday experiences students have with simple machines. With a thorough observation of their personal experiences, students will have a better appreciation of how simple machines can be applied to solve problems.

Lesson 1.2 – Energy Sources

The major topics in this lesson are electrical circuits and motor power. No matter how complex an electrical circuit may be, the voltage drop across any load is always the product of the current through the load and the resistance of the load. Continuously refer back to this relationship as the foundation and starting point for the analysis of all circuits. Likewise, no matter what work is being done by a motor, its efficiency is a ratio of the output power to the input power. No matter what happens between the input and output, remind students that it is these two values that define a motor's efficiency.

Lesson 1.3 – Energy Applications

The overarching theme in this lesson is that energy is neither gained nor destroyed; energy is transferred from one form to another. Students should enter each new problem with this in mind and should constantly consider how energy is being transferred or transformed at each step. Introduce the concept with examples that occur within students' lives on a daily basis.

Differentiation:

- Provide graphic organizers
- Provide multiple concrete examples
- Break extended projects into smaller identifiable milestones with checkpoints along the way
- Pair stronger students with struggling students for peer assistance

Interdisciplinary Connections:

- Design process – Scientific method
- Research process – English / Social Studies
- Writing skills – English

- Sketching - Art

Additional Resources:

- ***http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF.pdf*** International Society for Technology in Education standards.
- ***https://www.asme.org/*** American Society of Mechanical Engineers – additional resources specific to the practice of mechanical engineering
- ***http://www.asce.org/*** American Society of Civil Engineers – additional resources specific to the practice of civil engineering
- ***http://www.ieee.org/*** Institute of Electrical and Electronics Engineers – additional resources specific to the practice of electrical engineering
- ***https://www.aiche.org/*** American Institute of Chemical Engineers – additional resources specific to the practice of chemical engineering

Created By:
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Principles of Engineering
Grades 10-12
Unit 2

Subject	**Grade**	**Unit**	**Suggested Timeline**
Principles of Engineering	10-12	2 – Materials and Structures	8 weeks

Grade Level Summary
Structures – both natural and manmade – constantly surround us. Both the form of those structures and the materials from which they are made define those structures' performance. Students will explore how applied forces are distributed through structures and how structural members react to those forces. Additionally, material properties will studied to find how different materials respond to the same loads and how the increased use of recycled materials affects our choice of structural materials.

Grade Level Units
Unit 1 – Energy and Power
Unit 2 – Materials and Structures
Unit 3 – Control Systems
Unit 4 – Statistics and Kinematics

Unit Title
Materials and Structures

Unit Overview
Unit 2 begins with a study of the geometry of structural members. Students will calculate the geometric properties that allow us to find how a structural member will respond to a specific force or combinations of forces. After studying individual structural members, the focus will broaden to the analysis of pin connected truss systems. Students will calculate the components of force vectors, the distribution of forces through trusses, and support reactions. To finish the study of trusses, students will individually design their own truss, predict how an applied load will cause their truss to fail, and load the trusses to failure to verify or adjust their predictions. A study of materials begins with categorizing materials based on their properties and a study of how recycling affects material innovation. The exploration of materials then moves to calculating how materials react to applied loads. Students will learn how the relationship between stress and strain changes with increased stress for a given material. The models we create for this relationship will then allow students to predict how material samples will fail before actually destructively testing those samples while comparing actual material properties to published properties. Unit 2 will culminate with a project in which students will model a structure designed to resist a certain applied load using the static analysis and material property tools learned throughout the unit.

Unit Essential Questions	**Key Understandings**
1-1. Why is it crucial for designers and engineers to construct accurate free body diagrams of the elements and structures they design? 1-2. Why must designers and engineers calculate forces acting on bodies and structures? 1-3. When solving truss forces, why is it important to know that the structure is statically determinate?	1-1. Laws of motion describe the interaction of forces acting on a body. 1-2. Structural member properties including centroid location, moment of inertia, and modulus of elasticity are important considerations for structure design. 1-3. Static equilibrium occurs when the sum of all forces acting on a body are equal to zero. 1-4. Applied forces are vector quantities with a defined magnitude, direction, and sense, and can be broken into vector components. 1-5. Forces acting at a distance from an axis or point attempt to make -- or cause -- an object to rotate. 1-6. In a statically determinate truss, translational and rotational equilibrium equations can be used to calculate external and internal forces. 1-7. Free body diagrams are used to illustrate and calculate forces acting upon a given body
2-1. How does an engineer predict the performance and safety for a selected material? 2-2. What are the advantages and disadvantages of utilizing	2-1. Materials are the substances of which all things are made. 2-2. Materials are composed of elements and are categorized

synthetic material designed by engineers? 2-3. What ethical issues pertain to engineers designing synthetic materials? 2-4. What did you learn about the significance of selecting materials for product design? 2-5. How can an existing product be changed to incorporate different processes to make it less expensive and provide better performance? 2-6. How does an engineer decide which manufacturing process to use for a given material? 2-7. How do the recycling codes and symbols differ from state to state?	by physical and chemical properties. 2-3. Materials consist of pure elements, compounds, and mixtures and are typically classified as metallic, ceramic, organic, polymeric, and composite. 2-4. Material properties including recyclability and cost are important considerations for engineers when choosing appropriate materials for a design. 2-5. Material selection is based upon mechanical, thermal, electromagnetic, and chemical properties. 2-6. Raw materials undergo various manufacturing processes in the production of consumer goods.
3-1. Why is it critical for engineers to document all calculation steps when solving problems? 3-2. How is material testing data useful? 3-3. Stress strain curve data points are useful in determining what specific material properties?	3-1. Engineers utilize a design process and mathematical formulas to solve and document design problems. 3-2. Material testing aids in determining a product's reliability, safety, and predictability in function. 3-3. Engineers perform destructive and non-destructive tests on material specimens for the purpose of identifying and verifying the properties of various materials. 3-4. Material testing provides a reproducible evaluation of material properties. 3-5. Tensile testing data is used to create a test sample stress strain curve.
4-1. What is a design brief and what are design constraints? 4-2. Why is a design process so important to follow when creating a solution to a problem? 4-3. What is a decision matrix and why is it used? 4-4. What does consensus mean, and how do teams use consensus to make decisions? 4-5. How do the properties and types of materials affect the solution to a design problem?	4-1. Design problems can be solved by individuals or teams. 4-2. Engineers use a design process to create solutions to existing problems. 4-3. Design briefs are used to identify the problem specifications and to establish project constraints. 4-4. Teamwork requires constant communication to achieve the desired goal. 4-5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

Focus Standards Addressed in the Unit	
3.4.10.C1	Apply the components of the technological design process.
3.4.12.C2	Apply the concept that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
CC.2.3.HS.A.13	Analyze relationships between two-dimensional and three-dimensional objects.
CC.2.3.HS.A.14	Apply geometric concepts to model and solve real world problems.
CC.2.1.HS.F.4	Use units as a way to understand problems and to guide the solution of multi-step problems.
CC.2.1.HS.F.5	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CC.1.3.11-12.J	Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.
CC.1.4.9-10.W	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.

CC.1.5.9-10.D	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning; ensure that the presentation is appropriate to purpose, audience, and task.

Important Standards Addressed in the Unit	
3.4.10.B.4	Recognize that technological development has been evolutionary, the result of a series of refinements to a basic invention.
CC.2.3.HS.A.12	Explain volume formulas and use them to solve problems.
CC.2.2.HS.D.1	Interpret the structure of expressions to represent a quantity in terms of its context.
CC.2.1.HS.F.3	Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.
CC.2.3.HS.A.14	Apply geometric concepts to model and solve real world problems.
CC.1.2.11-12.A	Determine and analyze the relationship between two or more central ideas of a text, including the development and interaction of the central ideas; provide an objective summary of the text.
CC.1.2.11–12.B	Cite strong and thorough textual evidence to support analysis of what the text says explicitly, as well as inferences and conclusions based on and related to an author's implicit and explicit assumptions and beliefs.
CC.1.2.11–12.G	Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
CC.1.4.11–12.A	Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately.
CC.1.4.11–12.B	Write with a sharp, distinct focus identifying topic, task, and audience.
CC.1.4.11–12.F	Demonstrate a grade-appropriate command of the conventions of standard English grammar, usage, capitalization, punctuation, and spelling.
CC.1.4.11–12.S	Draw evidence from literary or informational texts to support analysis, reflection, and research, applying grade-level reading standards for literature and literary nonfiction.
CC.1.4.11–12.V	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.
CC.1.4.11–12.X	Write routinely over extended time frames (time for research, 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.
CC.1.5.9-10.G	Demonstrate command of the conventions of standard English when speaking based on Grades 9–10 level and content.

Misconceptions	**Proper Conceptions**
1. Structures will react to loads differently depending on the material used for construction.	1. When we perform a static analysis, the loads are distributed through the structure based on geometry; the distribution is not material dependent. Individual member stresses are also distributed based
2. Recycling is mainly about keeping plastic bottles out of landfills.	2. Recycling is a major part of manufacturing and covers many materials. Much of the wasted material produced by manufacturing processes is captured and returned to be reused in the process. A significant percentage of structural steel is made using recycled material. Recycling is much more than putting your household bin at the curb every week.
3. When an object fails under loading, it immediately	3. Most materials will go through several

goes from "good" to "bad".	transformations as the stress in them increases. While visible failure is often sudden, the relationship between stress and strain will actually have distinct and predictable points of change when graphed as stress increases.
4. Points of failure are always predictable in a truss.	4. While we can always predict where the highest theoretical stresses will occur in truss members, we cannot always predict variables such as material defects and quality of construction. Variables such as these are the reason that safety factors are included in the design of most products.

Concepts	**Competencies**	**Vocabulary**	
• Statics • Material properties • Material testing	• Distribute applied loads through trusses and calculate beam deflections • Describe various manufacturing processes and the materials used in them • Calculate material properties based on geometry and applied failure loads	Cable Centroid Compression Force Concurrent Force Systems Cross-Sectional Area Direction Fixed Support Flange Free Body Diagram Gusset Joint Magnitude Member Method of Joints Moment Moment of Inertia Newton's First Law Newton's Second Law Newton's Third Law Pinned Support Planar Truss Resultant Force Roller Support Scalar Sense Simple Truss Static Equilibrium Statically Indeterminate Structure Tension Force Vector Quantity Additive Process Ceramic Codes Composite Decision Matrix Finishing Forming Liability Manufacturing Material Mechanical Properties Metals Physical Properties Polymers Product Life Cycle	Axial Stress Breaking Stress Compression Deformation Destructive Testing Elastic Limit Elongation Factor of Safety Failure Point Fatigue Hooke's Law Modulus of Elasticity Nondestructive Testing Problem Solving Proportional Limit Quality Control Reliability Resilience Rupture Strength Shear Stress Standard Deviation Statistics Strain Stress Stress-Strain Curve Tension Toughness Ultimate Stress Variance Accuracy Assembly Brainstorming Component Consensus Constraint Decision Matrix Design Brief Design Modification Design Process Design Statement Designer Open-Ended Pictorial Sketch Problem Statement Purpose Sketch Solid Modeling

		Raw Material Recycling Subtractive Process Synthetic	Target Consumer Team

Assessments

Design Challenges – Students will be given a problem through a design brief for which they will develop a solution in teams within one class period.

Homework – Occasional homework assignments will be given to reinforce classroom concepts. Homework will be graded for completeness (including level of documentation of work) and will be used to formatively assess if additional instruction is needed.

Engineering Notebook Checks – Students will maintain a formal engineering notebook to document their work throughout the course. Periodic checks will assess proper notebook format and content. Certain projects will be completely contained within the engineering notebook and will be assessed according to the rubric provided for that project.

Vocabulary Quizzes – Understanding and using technical language is an important component of this course. Students will be expected to acquire and use new terms. Periodic quizzes within each unit will assess their ability to identify new vocabulary.

Oral Presentations – Students will report project solutions via oral presentations to the class. Content and presentation style will be assessed according to a standard rubric for each project.

Unit Tests / Unit Projects – Each unit will include a summative written test or project. Projects may be assessed through a presentation, engineering notebook review, electronic submission, or a combination of one or more of these. Rubrics and design briefs will be provided with each project to clearly communicate the content and performance expectations for that project.

Suggested Strategies to Support Design of Coherent Instruction

Charlotte Danielson's Framework for Teaching: Domain 3 Instruction

Lesson 2.1 - Statics

Vectors will be a new – or at least lightly explored -- concept for most students. All students however, will have been introduced to right triangles on at least some level. For this reason, share two methods of breaking down vectors into their components: first using trigonometric ratios, and next as ratios of side lengths of right triangles. In this way students who have already worked with trigonometric ratios in geometry will have two familiar tools to help them with vectors. Students who have not yet taken geometry will also have two tools to use with vector components, but at least one of the underlying concepts will be familiar to them.

Lesson 2.2 – Material Properties

The focus of this lesson is to become familiar with different material manufacturing processes. Use this lesson as an overarching theme for all of the lessons in the unit to encourage students to always consider how products are made or how they might be made differently. Practical examples of manufacturing processes abound on YouTube and the websites of industry organizations.

Lesson 2.3 – Material Testing

Begin with a strict linear relationship between stress and strain so that students can grasp the difference between these two separate but closely related measurements. Remind that stress is purely a function of geometry while strain is material dependent. Once this concept has been mastered, demonstrate some stress – strain graphs for actual samples so that students can visualize the non-linear range of the relationship. Seeing this in action before performing theoretical calculations will help with understanding.

Differentiation:

- Provide graphic organizers
- Provide multiple concrete examples
- Break extended projects into smaller identifiable milestones with checkpoints along the way
- Pair stronger students with struggling students for peer assistance

Interdisciplinary Connections:

- Design process – Scientific method
- Research process – English / Social Studies
- Writing skills – English
- Sketching - Art

Additional Resources:

- ***http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF.pdf*** International Society for Technology in Education standards.
- ***https://www.asme.org/*** American Society of Mechanical Engineers – additional resources specific to the practice of mechanical engineering
- ***http://www.asce.org/*** American Society of Civil Engineers – additional resources specific to the practice of civil engineering
- ***http://www.ieee.org/*** Institute of Electrical and Electronics Engineers – additional resources specific to the practice of electrical engineering
- ***https://www.aiche.org/*** American Institute of Chemical Engineers – additional resources specific to the practice of chemical engineering

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Principles of Engineering

Grades 10-12

Unit 3

Subject	Grade	Unit	Suggested Timeline
Principles of Engineering	10-12	3 – Control Systems	9 weeks

Grade Level Summary

Control systems are used to automate processes and provide direction based on input or environmental factors. Both household devices -- from thermostats to microwave ovens, and industrial devices -- from hoists to programmable CNC machines, incorporate electrical and mechanical systems that regulate their function. In this unit students will use programmable electrical controls as well as pneumatic and hydraulic pressure controls to perform functions that solve various problems.

Grade Level Units

Unit 1 – Energy and Power
Unit 2 – Materials and Structures
Unit 3 – Control Systems
Unit 4 – Statistics and Kinematics

Unit Title

Control Systems

Unit Overview

Unit 3 begins with an introduction to programming robotic control systems. Flow charts will be used to help with planning and visualizing programming structures. Students will complete several guided activities to become familiar with the computer programming language and the physical parts, sensors, and switches available to them. After becoming familiar with the robotics systems, students will create programs to solve a series of problems. Following our introduction to robotics, students will then investigate fluid power. Pneumatic and hydraulic systems will be explored, and students will design and test their own fluid powered mechanism. The unit will end with an open-ended design challenge. In order to solve the challenge's problem, teams will have to program and build a robotic system that automatically performs required tasks.

Unit Essential Questions

1-1. What are the advantages and disadvantages of using programmable logic to control machines versus monitoring and adjusting processes manually?
1-2. What are some everyday seemingly simple devices that contain microprocessors, and what function do the devices serve?
1-3. What questions must designers ask when solving problems in order to decide between digital or analog systems and between open or closed loop systems?

2-1. What impact does fluid power have on our everyday lives?
2-2. Can you identify devices or systems that do not use fluid power that might be improved with the use of fluid power?
2-3. What are similarities and differences of mechanical advantage in simple machines and hydraulic systems?
2-4. 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?

Key Understandings

1-1. Flowcharts provide a step by step schematic representation of an algorithm or process.
1-2. Control systems are designed to provide consistent process control and reliability.
1-3. Control system protocols are an established set of commands or functions typically created in a computer programming language.
1-4. Closed loop systems use digital and analog sensor feedback to make operational and process decisions.
1-5. Open loop systems use programming constants such as time to make operational and process decisions.
2-1. Fluid power systems are categorized as either pneumatic, which utilizes gas, or hydraulic, which utilizes liquid.
2-2. Fluid power is possible because in a system of confined fluid, pressure acts equally in all directions.
2-3. The most basic components of all fluid power systems include a reservoir or receiver, a pump or compressor, a valve, and a cylinder.
2-4. Fluid power systems are designed to transmit force over great distances, multiply an input force, and increase the distance that an output will move.
2-5. Laws about the behavior of fluid systems and standard conventions for calculating values within fluid systems aid in the design and understanding of such systems.
2-6. Standard schematic symbols and conventions are used to

3-1. What is a design brief and what are design constraints? 3-2. Why is a design process so important to follow when creating a solution to a problem? 3-3. What is a decision matrix and why is it used? 3-4. What does consensus mean, and how do teams use consensus to make decisions? 3-5. How do the properties and types of materials affect the solution to a design problem?	communicate fluid power designs. 3-1. Design problems can be solved by individuals or teams. 3-2. Engineers use a design process to create solutions to existing problems. 3-3. Design briefs are used to identify the problem specifications and to establish project constraints. 3-4. Teamwork requires constant communication to achieve the desired goal. 3-5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

Focus Standards Addressed in the Unit	
3.4.10.C1	Apply the components of the technological design process.
3.4.12.C2	Apply the concept that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
CC.2.1.HS.F.5	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CC.1.4.9-10.W	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.
CC.1.5.9-10.D	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning; ensure that the presentation is appropriate to purpose, audience, and task.

Important Standards Addressed in the Unit	
CC.2.2.HS.D.1	Interpret the structure of expressions to represent a quantity in terms of its context.

Misconceptions	Proper Conceptions
1. I already know what the program should do; planning is a waste of time.	1. Knowing what needs to be done by a computer program is generally disconnected from being able to immediately produce working code for that program. Creating flowcharts and using language to describe the code before actually writing it helps the programmer visualize connections and sequences that are not always obvious while coding.
2. Including comments in computer code is not necessary since the programmer already knows that the code is doing.	2. No matter how experienced a computer programmer may be, comments are an important component of computer code. Once time has passed, comments allow the programmer to quickly go back and make adjustments without having to retrace steps. More importantly, comments allow other programmers to understand and adjust the flow of the code. Programming is communication and comments are a critical part of effective communication.
3. Pressure and force are the same thing.	3. Pressure and force are related but not synonymous. Force is a measurement of the effect one fluid or object has on another. Pressure is the measure of that force over a given area.
4. Fluid pressure only acts down because of gravity.	4. Fluid exerts pressure on any surface with which it is in contact and that pressure always acts in a direction perpendicular to the surface.

Concepts	Competencies	Vocabulary	
• Robotics • Fluid power	• Plan and create computer programs to predictably control sensors and switches • Calculate input and output forces in a fluid controlled system	Algorithm Analog Signal Analog to Digital Closed Loop System Data Digital Signal Digital to Analog Electromagnet Feedback Flowchart Input Interface Microprocessor Normally Closed Normally Open NTC Resistor Open Loop System Output Photocell Polarity Potentiometer Programmable Logic Controller Reed Switch Sensor Subroutine Switch Transistor Accuracy Assembly Brainstorming Component Consensus Constraint Decision Matrix Design Brief Design Modification Design Process Design Statement Designer Open-Ended Pictorial Sketch Problem Statement Purpose Sketch Solid Modeling Target Consumer Team	Absolute Pressure Atmospheric Pressure Boyle's Law Charles' Law Check Valve Compressor Crank Cylinder Directional-Control Valve Double-Acting Cylinder Filter Flow Meter Flow Rate Flow Velocity Flow-Control Valve Fluid Power Gay-Lussac's Law Hydraulics Lubricator Pascal's Law Piston Pneumatics Pressure Pressure Regulator Pressure Relief Valve Pump Receiver Tank Reservoir Single-Acting Cylinder Solenoid Transmission Lines Valve Viscosity Volume

Assessments

Design Challenges – Students will be given a problem through a design brief for which they will develop a solution in teams within one class period.

Homework – Occasional homework assignments will be given to reinforce classroom concepts. Homework will be graded for completeness (including level of documentation of work) and will be used to formatively assess if additional instruction is needed.

Engineering Notebook Checks – Students will maintain a formal engineering notebook to document their work throughout the course. Periodic checks will assess proper notebook format and content. Certain projects will be completely contained within the engineering notebook and will be assessed according to the rubric provided for that project.

Vocabulary Quizzes – Understanding and using technical language is an important component of this course. Students will be expected to acquire and use new terms. Periodic quizzes within each unit will assess their ability to identify new vocabulary.

Oral Presentations – Students will report project solutions via oral presentations to the class. Content and presentation style will be assessed according to a standard rubric for each project.

Unit Tests / Unit Projects – Each unit will include a summative written test or project. Projects may be assessed through a presentation, engineering notebook review, electronic submission, or a combination of one or more of these. Rubrics and design briefs will be provided with each project to clearly communicate the content and performance expectations for that project.

Suggested Strategies to Support Design of Coherent Instruction

Charlotte Danielson's Framework for Teaching: Domain 3 Instruction

Lesson 3.1 – Machine Control

Most students will have limited to no experience with developing computer code. For this reason, start only with concepts. Share what the components of our robotic kits can do, and develop some flowcharts showing how these components can be used to solve small problems. As actual code becomes familiar, continue with a combination of creating new code and analyzing existing code to help students see the structure of programs as they develop their own style. Emphasize the importance of planning and commenting throughout the lesson.

Lesson 3.2 – Fluid Power

Introduce fluid power with relatively common examples like lifts and amusement park rides that use hydraulic power to do work. Utilize students' earlier experience with thermodynamics to help students understand the concept of pressurized fluid as a tool to do work.

Differentiation:

- Provide graphic organizers
- Provide multiple concrete examples
- Break extended projects into smaller identifiable milestones with checkpoints along the way
- Pair stronger students with struggling students for peer assistance

Interdisciplinary Connections:

- Design process – Scientific method
- Research process – English / Social Studies
- Writing skills – English
- Sketching - Art

Additional Resources:

- ***http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF.pdf*** International Society for Technology in Education standards.
- ***https://www.asme.org/*** American Society of Mechanical Engineers – additional resources specific to the practice of mechanical engineering
- ***http://www.asce.org/*** American Society of Civil Engineers – additional resources specific to the practice of civil engineering
- ***http://www.ieee.org/*** Institute of Electrical and Electronics Engineers – additional resources specific to the practice of electrical engineering
- ***https://www.aiche.org/*** American Institute of Chemical Engineers – additional resources specific to the practice of chemical engineering

Created By:

Rick Geesaman

Principles of Engineering

Grades 10-12

Unit 4

Subject	Grade	Unit	Suggested Timeline
Principles of Engineering	10-12	4 – Statistics and Kinematics	7 weeks

Grade Level Summary

Statistics allow us to take a relatively small sample of measurements and extrapolate properties of that sample to make predictions about a broader population of measurements. In manufacturing, this allows engineers to validate or improve processes based on measurements of samples taken from the manufacturing line. The effectiveness of in-service mechanisms can also be monitored using statistics, and adjustments and repairs can be scheduled based on measurement data. Kinematics is the study of movement, and equations can be created to model and predict motion. In this lesson, students will specifically use statistics and kinematics to validate the reliability of a projectile launcher that they design and build.

Grade Level Units

Unit 1 – Energy and Power
Unit 2 – Materials and Structures
Unit 3 – Control Systems
Unit 4 – Statistics and Kinematics

Unit Title

Statistics and Kinematics

Unit Overview

Unit 4 opens with a study of probability. Students will perform experiments to find actual outcomes of specific trials with various sample sizes. The results of these experiments will be compared and contrasted with the predicted outcomes based on theoretical probability. Statistics will be studied next with students using samples to create descriptive statistics, and then applying inferential statistics to make predictions about the total population that includes their samples. The focus of the unit will then switch to kinematics and projectile motion. Students will calculate theoretical travel distances, and then build a projectile launcher to compare actual travel to predicted travel. Launcher data will also be collected to perform a statistical performance analysis by which students will consider the launcher's reliability based on measures of central tendency and variation.

Unit Essential Questions	Key Understandings
1-1. Why is it crucial for designers and engineers to utilize statistics throughout the design process? 1-2. Why is process control a necessary statistical process for ensuring product success 1-3. Why is theory-based data interpretation valuable in decision making? 1-4. Why is experiment-based data interpretation valuable in decision making?	1-1. Engineers use statistics to make informed decisions based upon established principles. 1-2. Visual representations of data analyses allow for easy distribution and understanding of data. 1-3. Statistics is based upon both theoretical and experimental data analysis.
2-1. What are the relationships between distance, displacement, speed, velocity, and acceleration? 2-2. Why is it important to understand and be able to control the motion of a projectile?	2-1. When working with bodies in motion, engineers must be able to differentiate and calculate distance, displacement, speed, velocity, and acceleration. 2-2. When air resistance is not taken into account, released objects will experience acceleration due to gravity, also known as freefall. 2-3. Projectile motion can be predicted and controlled using kinematics equations. 2-4. When a projectile is launched, velocity in the X direction remains constant; whereas with time, the velocity in the Y direction changes in magnitude and direction due to gravity.

Focus Standards Addressed in the Unit	
3.4.10.C1	Apply the components of the technological design process.
3.4.10.C2	Analyze a prototype and/or create a working model to test a design concept by making actual observations and necessary adjustments.
CC.1.3.11–12.J	Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college- and career-readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.
CC.1.4.9-10.W	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.
CC.1.5.9-10.D	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning; ensure that the presentation is appropriate to purpose, audience, and task.
CC.2.4.HS.B.1	Summarize, represent, and interpret data on a single count or measurement variable.
CC.2.4.HS.B.4	Recognize and evaluate random processes underlying statistical experiments.
CC.2.4.HS.B.5	Make inferences and justify conclusions based on sample surveys, experiments, and observational studies.
CC.2.4.HS.B.6	Use the concepts of independence and conditional probability to interpret data.
CC.2.4.HS.B.7	Apply the rules of probability to compute probabilities of compound events in a uniform probability model.
CC.2.1.HS.F.1	Apply and extend the properties of exponents to solve problems with rational exponents.
CC.2.1.HS.F.3	Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.
CC.2.1.HS.F.4	Use units as a way to understand problems and to guide the solution of multi-step problems.
CC.2.1.HS.F.5	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CC.2.3.HS.A.7	Apply trigonometric ratios to solve problems involving right triangles.
CC.2.4.HS.B.1	Summarize, represent, and interpret data on a single count or measurement variable.

Important Standards Addressed in the Unit	
CC.1.4.11–12.U	Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments and information.
CC.2.1.HS.F.1	Apply and extend the properties of exponents to solve problems with rational exponents.
CC.2.2.HS.D.1	Interpret the structure of expressions to represent a quantity in terms of its context.
CC.2.2.HS.D.7	Create and graph equations or inequalities to describe numbers or relationships.
CC.2.2.HS.D.10	Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically.
CC.2.3.HS.A.14	Apply geometric concepts to model and solve real world problems.

Misconceptions	Proper Conceptions
1. Probability and odds are the same thing.	1. While related, the probability and the odds of an event occurring are not the same. Probability is a ratio of a desired outcome to total outcomes, and odds is a ratio of desired outcomes to undesired outcomes.
2. If a graph of my sample data doesn't look exactly like a normal distribution, it must represent some other distribution.	2. A small sample size from a population that is normally distributed may not appear to be normally distributed. However, we can use the smaller sample to make inferences based on the population's distribution.
3. A larger projectile will have less travel time than a smaller projectile because it will fall to the ground faster.	3. Travel time is independent of mass. Any two objects with the same initial velocity and height will have the same travel path.
4. An object dropped from a moving platform will drop straight down because it was not launched forward.	4. The dropped object will have an initial horizontal velocity component that matches that of the platform. Ignoring wind resistance, the object will continue maintain that horizontal velocity throughout its travel.

Concepts	Competencies	Vocabulary	
• Statistics • Kinematics	• Analyze a data set and make statistical predictions about the population containing that sample • Use given information about a projectile's motion to calculate additional parameters (ie: initial velocity, horizontal travel, time traveled, maximum height, etc.)	Accuracy Bar Chart Bayes' Theorem Data Data Variation Deviation Experiment Event Frequency Distribution Frequency Polygons Histogram Mean Mean Deviation Median Mode Normal Distribution Outcome Pie Chart Probability Process Control Qualitative Data Quantitative Data Quality Assurance Reliability Sample Space Standard Deviation Statistics Statistical Process Control Tolerance Variance	Acceleration Displacement Distance Free Fall Speed Velocity

Assessments

Design Challenges – Students will be given a problem through a design brief for which they will develop a solution in teams within one class period.

Homework – Occasional homework assignments will be given to reinforce classroom concepts. Homework will be graded for completeness (including level of documentation of work) and will be used to formatively assess if additional instruction is needed.

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Unit Tests / Unit Projects – Each unit will include a summative written test or project. Projects may be assessed through a presentation, engineering notebook review, electronic submission, or a combination of one or more of these. Rubrics and design briefs will be provided with each project to clearly communicate the content and performance expectations for that project.

Suggested Strategies to Support Design of Coherent Instruction

Charlotte Danielson's Framework for Teaching: Domain 3 Instruction

Lesson 4.1 – Statistics

Students will have experience with measures of central tendency so capitalize on this prior knowledge to introduce the more abstract concepts of variation. To link statistical analysis to real world situations that students see every day. Use examples like human height (specifically actual student heights), shoe size, test scores, etc. to illustrate common occurrences of symmetrical probability distributions.

Lesson 4.2 – Kinematics

One of the more difficult concepts for students to grasp in this topic is that given an initial launch angle, the travel time for a projectile is independent of its mass when we ignore air resistance and other environmental variables. From the start, work to dispel the misconception that mass affects the way that earth's gravity accelerates an object.

Differentiation:

- Provide graphic organizers
- Provide multiple concrete examples
- Break extended projects into smaller identifiable milestones with checkpoints along the way
- Pair stronger students with struggling students for peer assistance

Interdisciplinary Connections:

- Design process – Scientific method
- Research process – English / Social Studies
- Writing skills – English
- Sketching - Art

Additional Resources:

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- ***https://www.asme.org/*** American Society of Mechanical Engineers – additional resources specific to the practice of mechanical engineering
- ***http://www.asce.org/*** American Society of Civil Engineers – additional resources specific to the practice of civil engineering
- ***http://www.ieee.org/*** Institute of Electrical and Electronics Engineers – additional resources specific to the practice of electrical engineering
- ***https://www.aiche.org/*** American Institute of Chemical Engineers – additional resources specific to the practice of chemical engineering

Created By:

Rick Geesaman

NORTHERN YORK COUNTY SCHOOL DISTRICT

Principles of Engineering

June 2015

I. Philosophy

Principles of Engineering (POE) is a foundational course in Project Lead The Way's (PLTW) high school engineering pathway. POE is the second course in Northern High School's engineering course sequence following Introduction to Engineering Design (IED). The course offers high school students who are interested in design and engineering or other technical careers an opportunity to explore the physical science behind engineering practice. Students will explore energy and power, materials and structures, control systems, and statistics and motion. Students will use the same Engineering Design Process developed in IED to solve problems throughout the course. Upon completion of the course, students will complete an online PLTW assessment.

II. Core Concepts

Engineering is a profession rooted in solving problems. While the primary focus of IED was learning to use the engineering design process, the focus of POE will be to develop a knowledge of broad engineering topics for additional coursework. Students will refine their problem solving, research, and design skills. Throughout the course, students will also develop additional work documentation, collaboration, and presentation skills. Project based design challenges in each unit will require students to physically apply the theoretical concepts studied within that unit to solve open-ended problems. Opportunities to explore the engineering profession more deeply are also included in the course.

Course of Study

Marking Period 1

Unit 1: Energy and Power – A unit-long research project will allow students to research and present information regarding a branch of engineering practice. Mechanisms and simple machines are explored focusing on the relationship between input and output forces. Energy types and sources and the conversion of energy will be investigated along with electrical circuits. Thermal conductivity will be examined and materials will be considered for their abilities to act as insulators or conductors. The unit concludes with the design and construction of a simulated renewable electrical energy distribution system.

Marking Period 2

Unit 2: Materials and Structures – This unit begins by looking at static force distribution through structures. Students will evaluate the internal distribution of forces through structural trusses and determine the external reactions required for static equilibrium. Once students have mastered the analysis of truss forces, they will construct their own trusses, predict the failure mode, and destructively test the trusses to confirm or refine their predictions. After investigating statics, material properties will be explored. Students will be introduced to some of the basic material properties used in engineering. Recycling and disposal of materials after their useful life has ended will also be considered. Next students will experience both destructive and non-destructive material testing to find how engineers verify expected material properties and validate material manufacturing processes. Finally students will design their own bridge and will use testing software to virtually load test and optimize their design.

Marking Period 3

Unit 3: Control Systems– Computers control increasingly more devices and processes every day. We begin this unit learning to control mechanical processes using computer hardware and software. Students will then see how pneumatic and hydraulic power can also be used to control mechanical systems. The unit culminates with a design challenge in which students will design their own control system to solve a given problem.

Marking Period 4

Unit 4: Statistics and Kinematics – Students will use statistical calculations to analyze data and will calculate the probability of simple and compound events occurring. Projectile motion will be explored and predicted using kinematics equations. The unit will conclude with student teams designing and building their own projectile launchers and performing statistical analysis to find their launchers' reliability.

1) Texts and Resources

- PowerPoint presentations
- PLTW activities
- PLTW projects
- VEX Robotics Kits
- Student PC's with office productivity software
- Autodesk Inventor solid modeling computer software

2) Expected Levels of Achievement

Students are expected to maintain a minimum grade of 70%. Assessments – as outlined below – will measure the students' ability to apply an engineering design process and engineering modeling tools to solve problems throughout the course. An end of course standardized PLTW assessment will evaluate the students' mastery of the course concepts.

Grading System:

93-100	=	A	(excellent progress)
85-92	=	B	(above average progress)
77-84	=	C	(average progress)
70-76	=	D	(below average progress)
Below 70	=	F	(failing)
Unfinished	=	I	(some incomplete work)

3) Procedures for Evaluation

1. **Written assessments** may include but will not necessarily be limited to:
    - Quizzes within each unit
    - Unit tests
    - Maintaining a formal engineering notebook
    - Reports summarizing problem solutions
    - Homework assignments
    - Course portfolio
    - Final exam

2. **Project assessments** may include but will not necessarily be limited to:
    - Autodesk Inventor solid model presentations
    - Pictorial representations
    - Oral presentations
    - Computer generated presentations
    - Physical model presentations

3. Missed work must be made up in accordance with current NHS policy. For extended absences of more than three days, special consideration for extended time may be arranged as necessary. Assignments will be provided online when possible to help students keep up with missed work.

4. All students are expected to produce their own original work in satisfying the requirements of this course, and to cite the use of others' work included in their own as necessary. Violations of this expectation will result in a score of "zero" for the assignment on which the violation occurred along with an administrative referral.

Northern York County School District Curriculum

Course Name	Principles of Engineering
Grade Level	10-12
Credits	1.06 Credits (Weighted GPA)
Instructional Procedures	**Refer to individual Unit Curriculum Unit Framework documents**

Unit 1	**Energy and Power**		
Time Frame	**10 Weeks**		
1.1	**Mechanisms**		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Engineers and engineering technologists apply math, science, and discipline specific skills to solve problems.	Why is it important to begin considering career paths during high school?	**CC.2.1.HS.F.3** Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.	ABET Actual Mechanical Advantage Belt Career Chain Effort Force Efficiency Friction Fulcrum Gear Ideal Mechanical Advantage Idler Gear Inclined Plane Lever Mechanism Moment
2. Engineers and engineering technologists apply math, science, and discipline specific skills to solve problems.	What career opportunities are available to match your specific interests?	**CC.2.1.HS.F.4** Use units as a way to understand problems and to guide the solution of multi-step problems.	
3. Technical communication can be accomplished in oral, written, and visual forms and must be organized in a clear and concise manner.	What are some current applications of simple machines, gears, pulleys, and sprockets?	**CC.2.1.HS.F.5** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	

4. Most mechanisms are composed of gears, sprockets, pulley systems, and simple machines.	What are some strategies that can be used to make everyday mechanisms more efficient?	**CC.2.2.HS.C.5** Construct and compare linear, quadratic, and exponential models to solve problems.	Pitch Pulley Resistance Force Screw Simple Machine Sprocket Static Equilibrium Technical Communication Torque Wedge Wheel and Axle
5. Mechanisms are used to redirect energy within a system by manipulating force, speed, and distance.	What are the trade-offs of mechanical advantage related to design?	**CC.2.2.HS.D.1** Interpret the structure of expressions to represent a quantity in terms of its context.	
6. Mechanical advantage ratios mathematically evaluate input work versus output work of mechanisms.	Why must efficiency be calculated and understood during the design process?	**CC.2.2.HS.D.7** Create and graph equations or inequalities to describe numbers or relationships.	
		CC.2.2.HS.D.10 Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically.	
		CC.2.3.HS.A.14 Apply geometric concepts to model and solve real world problems.	
		CC.1.4.9-10.W 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.	
		CC.1.5.9-10.D Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of	

		reasoning; ensure that the presentation is appropriate to purpose, audience, and task.	
		CC.1.5.9-10.G Demonstrate command of the conventions of standard English when speaking based on Grades 9–10 level and content.	
		CC.1.3.11-12.J Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	
1.2	**Energy Sources**		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Energy source classifications include nonrenewable, renewable, and inexhaustible.	What sources of energy are available for use? What are the benefits and drawbacks regarding efficiency, usefulness, and the environment?	**3.2.P.B4** Develop qualitative and quantitative understanding of current, voltage, resistance, and the connections among them.	Alternative Energy Ampere Biomass Current Electrical Energy Electricity Electromagnetic Induction Efficiency Energy Energy Conversion Environmental Protection Agency Fossil Fuel Generator Geothermal Energy Gravitational Energy
2. Energy source processes include harnessing, storing, transporting, and converting.	What emerging technologies are or may be on the horizon that will provide energy more efficiently.	**3.4.12.E3** Compare and contrast energy and power systems as they relate to pollution, renewable and non-renewable resources, and conservation.	
3. Energy often needs to be converted from one form to another to meet the needs of a given system.	What are the different energy sources that		

	are used to deliver energy to your community?		Induction Inexhaustible Energy Kinetic Energy Nonrenewable Energy Ohm Ohm's Law Parallel Circuit Potential Energy Power Converter Power Grid Renewable Energy Resistance Work Turbine Power Rotor Series Circuit Volt Voltage
4. An understanding of work, energy, and power is required to determine system efficiency.	What are some examples in your community of individuals or businesses harnessing their own energy?		
5. An understanding of the basics of electricity requires the understanding of the three fundamental concepts of voltage, current, and resistance.	Where and how is the electricity that reaches your home produced?		
6. The atomic structure of a material determines whether it is a conductor, an insulator, or a semiconductor.	What efficient uses of energy and power can you identify at home, school, or work?		
	What is the relationship between resistance, current, and voltage within an electrical system?		
	What are the distinguishing characteristics between series and parallel circuits?		
	How do you calculate the efficiency of an electrical mechanical system?		

1.3	Energy Applications		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Energy management is focused on efficient and accessible energy use.	What limitations affect electricity production using solar cells?	**3.2.P.B3** Analyze the factors that influence convection, conduction, and radiation between objects or regions that are at different temperatures.	Active Solar Energy Collection Alternative Energy Ampere Conduction Convection Current Electrical Energy Electirctiy Electromagnetic Energy Electorlysis Energy Entropy First Law of Thermodynamics Fuel Cell Stack Heat Kelvin Line of Best Fit Ohm Ohm's Law Passive Solar Energy Collection Product Development Lifecycle Radiation Renewable Energy Resistance R-value Second Law of Thermodynamics Temperature Thermal Equilibrium Thermodynamic System Thermodynamics U-value Volt
2. System energy requirements must be understood in order to select the proper energy source.	What limitations affect electricity production using hydrogen fuel cells?	**3.4.10.E3** Compare and contrast the major forms of energy: thermal, radiant, electrical, mechanical, chemical, nuclear and others.	
3. Energy systems can include multiple energy sources that can be combined to convert energy into useful forms.	How can system configuration affect voltage and current?		
4. Hydrogen fuel cells created electricity and heat through an electrochemical process that converts hydrogen and oxygen into water.	How does thermodynamics relate to energy and power?		
5. Solar cells convert light energy into electricity by using photons to create electron flow.	What are some everyday examples of the First and Second Laws of Thermodynamics?		
6. Thermodynamics is the study of the effects of work, thermal energy, and energy on a system.			
7. Thermal energy can transfer via convection, conduction, or radiation.			
8. Material conductivity, resistance, and energy transfer can be calculated.			

			Voltage Zeroth Law of Thermodynamics
1.4	**Design Problem: Energy and Power**		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Design problems can be solved by individuals or teams.	What is a design brief and what are design constraints?	**3.4.10.C1** Apply the components of the technological design process.	Accuracy Assembly Brainstorming Component Consensus Constraint Decision Matrix Design Brief Design Modification Design Process Design Statement Designer Open-Ended Pictorial Sketch Problem Statement Purpose Sketch Solid Modeling Target Consumer Team
2. Engineers use a design process to create solutions to existing problems.	Why is a design process so important to follow when creating a solution to a problem?	**CC.2.1.HS.F.3** Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.	
3. Design briefs are used to identify the problem specifications and to establish project constraints.	What is a decision matrix and why is it used?	**CC.2.1.HS.F.4** Use units as a way to understand problems and to guide the solution of multi-step problems.	
4. Teamwork requires constant communication to achieve the desired goal.	What does consensus mean, and how do teams use consensus to make decisions?	**CC.2.1.HS.F.5** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.			

<table>
<tr><th>Unit 2</th><th colspan="3">Materials and Structures</th></tr>
<tr><th>Time Frame</th><th colspan="3">8 Weeks</th></tr>
<tr><th>2.1</th><th colspan="3">Statics</th></tr>
<tr><th>Key Concepts</th><th>Essential Questions</th><th>PA Academic Standards</th><th>Terminology</th></tr>
<tr><td>1. Laws of motion describe the interaction of forces acting on a body.</td><td>Why is it crucial for designers and engineers to construct accurate free body diagrams of the elements and structures they design?</td><td>3.4.10.B4 Recognize that technological development has been evolutionary, the result of a series of refinements to a basic invention.</td><td rowspan="4">Cable
Centroid
Compression Force
Concurrent Force Systems
Cross-Sectional Area
Direction
Fixed Support
Flange
Free Body Diagram
Gusset
Joint
Magnitude
Member
Method of Joints
Moment
Moment of Inertia
Newton’s First Law
Newton’s Second Law
Newton’s Third Law
Pinned Support
Planar Truss
Resultant Force
Roller Support
Scalar
Sense
Simple Truss
Static Equilibrium
Statically Indeterminate
Structure
Tension Force
Vector Quantity</td></tr>
<tr><td>2. Structural member properties including centroid location, moment of inertia, and modulus of elasticity are important considerations for structure design.</td><td>Why must designers and engineers calculate forces acting on bodies and structures?</td><td>3.4.10.C1 Apply the components of the technological design process.</td></tr>
<tr><td>3. Static equilibrium occurs when the sum of all forces acting on a body are equal to zero.</td><td>When solving truss forces, why is it important to know that the structure is statically determinate?</td><td>3.4.12.C2 Apply the concept that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.</td></tr>
<tr><td>4. Applied forces are vector quantities with a defined magnitude, direction, and sense, and can be broken into vector components.</td><td></td><td>CC.1.4.9-10.W 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</td></tr>
</table>

		following a standard format for citation.	
5. Forces acting at a distance from an axis or point attempt to make -- or cause -- an object to rotate.		**CC.1.5.9-10.D** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning; ensure that the presentation is appropriate to purpose, audience, and task.	
6. In a statically determinate truss, translational and rotational equilibrium equations can be used to calculate external and internal forces.		**CC.1.5.9-10.G** Demonstrate command of the conventions of standard English when speaking based on Grades 9–10 level and content.	
7. Free body diagrams are used to illustrate and calculate forces acting upon a given body.		**CC.1.2.11-12.J** Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	

2.2	Material Properties		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Materials are the substances of which all things are made.	How does an engineer predict the performance and safety for a selected material?	**CC.2.1.HS.F.3** Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.	Additive Process Ceramic Codes Composite Decision Matrix Finishing Forming Liability Manufacturing Material Mechanical Properties Metals Physical Properties Polymers Product Life Cycle Raw Material Recycling Subtractive Process Synthetic
2. Materials are composed of elements and are categorized by physical and chemical properties.	What are the advantages and disadvantages of utilizing synthetic material designed by engineers?	**CC.2.1.HS.F.4** Use units as a way to understand problems and to guide the solution of multi-step problems.	
3. Materials consist of pure elements, compounds, and mixtures and are typically classified as metallic, ceramic, organic, polymeric, and composite.	What ethical issues pertain to engineers designing synthetic materials?	**CC.2.1.HS.F.5** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	
4. Material properties including recyclability and cost are important considerations for engineers when choosing appropriate materials for a design.	What did you learn about the significance of selecting materials for product design?	**CC.2.3.HS.A.12** Explain volume formulas and use them to solve problems.	
5. Material selection is based upon mechanical, thermal, electromagnetic, and chemical properties.	How can an existing product be changed to incorporate different processes to make it less expensive and provide better performance?	**CC.2.3.HS.A.13** Analyze relationships between two-dimensional and three-dimensional objects.	
6. Raw materials undergo various manufacturing processes in the production of consumer goods.	How does an engineer decide which manufacturing process to use for a given material?	**CC.2.3.HS.A.14** Apply geometric concepts to model and solve real world problems.	

	How do the recycling codes and symbols differ from state to state?	**CC.1.2.11-12.A** Determine and analyze the relationship between two or more central ideas of a text, including the development and interaction of the central ideas; provide an objective summary of the text.	
		CC.1.2.11–12.B Cite strong and thorough textual evidence to support analysis of what the text says explicitly, as well as inferences and conclusions based on and related to an author's implicit and explicit assumptions and beliefs.	
		CC.1.2.11–12.G Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.	
		CC.1.3.11–12.J Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college- and career-readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	
		CC.1.4.11–12.A Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately.	

		CC.1.4.11–12.B Write with a sharp, distinct focus identifying topic, task, and audience.	
		CC.1.4.11–12.F Demonstrate a grade-appropriate command of the conventions of standard English grammar, usage, capitalization, punctuation, and spelling.	
		CC.1.4.11–12.S Draw evidence from literary or informational texts to support analysis, reflection, and research, applying grade-level reading standards for literature and literary nonfiction.	
		CC.1.4.11–12.V 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.	
		CC.1.4.11–12.X Write routinely over extended time frames (time for research, 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.	

2.3	Material Testing		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Engineers utilize a design process and mathematical formulas to solve and document design problems.	Why is it critical for engineers to document all calculation steps when solving problems?	**CC.2.1.HS.F.3** Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.	Axial Stress Breaking Stress Compression Deformation Destructive Testing Elastic Limit Elongation Factor of Safety Failure Point Fatigue Hooke's Law Modulus of Elasticity Nondestructive Testing Problem Solving Proportional Limit Quality Control Reliability Resilience Rupture Strength Shear Stress Standard Deviation Statistics Strain Stress Stress-Strain Curve Tension Toughness Ultimate Stress Variance
2. Material testing aids in determining a product's reliability, safety, and predictability in function.	How is material testing data useful?	**CC.2.1.HS.F.4** Use units as a way to understand problems and to guide the solution of multi-step problems.	
3. Engineers perform destructive and non-destructive tests on material specimens for the purpose of identifying and verifying the properties of various materials.	Stress strain curve data points are useful in determining what specific material properties?	**CC.2.1.HS.F.5** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	
4. Material testing provides a reproducible evaluation of material properties.		**CC.2.2.HS.D.1** Interpret the structure of expressions to represent a quantity in terms of its context.	
5. Tensile testing data is used to create a test sample stress strain curve.			

2.4	Design Problem: Materials and Structures		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Design problems can be solved by individuals or teams.	What is a design brief and what are design constraints?	**3.4.10.C1** Apply the components of the technological design process.	Accuracy Assembly Brainstorming Component Consensus Constraint Decision Matrix Design Brief Design Modification Design Process Design Statement Designer Open-Ended Pictorial Sketch Problem Statement Purpose Sketch Solid Modeling Target Consumer Team
2. Engineers use a design process to create solutions to existing problems.	Why is a design process so important to follow when creating a solution to a problem?	**CC.2.1.HS.F.3** Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.	
3. Design briefs are used to identify the problem specifications and to establish project constraints.	What is a decision matrix and why is it used?	**CC.2.1.HS.F.4** Use units as a way to understand problems and to guide the solution of multi-step problems.	
4. Teamwork requires constant communication to achieve the desired goal.	What does consensus mean, and how do teams use consensus to make decisions?		
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.	How do the properties and types of materials affect the solution to a design problem?		

Unit 3	Control Systems		
Time Frame	**9 Weeks**		
3.1	**Machine Control**		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Flowcharts provide a step by step schematic representation of an algorithm or process.	What are the advantages and disadvantages of using programmable logic to control machines versus monitoring and adjusting processes manually?	**3.4.12.C2** Apply the concept that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.	Algorithm Analog Signal Analog to Digital Closed Loop System Data Digital Signal Digital to Analog Electromagnet Feedback Flowchart Input Interface Microprocessor Normally Closed Normally Open NTC Resistor Open Loop System Output Photocell Polarity Potentiometer Programmable Logic Controller Reed Switch Sensor Subroutine Switch Transistor
2. Control systems are designed to provide consistent process control and reliability.	What are some everyday seemingly simple devices that contain microprocessors, and what function do the devices serve?	**CC.1.4.9-10.W** 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.	
3. Control system protocols are an established set of commands or functions typically created in a computer programming language.	What questions must designers ask when solving problems in order to decide between digital or analog systems and between open or closed loop systems?	**CC.1.5.9-10.D** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning; ensure that the presentation is appropriate to purpose, audience, and task.	

4. Closed loop systems use digital and analog sensor feedback to make operational and process decisions.			
5. Open loop systems use programming constants such as time to make operational and process decisions.			
3.2	**Fluid Power**		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Fluid power systems are categorized as either pneumatic, which utilizes gas, or hydraulic, which utilizes liquid.	What impact does fluid power have on our everyday lives?	**3.4.10.C1** Apply the components of the technological design process.	Absolute Pressure Atmospheric Pressure Boyle's Law Charles' Law Check Valve Compressor Crank Cylinder Directional-Control Valve Double-Acting Cylinder Filter Flow Meter Flow Rate Flow Velocity Flow-Control Valve Fluid Power Gay-Lussac's Law Hydraulics Lubricator Pascal's Law Piston Pneumatics Pressure Pressure Regulator Pressure Relief Valve Pump Receiver Tank Reservoir Single-Acting Cylinder Solenoid Transmission Lines Valve
2. Fluid power is possible because in a system of confined fluid, pressure acts equally in all directions.	Can you identify devices or systems that do not use fluid power that might be improved with the use of fluid power?	**CC.2.2.HS.D.1** Interpret the structure of expressions to represent a quantity in terms of its context.	
3. The most basic components of all fluid power systems include a reservoir or receiver, a pump or compressor, a valve, and a cylinder.	What are similarities and differences of mechanical advantage in simple machines and hydraulic systems?		
4. Fluid power systems are designed to transmit force over great distances, multiply an input force, and increase the distance that an output will move.	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?		
5. Laws about the behavior of fluid systems and standard conventions for calculating values within fluid systems aid in the design and understanding of such systems.			
6. Standard schematic symbols and conventions are used to communicate fluid power designs.			

			Viscosity Volume
3.3	**Design Problem: Control Systems**		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Design problems can be solved by individuals or teams.	What is a design brief and what are design constraints?	**3.4.10.C1** Apply the components of the technological design process.	Accuracy Assembly Brainstorming Component Consensus Constraint Decision Matrix Design Brief Design Modification Design Process Design Statement Designer Open-Ended Pictorial Sketch Problem Statement Purpose Sketch Solid Modeling Target Consumer Team
2. Engineers use a design process to create solutions to existing problems.	Why is a design process so important to follow when creating a solution to a problem?	**CC.2.1.HS.F.5** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	
3. Design briefs are used to identify the problem specifications and to establish project constraints.	What is a decision matrix and why is it used?		
4. Teamwork requires constant communication to achieve the desired goal.	What does consensus mean, and how do teams use consensus to make decisions?		
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.	How do the properties and types of materials affect the solution to a design problem?		

Unit 4	Statistics and Kinematics		
Time Frame	**7 Weeks**		
4.1	**Statistics**		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. Engineers use statistics to make informed decisions based upon established principles.	Why is it crucial for designers and engineers to utilize statistics throughout the design process?	**CC.2.4.HS.B.1** Summarize, represent, and interpret data on a single count or measurement variable.	Accuracy Bar Chart Bayes' Theorem Data Data Variation Deviation Experiment Event Frequency Distribution Frequency Polygons Histogram Mean Mean Deviation Median Mode Normal Distribution Outcome Pie Chart Probability Process Control Qualitative Data Quantitative Data Quality Assurance Reliability Sample Space Standard Deviation Statistics Statistical Process Control Tolerance Variance
2. Visual representations of data analyses allow for easy distribution and understanding of data.	Why is process control a necessary statistical process for ensuring product success?	**CC.2.4.HS.B.4** Recognize and evaluate random processes underlying statistical experiments.	
3. Statistics is based upon both theoretical and experimental data analysis.	Why is theory-based data interpretation valuable in decision making?	**CC.2.4.HS.B.5** Make inferences and justify conclusions based on sample surveys, experiments, and observational studies.	
	Why is experiment-based data interpretation valuable in decision making?	**CC.2.4.HS.B.6** Use the concepts of independence and conditional probability to interpret data.	
		CC.2.4.HS.B.7 Apply the rules of probability to compute probabilities of compound events in a uniform probability model.	

4.2	Kinematics		
Key Concepts	**Essential Questions**	**PA Academic Standards**	**Terminology**
1. When working with bodies in motion, engineers must be able to differentiate and calculate distance, displacement, speed, velocity, and acceleration.	What are the relationships between distance, displacement, speed, velocity, and acceleration?	**3.4.10.C1** Apply the components of the technological design process.	Acceleration Displacement Distance Free Fall Speed Velocity
2. When air resistance is not taken into account, released objects will experience acceleration due to gravity, also known as freefall.	Why is it important to understand and be able to control the motion of a projectile?	**3.4.10.C2** Analyze a prototype and/or create a working model to test a design concept by making actual observations and necessary adjustments.	
3. Projectile motion can be predicted and controlled using kinematics equations.		**CC.2.1.HS.F.1** Apply and extend the properties of exponents to solve problems with rational exponents.	
4. When a projectile is launched, velocity in the X direction remains constant; whereas with time, the velocity in the Y direction changes in magnitude and direction due to gravity.		**CC.2.1.HS.F.3** Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays.	
		CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems.	
		CC.2.1.HS.F.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	
		CC.2.2.HS.D.1 Interpret the structure of expressions to represent a quantity in terms of its context.	

		CC.2.2.HS.D.7 Create and graph equations or inequalities to describe numbers or relationships.	
		CC.2.2.HS.D.10 Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically.	
		CC.2.3.HS.A.7 Apply trigonometric ratios to solve problems involving right triangles.	
		CC.2.3.HS.A.14 Apply geometric concepts to model and solve real world problems.	
		CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable.	
		CC.1.3.11–12.J Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college- and career-readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	
		CC.1.4.11–12.U Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments and information.	