CURRICULUM

FOR

PRINCIPLES OF ENGINEERING

GRADES 10-12

This curriculum is part of the Educational Program of Studies of the Rahway Public Schools.

ACKNOWLEDGMENTS

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Subject/Course Title:
Principles of Engineering
Grade 10-12

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RAHWAY PUBLIC SCHOOLS CURRICULUM

Principles of Engineering - Grades 10-12

PACING GUIDE

Unit	Title	Pacing
1	Energy and Power	10 weeks
2	Materials and Statics	6 weeks
3	Control Systems	9 weeks
4	Statistics and Kinematics	6 weeks

ACCOMMODATIONS

504 Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Provide extra visual and verbal cues and prompts.
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Weekly home-school communication tools (notebook, daily log, phone calls or email messages).
- Provide study sheets and teacher outlines prior to assessments.
- Quiet corner or room to calm down and relax when anxious.
- Reduction of distractions.
- Permit answers to be dictated.
- Hands-on activities.
- Use of manipulatives.
- Assign preferential seating.
- No penalty for spelling errors or sloppy handwriting.
- Follow a routine/schedule.
- Provide student with rest breaks.
- Use verbal and visual cues regarding directions and staying on task.
- Assist in maintaining agenda book.

IEP Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Differentiate reading levels of texts (e.g., Newsela).
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide extra visual and verbal cues and prompts.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Provide students with additional information to supplement notes.
- Modify questioning techniques and provide a reduced number of questions or items on tests.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Provide study sheets and teacher outlines prior to assessments.
- Use of manipulatives.
- Have students work with partners or in groups for reading, presentations, assignments, and analyses.
- Assign appropriate roles in collaborative work.
- Assign preferential seating.
- Follow a routine/schedule.

Gifted and Talented Accommodations:

- Differentiate reading levels of texts (e.g., Newsela).
- Offer students additional texts with higher lexile levels.
- Provide more challenging and/or more supplemental readings and/or activities to deepen understanding.
- Allow for independent reading, research, and projects.
- Accelerate or compact the curriculum.
- Offer higher-level thinking questions for deeper analysis.
- Offer more rigorous materials/tasks/prompts.
- Increase number and complexity of sources.
- Assign group research and presentations to teach the class.

ELL Accommodations:

- Provide extended time.
- Assign preferential seating.
- Assign peer buddy who the student can work with.
- Check for understanding frequently.
- Provide language feedback often (such as grammar errors, tenses, subject-verb agreements, etc…).
- Have student repeat directions.
- Make vocabulary words available during classwork and exams.
- Use study guides/checklists to organize information.
- Repeat directions.
- Increase one-on-one conferencing.
- Allow student to listen to an audio version of the text.

● Assign/allow for leadership roles during collaborative work and in other learning activities.	● Give directions in small, distinct steps. ● Allow copying from paper/book. ● Give student a copy of the class notes. ● Provide written and oral instructions. ● Differentiate reading levels of texts (e.g., Newsela). ● Shorten assignments. ● Read directions aloud to student. ● Give oral clues or prompts. ● Record or type assignments. ● Adapt worksheets/packets. ● Create alternate assignments. ● Have student enter written assignments in criterion, where they can use the planning maps to help get them started and receive feedback after it is submitted. ● Allow student to resubmit assignments. ● Use small group instruction. ● Simplify language. ● Provide scaffolded vocabulary and vocabulary lists. ● Demonstrate concepts possibly through the use of visuals. ● Use manipulatives. ● Emphasize critical information by highlighting it for the student. ● Use graphic organizers. ● Pre-teach or pre-view vocabulary. ● Provide student with a list of prompts or sentence starters that they can use when completing a written assignment. ● Provide audio versions of the textbooks. ● Highlight textbooks/study guides. ● Use supplementary materials. ● Give assistance in note taking ● Use adapted/modified textbooks. ● Allow use of computer/word processor. ● Allow student to answer orally, give extended time (time-and-a-half). ● Allow tests to be given in a separate location (with the ESL teacher). ● Allow additional time to complete assignments and/or assessments. ● Read question to student to clarify. ● Provide a definition or synonym for words on a test that do not impact the validity of the exam. ● Modify the format of assessments. ● Shorten test length or require only selected test items. ● Create alternative assessments. ● On an exam other than a spelling test, don't take points off for spelling errors.

UNIT OVERVIEW

Content Area: Principles of Engineering

Unit Title: Energy and Power

Target Course/Grade Level: 10-12

Unit Summary: The goal of this unit is to introduce students to mechanisms, energy sources, and alternative energy applications. Students will gain an understanding of mechanisms through the application of theory-based calculations accompanied by lab experimentation. Students will also learn that energy and power can be transferred and transformed. They will have an opportunity to investigate thermal energy and alternative energy sources and applications. The unit concludes with students working in teams to solve a design problem that focuses on energy and power.

Approximate Length of Unit: 12 weeks

LEARNING TARGETS

NJ Student Learning Standards:
9.1.12.A.3: Analyze the relationship between various careers and personal earning goals.
9.1.12.A.4: Identify a career goal and develop a plan and timetable for achieving it, including educational/training requirements, costs, and possible debt.
9.2.8.B.5: Analyze labor market trends using state and federal labor market information and other resources available online.
9.3.ST.5: Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
9.3.ST.6: Demonstrate technical skills needed in a chosen STEM field.
9.3.ST-SM.2: Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
9.3.ST-SM.1: Apply science and mathematics to provide results, answers and algorithms for engineering and te chnological activities.
9**.4.12.O.(1).7:** Use mathematics, science, and technology concepts and processes to solve problems in projects involving design and/or production (e.g., medical, agricultural, biotechnological, energy and power, information and communication, transportation, manufacturing, and construction).
9.4.12.O.(1).5: Explain relevant physical properties of materials used in engineering and technology.

Career Readiness, Life Literacies, and Key Skills:

9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt rep•

9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving.

9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).

9.4.12.TL.1: Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.

21st Century Learning Standards

Career Ready Practices:

CRP1. Act as a responsible and contributing citizen and employee.

CRP2. Apply appropriate academic and technical skills.

CRP4. Communicate clearly and effectively and with reason.

CRP5. Consider the environmental, social and economic impacts of decisions.

CRP6. Demonstrate creativity and innovation.

CRP7. Employ valid and reliable research strategies.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

CRP9. Model integrity, ethical leadership and effective management.

CRP10. Plan education and career paths aligned to personal goals.

CRP11. Use technology to enhance productivity.

Interdisciplinary Connections and Standards:

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Mathematical Practices

MP.1. Make sense of problems and persevere in solving them.

MP.2. Reason abstractly and quantitatively.

MP.3. Construct viable arguments and critique the reasoning of others.

MP.4. Model with mathematics.

MP.5. Use appropriate tools strategically.

MP.6. Attend to precision.

MP.7. Look for and make use of structure.

MP.8. Look for and express regularity in repeated reasoning.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

RST.9-10.3: Follow precisely a complex multi-step procedure when carrying out experiments, taking measurements, or performing technical

RST.9-10.5: Analyze the relationship among concepts in a text, including relationship among key terms (e.g., force, friction, reaction force, energy, work)

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically

(e.g., in an equation) into words.

Unit Understandings:

Students will understand that…

- Engineers and engineering technologists apply math, science, and discipline specific skills to solve problems.
- Engineering and engineering technology careers offer creative job opportunities for individuals with a wide variety of backgrounds and goals.
- Technical communication can be accomplished in oral, written, and visual forms and must be organized in a clear and concise manner.
- Energy source classifications include nonrenewable, renewable, and inexhaustible.
- Energy source processes include harnessing, storing, transporting, and converting.
- An understanding of work, energy, and power is required to determine system efficiency.
- An understanding of the basics of electricity requires the understanding of the three fundamental concepts of voltage, current, and resistance.
- System energy requirements must be understood in order to select the proper energy source.
- Energy systems can include multiple energy sources that can be combined to convert energy into useful forms.
- Hydrogen fuel cells create electricity and heat through an electrochemical process that converts hydrogen and oxygen into water.
- Solar cells convert light energy into electricity by using photons to create electron flow.
- Design problems can be solved by individuals or in teams.
- Engineers use a design process to create solutions to existing problems.
- Design briefs are used to identify the problem specifications and to establish project constraints.
- Teamwork requires constant communication to achieve the desired goal.

Unit Essential Questions:

- Why is it important to begin considering career paths during high school?
- What career opportunities are available to match your specific interests?
- What are some current applications of simple machines, gears, pulleys, and sprockets?
- What are the trade-offs of mechanical advantage related to design?
- What sources of energy are available for use?

- What are the benefits and drawbacks regarding efficiency, usefulness, and the environment?
- What emerging technologies are or may be on the horizon that will provide energy more efficiently?
- What are the different energy sources that are used to deliver energy to your community?
- Describe and identify inefficient use of energy and power at home, school, or work.
- What is the relationship between resistance, current, and voltage within an electrical system?
- Explain the distinguishing characteristics between series and parallel circuits.
- What limitations affect electricity production using hydrogen fuel cells?
- How can system configuration affect voltage and current?
- How does thermodynamics relate to energy and power?
- What are some everyday examples of the First and Second Laws of Thermodynamics?
- What is a design brief and what are design constraints?
- Why is a design process so important to follow when creating a solution to a problem?
- What is a decision matrix and why is it used?
- What does consensus mean, and how do teams use consensus to make decisions?

Knowledge and Skills:

Students will know…

- The definition of the following terms:

ABET,	*Efficiency,*	*Friction*
Fulcrum	*Gear*	*Ideal Mechanical Advantage*
Lever	*Mechanism*	*Moment*
Pulley	*Resistance Force*	*Simple Machine*
Static Equilibrium	*Torque*	*Wedge*
Current	*Resistance*	*Resistor*
Power	*Voltage*	*Watts*

- how to differentiate between engineering and engineering technology.
- how to conduct a professional interview and reflect on it in writing.
- how to identify and differentiate among different engineering disciplines.
- how to measure forces and distances related to mechanisms.
- how to distinguish between the six simple machines, their attributes, and components.

- how to calculate mechanical advantage and drive ratios of mechanisms.
- how to design, create, and test gear, pulley, and sprocket systems.
- how to calculate work and power in mechanical systems.
- how to identify and categorize energy sources as nonrenewable, renewable, or inexhaustible.
- how to create and deliver a presentation to explain a specific energy source.
- the possible types of power conversion.
- how to calculate work and power.
- how to demonstrate the correct use of a digital multimeter.
- how to determine efficiency of a system that converts an electrical input to a mechanical output.
- how to calculate circuit resistance, current, and voltage using Ohm's law.
- how to understand the advantages and disadvantages of parallel and series circuit design in an application.
- how to brainstorm and sketch possible solutions to an existing design problem.
- how to create a decision-making matrix for a design problem.
- how to present a workable solution to the design problem.

Students will be able to…

- identify and categorize energy sources as nonrenewable, renewable, or inexhaustible.
- design, create, test, and evaluate a compound machine design.
- conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.
- identify and utilize the steps of the engineering design process.
- solve basic engineering challenges through an engineer's mentality.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Formative Assessments
- Summative Assessment
- Class Participation (Very Important)
- Completion of reinforcement worksheets and note sheets
- Student class presentations
- Group projects
- End of Unit Assessment
- Lab reports

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class Lectures
- Supportive Worksheet and note sheets
- Lab activities
- Field trips to engineering/technical sites
- Group and Independent research projects

RESOURCES

Teacher Resources:

- Presentations designed for class lectures
- Engineering/Technology websites
- Teacher designed worksheets
- Project Lead The Way
- Energy and Power textbooks
- IEEE Careers in Power & Energy.
- https://www.energy.gov/eere/education/energy-literacy-essential-principles-energy-education
- https://www.ee-scholarship.org/careers-in-power-energy
- Work, Energy and Power - Basics https://www.youtube.com/watch?v=_MR1Dp8-F8w
- Electric Power and Energy https://www.youtube.com/watch?v=qTOY53JOUcA

Equipment Needed:

- Classroom computers
- Electricity and Electronics Software
- Multimeter, generators, transformers, circuit breakers, relays

UNIT OVERVIEW

Content Area: Principles of Engineering

Unit Title: Materials and Statics

Target Course/Grade Level: Grades 10-12

Unit Summary: The goal of this unit is for students to have a more concrete understanding of engineering through materials properties and statics. Students begin by learning about beam deflection and then forces on truss structures. The students learn about material properties which lead students to develop the ability to properly select a material for a given task and how to reuse/recycle materials for continued and unique uses. The primary way of studying materials properties in this unit is through destructive and non-destructive material testing on various materials. Tensile testing is the major destructive test. Students are engaged in how machines perform these tests and use either a classroom machine or a simulation to further their understanding of these processes. This unit concludes with a design problem whereby students, working in teams, follow the design process to solve a design problem.

Approximate Length of Unit: 9 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

9.4.12.O.(1).5: Explain relevant physical properties of materials used in engineering and technology.

9.4.12.O.(1).4: Demonstrate the ability to use Newton's laws of motion to analyze static and dynamic systems with and without the presence of external forces.

9.3.MN-PPD.5: Develop procedures to create products that meet customer needs.

9.3.MN-QA.1: Evaluate production operations for product and process quality.

9.3.MN-QA.3: Coordinate work teams to create a product that meets quality assurance standards.

9.3.MN-QA.4: Employ project management processes using data and tools to deliver quality, value-added products.

9.3.ST.:1:
Apply engineering skills in a project that requires project management, process control and qualit y assurance.

9.3.MN-PPD.2: Research, design, and implement alternative manufacturing processes to manage production of new and/or improved products.

9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.

9.3.ST-ET.4: Apply the elements of the design process.

9.3.ST-SM.4: Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
9.4.12.M.(4).1:Use communications strategies common to quality assurance careers to ensure that production meets business requirements.
9.4.12.O.(1).3: Demonstrate the ability to select, apply, and convert systems of measurement to solve problems.
9.4.12.O.(1).7: Use mathematics, science, and technology concepts and processes to solve problems in projects involving design and/or production (e.g., medical, agricultural, biotechnological, energy and power, information and communication, transportation, manufacturing, and construction).

Career Readiness, Life Literacies, and Key Skills:
9.3.12.AC-DES.2: Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
9.3.12.AC-DES.6: Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
9**.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.TL.1: Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.

21st Century Learning Standards
Career Ready Practices:
CRP1. Act as a responsible and contributing citizen and employee.
CRP2. Apply appropriate academic and technical skills.
CRP4. Communicate clearly and effectively and with reason.
CRP5. Consider the environmental, social and economic impacts of decisions.
CRP6. Demonstrate creativity and innovation.
CRP7. Employ valid and reliable research strategies.
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP9. Model integrity, ethical leadership and effective management.
CRP10. Plan education and career paths aligned to personal goals.
CRP11. Use technology to enhance productivity.

Interdisciplinary Connections and Standards:
HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Mathematical Practices.

MP.1. Make sense of problems and persevere in solving them.
MP.2. Reason abstractly and quantitatively.
MP.3. Construct viable arguments and critique the reasoning of others.
MP.4. Model with mathematics.
MP.5. Use appropriate tools strategically.
MP.6. Attend to precision.
MP.7. Look for and make use of structure.
MP.8. Look for and express regularity in repeated reasoning

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

WHST.9-10.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

RST.9-10.5: Analyze the relationship among concepts in a text, including relationship among key terms (e.g., force, friction, reaction force, energy, work)

RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Unit Understandings:

Students will understand that…

- the Laws of Motion describe the interaction of forces acting on a body.
- structural member properties including centroid location, moment of inertia, and modulus of elasticity are important considerations for structure design.
- static equilibrium occurs when the sum of all forces acting on a body are equal to zero.
- applied forces are vector quantities with a defined magnitude, direction, and sense, and can be broken into vector components.
- free body diagrams are used to illustrate and calculate forces acting upon a given body.
- materials consist of pure elements. Compounds and mixtures are typically classified as metallic, ceramic, organic, polymeric, and composite.

- material properties including recyclability and cost are important considerations for engineers when choosing appropriate materials for a design.
- material selection is based upon mechanical, thermal, electromagnetic, and chemical properties.
- engineers utilize a design process and mathematical formulas to solve and document design problems.
- design problems can be solved by individuals or in teams.
- engineers use a design process to create solutions to existing problems.
- design briefs are used to identify the problem specifications and establish project constraints.
- teamwork requires constant communication to achieve the desired goal.
- design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

Unit Essential Questions:

- Why is it crucial for designers and engineers to construct accurate free body diagrams of the parts and structures that they design?
- Why must designers and engineers calculate forces acting on bodies and structures?
- How does an engineer predict the performance and safety for a selected material?
- What are the advantages and disadvantages of utilizing synthetic materials designed by engineers?
- What ethical issues pertain to engineers designing synthetic materials?
- How does an engineer decide which manufacturing process to use for a given material?
- How do the recycling codes and symbols differ from state to state?
- Why is it critical for engineers to document all calculation steps when solving problems?
- What is a design brief?
- What are design constraints?
- Why is a design process so important to follow when creating a solution to a problem?
- What is a decision matrix and why is it used?
- What does consensus mean, and how do teams use consensus to make decisions?
- How do the properties and types of materials affect the solution to a design problem?

Knowledge and Skills:

Students will know...

- The definition of the following terms:

Cable	Centroid	Compression Force
Cross-Sectional Area	Direction	Joint
Magnitude	Moment	Moment of Inertia

Newton's First Law	Newton's Second Law	Newton's Third Law
Resultant Force	Roller Support	Scalar
Static Equilibrium	Statically Indeterminate	Structure
Tension Force	Vector Quantity	

- The Engineering Design Process

Students will be able to…

- create free body diagrams of objects, identifying all forces acting on the object.
- mathematically locate the centroid of structural members.
- differentiate between scalar and vector quantities.
- identify magnitude, direction, and sense of a vector.
- calculate the X and Y components given a vector.
- calculate moment forces given a specified axis.
- use equations of equilibrium to calculate unknown forces.
- calculate weight, volume, mass, density, and surface area of selected common household products.
- promote recycling using current media trends.
- utilize a five-step technique to solve word problems.
- brainstorm and sketch possible solutions to an existing design problem.
- create a decision making matrix for the design problem.
- select an approach that meets or satisfies the constraints given in a design brief.
- create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon your team's decision matrix.
- present a workable design solution.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Formative Assessments
- Summative Assessment
- Class Participation (Very Important)
- Completion of reinforcement Worksheets and note sheets
- Student class presentations
- Group projects
- End of Unit Assessment
- Lab reports

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class Lectures
- Supportive Worksheet and note sheets
- Lab activities
- Field trips to engineering/technical sites
- Group and Independent research projects

RESOURCES

Teacher Resources:

- Presentations designed for class lectures
- Engineering/Technology websites
- Teacher designed worksheets
- IEEE codes
- Metallurgical Engineers

- https://www.vault.com/industries-professions/professions/m/metallurgical-engineers

Equipment Needed:

- Classroom computers
- Sketchup Software

UNIT OVERVIEW

Content Area: Principles of Engineering

Unit Title: Control Systems

Target Course/Grade Level: Grades 10 -12

Unit Summary: The goal of this unit is for students to control mechanical systems by recognizing computer outputs and gaining an understanding of how to write code to control them. Additionally, they experiment with various input devices and learn how they can adapt computer code to control computer outputs. Furthermore, students gain an understanding of fluid power, both hydraulic and pneumatic. They begin to recognize the power and control advantages of fluid power. The unit concludes with students working in teams to solve a design problem that focuses on using control systems by integrating their prior knowledge, skills, and understandings from the unit on Simple Machines, the unit on Material Properties, and this unit.

Approximate Length of Unit: 11 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

9.3.12.AG-PST.5: Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.

9.3.12.AC.6: Read, interpret and use technical drawings, documents and specifications to plan a project.

9.3.MN-PPD.2: Research, design and implement alternative manufacturing processes to manage production of new and/or improved products.

9.3.ST.5 : Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.

9.3.ST.2: Use technology to acquire, manipulate, analyze and report data.

9.3.ST-SM.1: Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

9.3.ST-SM.4: Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

9.4.12.M.15: Employ critical thinking skills (e.g., analyze, synthesize, and evaluate) independently and in teams to solve problems and make decisions.

9.4.12.M.28: Use computer-based equipment containing embedded computers or processors to control devices.

9.4.12.O.(1).5: Explain relevant physical properties of materials used in engineering and technology.

9.4.12.O.(1).6: Explain relationships among specific scientific theories, principles, and laws that apply to technology and engineering.
9.4.12.O.(1).12: Model technical competence by developing and applying processes and concepts in the design process.

Career Readiness, Life Literacies, and Key Skills:
9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.
9.3.12.AC-DES.2: Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
9.3.12.AC-DES.6: Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.
9.3.ST-ET.4: Apply the elements of the design process.

21st Century Learning Standards
Career Ready Practices:
CRP1. Act as a responsible and contributing citizen and employee.
CRP2. Apply appropriate academic and technical skills.
CRP4. Communicate clearly and effectively and with reason.
CRP5. Consider the environmental, social and economic impacts of decisions.
CRP6. Demonstrate creativity and innovation.
CRP7. Employ valid and reliable research strategies.
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP9. Model integrity, ethical leadership and effective management.
CRP10. Plan education and career paths aligned to personal goals.
CRP11. Use technology to enhance productivity.

Interdisciplinary Connections and Standards:
HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
WHST.11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Mathematical Practices.
MP.1. Make sense of problems and persevere in solving them.
MP.2. Reason abstractly and quantitatively.
MP.3. Construct viable arguments and critique the reasoning of others.

MP.4. Model with mathematics.
MP.5. Use appropriate tools strategically.
MP.6. Attend to precision.
MP.7. Look for and make use of structure.
MP.8. Look for and express regularity in repeated reasoning

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

RST.9-10.3: Follow precisely a complex multi-step procedure when carrying out experiments, taking measurements, or performing technical

RST.9-10.5: Analyze the relationship among concepts in a text, including relationship among key terms (e.g., force, friction, reaction force, energy, work)

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Unit Understandings:

Students will understand that…

- control systems are designed to provide consistent process control and reliability.
- control system protocols are an established set of commands or functions typically created in a computer programming language.
- closed loop systems use digital and analog sensor feedback to make operational and process decisions.
- fluid power systems are categorized as either pneumatic, which utilizes gas, or hydraulic, which utilizes liquid.
- fluid power is possible because in a system of confined fluid, pressure acts equally in all directions.
- the most basic components of all fluid power systems include a reservoir or receiver, a pump or compressor, a valve, and a cylinder.
- fluid power systems are designed to transmit force over great distances, multiply an input force, and increase the distance that an output will move.
- 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.
- standard schematic symbols and conventions are used to communicate fluid power designs.
- design problems can be solved by individuals or in teams.

- engineers use a design process to create solutions to existing problems.
- design briefs are used to identify the problem specifications and to establish project constraints.
- teamwork requires constant communication to achieve the desired goal.
- design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions

Unit Essential Questions:

- What are the advantages and disadvantages of using programmable logic to control machines versus monitoring and adjusting processes manually?
- What are some everyday seemingly simple devices that contain microprocessors, and what function do the devices serve?
- What questions must designers ask when solving problems in order to decide between digital or analog systems and between open or closed loop systems?
- What impact does fluid power have on our everyday lives?
- Can you identify devices or systems that do not use fluid power that might be improved with the use of fluid power?
- What are similarities and differences of mechanical advantage in simple machines and hydraulic systems?
- Why are Pascal's Law, the perfect gas laws, Bernoulli's Principle, and other similar rules important to engineers and designers of fluid power systems?
- What is a design brief and what are design constraints?
- Why is a design process so important to follow when creating a solution to a problem?
- What is a decision matrix and why is it used?
- What does consensus mean, and how do teams use consensus to make decisions?
- How does the use of mechanisms affect the overall solution to a design problem?

Knowledge and Skills:

Students will know...

- the definition of the following terms:

  Closed Loop System Electromagnet Feedback

Flowchart	Input	Interface
Microprocessor	Normally Closed	Normally Open
Open Loop System	Output	Photocell
Polarity	Potentiometer	Reed Switch
Sensor	Subroutine	Switch

- how control systems influence product innovation processes.

Students will be able to...

- create detailed flow charts utilizing a computer software application.
- create control system operating programs utilizing computer software.
- create system control programs that utilize flowchart logic.
- differentiate between the characteristics of digital and analog devices.
- design and create a control system based on given needs and constraints.
- identify devices that utilize fluid power.
- identify and explain basic components and functions of fluid power devices.
- differentiate between the characteristics of pneumatic and hydraulic systems.
- design, create, and test a hydraulic device.
- design, create, and test a pneumatic device.
- calculate values in a fluid power system utilizing Pascal's Law.
- distinguish between pressure and absolute pressure.
- calculate values in a pneumatic system, utilizing the perfect gas laws.
- calculate flow rate, flow velocity, and mechanical advantage in a hydraulic system.
- brainstorm and sketch possible solutions to an existing design problem.
- create a decision-making matrix for a design problem.
- select an approach that meets or satisfies the constraints provided in a design brief.
- create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team's decision matrix.
- present a workable solution to the design problem.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Formative Assessments
- Summative Assessment
- Class Participation (Very Important)
- Completion of reinforcement Worksheets and note sheets
- Student class presentations
- Group projects
- End of Unit Assessment
- Lab reports

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class Lectures
- Supportive Worksheet and note sheets
- Lab activities
- Field trips to engineering/technical sites
- Group and Independent research projects

RESOURCES

Teacher Resources:

- Presentations designed for class lectures
- Engineering/Technology websites
- Teacher designed worksheets
- IEEE codes
- What is Control System https://www.youtube.com/watch?v=Im88eVfkeBo
- Aircraft Hydraulic Systems https://www.flightliteracy.com/aircraft-hydraulic-systems/

Equipment Needed:

- Classroom computers
- Sketchup Software
- Lab Equipment

UNIT OVERVIEW

Content Area: Principles of Engineering

Unit Title: Statistics and Kinematics

Target Course/Grade Level: Grades 10 - 12

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

Approximate Length of Unit: 8 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

S.ID.A.2: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.

8.2.12.C.7: Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.

3.A.1.1: Express the motion of an object using narrative, mathematical, and graphical representations. [SP 1.5, 2.1, 2.2]

9.3.ST.2: Use technology to acquire, manipulate, analyze and report data.

9.3.ST.4: Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.

9.3.GV-GOV.1: Employ research skills to gather and document factual information, analyze data and interpret statistics applicable to matters of public policy.

9.3.ST-SM.1: Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

9.3.ST-SM.2: Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

9.3.ST-SM.4: Apply critical thinking skills to review information, explain statistical analysis,

and to translate, interpret and summarize research and statistical data.

9.4.12.E.26: Employ critical thinking skills independently and in teams to solve problems and make decisions, (e.g., analyze, synthesize, and evaluate).

9.4.12.E.83: Research formative and summative assessment skills needed to enhance professional practice.

9.4.12.O.(1).2: Apply and use algebraic, geometric, and trigonometric relationships, characteristics, and properties to solve problems.

9.4.12.O.(1).4:Demonstrate the ability to use Newton's laws of motion to analyze static and dynamic systems with and without the presence of external forces.

9.4.12.O.(1).9: Employ concepts and processes for the application of technology to engineering.

9.4.12.O.(2).5: Demonstrate critical thinking abilities and skills needed to review information, to explain statistical analyses, and to translate, interpret, and summarize research and statistical data collected and analyzed as the result of an investigation.

Career Readiness, Life Literacies, and Key Skills:

9.3.ST-SM.4: Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data

9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.

9.3.12.AC-DES.2: Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.

9.3.ST-SM.2: Apply science and mathematics to the developments of plans, processes and projects that address real-world problems.

9.3.ST-ET.4: Apply the elements of the design process.

9.3.ST-ET.5: Apply the knowledge learned in STEM to solve problems.

21st Century Learning Standards

Career Ready Practices:

CRP1. Act as a responsible and contributing citizen and employee.

CRP2. Apply appropriate academic and technical skills.

CRP4. Communicate clearly and effectively and with reason.

CRP5. Consider the environmental, social and economic impacts of decisions.

CRP6. Demonstrate creativity and innovation.

CRP7. Employ valid and reliable research strategies.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

CRP9. Model integrity, ethical leadership and effective management.

CRP10. Plan education and career paths aligned to personal goals.

CRP11. Use technology to enhance productivity.

Interdisciplinary Connections and Standards:

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

WHST.9-12.7: Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under Investigation for citation.

Mathematical Practices.

MP.1. Make sense of problems and persevere in solving them.
MP.2. Reason abstractly and quantitatively.
MP.3. Construct viable arguments and critique the reasoning of others.
MP.4. Model with mathematics.
MP.5. Use appropriate tools strategically.
MP.6. Attend to precision.
MP.7. Look for and make use of structure.
MP.8. Look for and express regularity in repeated reasoning

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

WHST.9-10.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

W6: Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

RH.9-10.7: Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text, to analyze information presented via different mediums.

RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Unit Understandings:

Students will understand that…

- engineers use statistics to make informed decisions based upon established principles.
- statistics is based upon both theoretical and experimental data analysis.
- when working with bodies in motion, engineers must be able to differentiate and calculate distance, displacement, speed, velocity, and acceleration.
- when air resistance is not taken into account, released objects will experience acceleration due to gravity, also known as free fall.
- projectile motion can be predicted and controlled using kinematics equations.
- when a projectile is launched, velocity in the x direction remains constant; whereas, with time, the velocity in the Y direction in magnitude and direction changes due to gravity.
- design problems can be solved by individuals or in teams.

- engineers use a design process to create solutions to existing problems.
- design briefs are used to identify the problem specifications and establish project constraints.
- teamwork requires constant communication to achieve the desired goal.
- design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

Unit Essential Questions:

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

Knowledge and Skills:

Students will know...

- The definition of the following terms:

Alternative Hypothesis	Binomial	Block Design
Central limit Theorem	Correlation	Data
Descriptive Statistics	Empirical Rule	Experiment
Geometric	Histogram	Independent
Inferential Statistics	Interpolation	Law of Large Numbers
Mean	Median	Mode
Normal	Population	Probability
Qualitative	Quantitative	Quota Sample
Random Sample	Sampling Distribution	Scatter plot
Standard Deviation	Statistic	Statistical Significance
Stem plot	Systematic	Sample
Direction	Displacement	Coordinates
Velocity	Acceleration	Distance

- how the processes of gathering, organizing, interpreting, and formulating an understanding of data through probability and statistics
- how kinematics, which is concerned with the geometric aspects of motion, and kinetics, which are concerned with the forces causing the motion.

Performance Performance:

Students will be able to...

- calculate the theoretical probability that an event will occur.
- calculate the experimental frequency distribution of an event occurring.
- create a histogram to illustrate frequency distribution.
- calculate the central tendency of a data array, including mean, median, and mode.
- calculate data variation, including range, standard deviation,
- calculate distance, displacement, speed, velocity, and acceleration from data.
- calculate acceleration due to gravity given data from a free fall device.
- calculate the X and Y components of a projectile motion.

- determine the angle needed to launch a projectile a specific range given the projectile's initial velocity.
- create a decision-making matrix for their design problem.
- create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team's decision matrix.
- present a workable solution to the design problem.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Class Lectures
- Supportive Worksheet and note sheets
- Lab activities
- Field trips to engineering/technical sites
- Group and Independent research projects

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Vector Addition: To determine the value of a resultant of several vectors, and then compare that value to the values obtained through graphical and analytical methods
- Free-Fall Investigation: To determine and compare the acceleration of two objects dropped simultaneously.
- Class Lectures
- Supportive Worksheet and note sheets
- Lab activities
- Field trips to engineering/technical sites
- Group and Independent research projects

RESOURCES

Teacher Resources:

- Presentations designed for class lectures
- Engineering/Technology websites
- Teacher designed worksheets
- What is Kinematics https://www.youtube.com/watch?v=QpkDGtQIi4w
- Kinematics - The Basics https://www.youtube.com/watch?v=198u1x8TBTo

- Kinematics Studies 
- **https://www.dtb.com/engineering-design-kinematics.php**

Equipment Needed:

- Classroom computers
- Sketchup Software
- Lab Equipment
- Laboratory equipment as specified for lab activities