CASE

Agricultural Power and Technology
Expanded Lesson Review

The following is a complied listing of the concepts, performance objectives, standards alignments, and essential questions by lesson.

Lesson 1.1 Mechanical World

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Organization and record keeping are important to success in agricultural mechanics.	• Develop and keep an Agriscience Notebook to record and store information. (Activity 1.1.1)
2. The agricultural industry uses power and technology to produce food, fiber, and fuel that are essential for everyday life.	• Research systems in power and technology and explain how they are applied in agriculture. (Activity 1.1.2)
3. Power and technology increase the efficiency of agriculture, food, and natural resource production.	• Calculate and compare the efficiency of different tools. (Activity 1.1.3)
4. People in agricultural power and technology use the engineering design process to increase agricultural productivity and solve problems.	• Identify how an entrepreneur in agricultural mechanics used the engineering process to improve production of food, fiber, and fuel. (Activity 1.1.4)
	• Design a prototype using the engineering design process to solve a problem. (Project 1.1.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
3. Attend to personal health and financial well-being.
• CRP.03.01: Design and implement a personal wellness plan.
• CRP.03.02: Design and implement a personal financial management plan.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
Agriculture, Food, and Natural Resources Career Cluster
2. Evaluate the nature and scope of the Agriculture, Food & Natural Resources Career Cluster and the role agriculture, food and natural resources (AFNR) play in society and the economy.
• AG 2.3: Explain the types of industries, organizations, and activities part of AFNR.

Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.1: Select energy sources for power generation.
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.
ETS1.B: Developing Possible Solutions	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to clarify and/or seek additional information. ▪ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Design a test of a model to ascertain its reliability.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
	• Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
	• Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

	• Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks.

Understandings about the Nature of Science	
Science is a Human Endeavor	• Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **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.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What is agricultural mechanics?
2. Why are the terms agricultural mechanics and agricultural power and technology used interchangeably?
3. How can you use mechanical systems in agriculture?
4. What is the purpose of a tool?
5. Where do you use machines in the agricultural industry?
6. What makes a machine efficient?
7. How do you measure efficiency?
8. What are the major components of the engineering design process?
9. How do you use prototypes in the engineering design process?
10. How is the engineering design process used to improve agricultural production?
11. production and access to food, fiber, and fuel.

Lesson 1.2 Mechanical Basics

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Many forms of potential and kinetic energy are used in agriculture to complete tasks or work.	• Identify types of energy used and managed in agriculture. (Activity 1.2.1)
2. Machines in agriculture are designed to harness and transfer energy to perform work.	• Make a windmill to convert wind energy into mechanical energy. (Project 1.2.2)
3. Work and power calculations are used to determine efficiencies in agricultural systems.	• Calculate the work completed by a machine. (Activity 1.2.3) • Calculate and compare power in English and SI units. (Activity 1.2.4)
4. Communication and writing skills complement the operation of mechanical equipment used in agricultural power and technology careers.	• Develop a technical manual for machines that use different forms of energy. (Project 1.2.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.1: Select energy sources for power generation.
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS3: Energy	
PS3.A: Definitions of Energy	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. •

PS3.B: Conservation of Energy and Energy Transfer	• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
PS3.D: Energy in Chemical Processes and Everyday Life	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. •
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.B: Developing Possible Solutions	• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to clarify and refine a model, an explanation, or an engineering problem. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Mathematical representations are needed to identify some patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Open to Revision in Light of New Evidence	• Scientific explanations can be probabilistic. • Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. • Laws are statements or descriptions of the relationships among observable phenomena. • Scientists often use hypotheses to develop and test theories and explanations.
Science is a Human Endeavor	• Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Algebra	
Seeing Structure in Expressions	• *Interpret the structure of expressions. • *Write expressions in equivalent forms to solve problems.
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning.

	• Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). •
Integration of Knowledge and Ideas	• **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. •

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. • **WHST.9-10.6 –** Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. How is agriculture dependent upon the used of energy?
2. How does a machine harness energy?
3. What are the different forms of energy used in agriculture?
4. How is energy converted into a useable form?
5. What happens to energy when it is transferred through a machine?

6. How is force dependent upon energy?
7. How is force measured?
8. Why is agriculture dependent upon work?
9. What factors determine how much work a machine can accomplish?
10. How is power different than work?
11. How is power measured?
12. What is the difference between SI and English measurements of power?
13. What factors determine how much power a machine produces?
14. How is a technical manual developed?
15. Where is a technical manual used in industry?

Lesson 2.1 Safety Setting

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Site-specific safety policies and procedures are in place for agricultural mechanic shops and labs.	• Identify workplace hazards and the causes for accidents. (Activity 2.1.1) • Develop a standard set of safety requirements for an agricultural shop. (Project 2.1.2)
2. Safety must be planned and systematic for effective identification and management in a laboratory or shop.	• Assess a shop to determine if safety standards are being met and make recommendations for changes. (Project 2.1.3)
3. Personal protective equipment is the last line of defense against injury.	• Identify types of PPE and their uses in the shop. (Activity 2.1.4)
4. The purpose of first aid is to treat injuries or accidents in order to sustain life until professional medical attention can be received.	• Prepare an emergency first aid booklet. (Activity 2.1.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
1. Act as a responsible and contributing citizen and employee.
• CRP.01.01: Model personal responsibility in the workplace and community.
• CRP.01.02: Evaluate and consider the near-term and long-term impacts of personal and professional decisions on employers and community before taking action.
• CRP.01.03: Identify and act upon opportunities for professional and civic service at work and in the community.
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.

5. Consider the environmental, social and economic impacts of decisions.
• CRP.05.01: Assess, identify and synthesize the information and resources needed to make decisions that positively impact the workplace and community.
6. Demonstrate creativity and innovation.
• CRP.06.02: Assess a variety of workplace and community situations to identify ways to add value and improve the efficiency of processes and procedures.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.01: Apply reason and logic to evaluate workplace and community situations from multiple perspectives.
• CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
Agriculture, Food, and Natural Resources Career Cluster
1. Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Resources Career Cluster.
• AG 1.1: Explain how regulations and major laws impact management of AFNR activities.
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
• AG 3.1: Examine health risks associated with a particular skill to better form personnel safety guidelines.
• AG 3.2: Develop response plans to handle emergencies.
• AG 3.3: Identify hazards and acquire first aid skills to promote environmental safety.
• AG 3.4: Examine required regulations to maintain/improve safety, health and environmental management systems and sustainable business practices.
• AG 3.5: Enact procedures that demonstrate the importance of safety, health, and environmental responsibilities in the workplace.
• AG 3.6: Demonstrate methods to correct common hazards.
• AG.3.7: Demonstrate application of personal and group health and safety practices.
Power, Structural and Technical (AG-PST)
2. Operate and maintain mechanical equipment related to AFNR power, structural, and technical systems.
• AG-PST 2.1: Maintain machinery and equipment by performing scheduled service routines.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.B: Developing Possible Solutions	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.

Crosscutting Concepts	
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Range of Reading and Level of Text Complexity	• **RST.9-10.10 –** By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What are the most dangerous jobs in the United States?
2. Why does the agricultural industry have some of the most dangerous jobs?
3. What makes a job dangerous?
4. What are common injuries that occur on a job site?
5. What are the major causes of accidents?
6. Who sets standards for safe working environments?
7. How do you assess a work environment for safety?
8. What hazards might you find in an agricultural mechanics workplace?
9. What preventive measures can you take to make a work environment safe?
10. What materials or items should be available in a work environment in case an accident occurs?
11. What is first aid?
12. What factors determine how you provide first aid to a victim?
13. What type of personal protective equipment should you wear in an agricultural work area?
14. How do you select the PPE required for operating a tool or machine?

Lesson 2.2 Tool Operation

Concepts	Performance Objectives
Students will know and understand 1. Tools are designed for specific applications.	*Students will learn concepts by doing* • Select correct hand tools for a specific job. (Project 2.2.1)

2. The function of tools and machines will affect how they are operated. 3. Operating procedures for machines and tools keep the operator safe and the machine or tool in good working order.	• Identify the components of a power tool and determine any hazards present by using a safety evaluation form. (Activity 2.2.2) • Write an operating procedure for using a power tool safely. (Activity 2.2.3)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
11. Use technology to enhance productivity.
• CRP.11.01: Research, select and use new technologies, tools and applications to maximize productivity in the workplace and community.
Agriculture, Food, and Natural Resources Career Cluster
1. Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Resources Career Cluster.
• AG 1.1: Explain how regulations and major laws impact management of AFNR activities.
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
• AG 3.1: Examine health risks associated with a particular skill to better form personnel safety guidelines.
• AG 3.3: Identify hazards and acquire first aid skills to promote environmental safety.
• AG 3.4: Examine required regulations to maintain/improve safety, health and environmental management systems and sustainable business practices.
• AG 3.5: Enact procedures that demonstrate the importance of safety, health, and environmental responsibilities in the workplace.
• AG 3.6: Demonstrate methods to correct common hazards.
• AG.3.7: Demonstrate application of personal and group health and safety practices.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
2. Operate and maintain mechanical equipment related to AFNR power, structural, and technical systems.
• AG-PST 2.1: Maintain machinery and equipment by performing scheduled service routines.
• AG-PST 2.3: Operate machinery and equipment while observing all safety precautions.

Next Generation Science Standards Alignment

Crosscutting Concepts	
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect.

Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **RST.9-10.2 –** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • **RST.9-10.3 –** 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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.6 –** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
Range of Reading and Level of Text Complexity	• **RST.9-10.10 –** By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. •
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What are the hazards of using the wrong tool for a job?
2. Why are tools specialized for a particular job?
3. Why should people use the correct tool for a job?
4. What are the three components of all power tools?
5. Why are guards in place on power tools?
6. What are the hazardous motions and actions of a power tool?

7. What are common safety concerns when operating a power tool?
8. How are operating procedures for power tools similar?

Lesson 2.3 Tools of Measurement

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Precise and accurate measurements are important for fabrication of materials.	• Compare precise and accurate measurements using a combination square and caliper. (Activity 2.3.1)
2. Measurements are expressed in different forms and units.	• Measure the size of materials and convert the measurements to fractions or decimals. (Activity 2.3.2)
3. Estimation is used for completing a project or activity.	• Use pacing to estimate the distance between two points. (Activity 2.3.3)
4. The Pythagorean Theorem can be used to determine if a corner is square.	• Use the Pythagorean Theorem to determine if an area is square and square a corner using a 3-4-5 triangle. (Activity 2.3.4)
5. Area is calculated using mathematical formulas.	• Use mathematical formulas to measure an area of land. (Activity 2.3.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
11. Use technology to enhance productivity.
• CRP.11.01: Research, select and use new technologies, tools and applications to maximize productivity in the workplace and community.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
Science and Engineering Practices	
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability.

	• Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns.
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Geometry	
Congruence	• Make geometric constructions.
Similarity, Right Triangles, and Trigonometry	• *Define trigonometric ratios and solve problems involving right triangles.
Modeling with Geometry	• *Apply geometric concepts in modeling situations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.

Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
Integration of Knowledge and Ideas	• **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.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. How do you find the precision of a manufactured part?
2. What determines the accuracy of tool?
3. Why is it important to be precise and accurate when making measurements and cutting material?
4. Why do some measurement tools need to be more accurate than others?
5. What is a jig?
6. How are fractions converted to decimals?
7. Where are fractions and decimals used in agriculture?
8. When is it appropriate to make estimations?
9. What angle is considered square?
10. How do you use the 3-4-5 triangle method to square a corner?
11. Why are 90° corners important?
12. How is the area of an irregular shape measured?

Lesson 3.1 Heavy Metal

Concepts	**Performance Objectives**
Students will know and understand	*Students will learn concepts by doing*
1. Metals used in agriculture can be identified using physical properties.	• Identify metals based upon their physical properties. (Activity 3.1.1)
2. Chemical properties of metal determine how it reacts with other metals in the environment.	• Explain how metals chemically react in certain environmental conditions. (Activity 3.1.2) • Explain how metals react with each other. (Activity 3.1.3)
3. Mechanical properties of metal determine its service life and applications.	• Compare and contrast tensile strength, ductility, brittleness, and hardness of common metals used in agriculture. (Activity 3.1.4)
4. Metals physically change based upon environmental factors.	• Measure the thermal conductivity and thermal expansion of different metals. (Activity 3.1.5)

	• Treat metal with heat and compare the physical changes. (Activity 3.1.6)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
11. Use technology to enhance productivity.
• CRP.11.01: Research, select and use new technologies, tools and applications to maximize productivity in the workplace and community.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
4. Plan, build and maintain AFNR structures.
• AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS1: Matter and Its Interactions	
PS1.A: Structure and Properties of Matter	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
PS1.B: Chemical Reactions	• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
PS2: Motion and Stability: Forces and Interactions	
PS2.B: Types of Interactions	• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
PS3: Energy	
PS3.B: Conservation of Energy and Energy Transfer	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to clarify and/or seek additional information.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

	• Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
	• Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Crosscutting Concepts

Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
Scale, Proportion, and Quantity	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
	• Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• The total amount of energy and matter in closed systems is conserved.
Structure and Function	The way an object is shaped or structured determines many of its properties and functions.
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Stability and Change	For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.
	• Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Understandings about the Nature of Science

Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science disciplines share common rules of evidence used to evaluate explanations about natural systems.
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that has been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.
Science is a Way of Knowing	• Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge.
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.
Make Inferences and Justify Conclusions	• *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). •
Integration of Knowledge and Ideas	• **RST.9-10.9 –** Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
Range of Reading and Level of Text Complexity	• **RST.9-10.10 –** By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What types of metals are used in agriculture?
2. What are physical and chemical properties of metal?
3. How do the physical and chemical properties of a metal influence its use?
4. How does the environment affect metal components of a machine?
5. What are the mechanical properties of metals?
6. What factors determine if a metal is attracted to a magnet?
7. How does thermal conductivity influence choosing a metal?
8. How is a metal chosen for electrical wiring?
9. What happens to metals when they are exposed to heat?
10. How is annealing and tempering used to change the mechanical properties of metal?

Lesson 3.2 Woods and Plastics

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Wood is selected based on physical and mechanical properties.	• Determine the relationship between density and tensile strength of species of wood. (Activity 3.2.1)
2. Environmental factors determine the type of wood used for a project.	• Test the effect moisture has on the dimensional stability of different wood species. (Activity 3.2.2)
3. Plastics used in agriculture are designed for a specific purpose.	• Identify different types of plastics and their uses. (Project 3.2.3)
4. The chemical makeup of plastics determine their mechanical properties.	• Make plastics with varying mechanical properties. (Activity 3.2.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
Agriculture, Food, and Natural Resources Career Cluster
6. Analyze the interaction among AFNR systems in the production, processing and management of food, fiber and fuel and the sustainable use of natural resources.
• AG.6.2: Explain the interconnectedness of systems within AFNR.

Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
4. Plan, build and maintain AFNR structures.
• AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS1: Matter and Its Interactions	
PS1.A: Structure and Properties of Matter	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to clarify and/or seek additional information. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
	• Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
Constructing Explanations and	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Designing Solutions	• Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect.
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Structure and Function	The way an object is shaped or structured determines many of its properties and functions.
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Stability and Change	For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.
	• Much of science deals with constructing explanations of how things change and how they remain stable.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. • The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science disciplines share common rules of evidence used to evaluate explanations about natural systems. • Science includes the process of coordinating patterns of evidence with current theory.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.
Making Inferences and Justifying Conclusions	• *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **RST.9-10.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • **RST.9-10.2 –** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • **RST.9-10.3 –** 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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). • **RST.9-10.6 –** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
Production and Distribution of Writing	• **WHST.9-10.6 –** Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What are common defects found in lumber?
2. How does the density of lumber vary among different species?
3. What is the relationship between tensile strength and wood density?
4. What are structural concerns with lumber that has a high moisture content?
5. How does weather and humidity affect lumber volume?

6. Where are thermoplastics used in the agricultural industry?
7. What are the advantages and disadvantages of using thermoset plastic?
8. What types of plastics are used in agriculture?
9. How does the molecular makeup of a plastic affect its strength?
10. Why are cross-linked polymers a required component of a plastic?
11. How do polymers link together to make plastics?
12. How do cross-linked bonds in plastics affect a plastics strength?

Lesson 3.3 Fluid Material

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Fluids cool and lubricate agricultural machines and equipment.	• Determine how lubrication can reduce the friction produced in a machine. (Activity 3.3.1)
2. Solutions need to be mixed with the correct proportions to function correctly.	• Prepare solutions of water and antifreeze and compare their physical properties.(Activity 3.3.2)
3. Temperature can change the physical properties of fluids.	• Calculate the viscosity of different oils at varying temperatures. (Activity 3.3.3)
4. Machines use gases, such as air, to produce power.	• Observe and demonstrate the relationship between airflow and air pressure. (Activity 3.3.4)
	• Construct a windmill using Bernoulli's Principle as a basis for design. (Project 3.3.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
2. Operate and maintain mechanical equipment related to AFNR power, structural, and technical systems.
• AG-PST 2.3: Operate machinery and equipment while observing all safety precautions.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS3: Energy	
PS3.A: Definitions of Energy	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
PS3.B: Conservation of Energy and Energy Transfer	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • The availability of energy limits what can occur in any system.
PS3.C: Relationship Between Energy and Forces	• When two objects interacting through a field change relative position, the energy stored in the field is changed.
PS3.D: Energy in Chemical Processes and Everyday Life	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.
ETS1.B: Developing Possible Solutions	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.
Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to clarify and/or seek additional information. ▪ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem. • Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability.

	• Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between variables. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Engaging in Argument from Evidence	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

	• Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect.
Scale, Proportion, and Quantity	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
	• Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
Structure and Function	The way an object is shaped or structured determines many of its properties and functions.
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Stability and Change	For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.
	• Much of science deals with constructing explanations of how things change and how they remain stable.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. • Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. • The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science disciplines share common rules of evidence used to evaluate explanations about natural systems. • Science includes the process of coordinating patterns of evidence with current theory. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
Science Models, Laws, Mechanisms, and	• Theories and laws provide explanations in science, but theories do not with time become laws or facts. • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that has been repeatedly confirmed through observation and experiment, and the science community

Theories Explain Natural Phenomena	validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. • Laws are statements or descriptions of the relationships among observable phenomena. • Scientists often use hypotheses to develop and test theories and explanations.
Science is a Way of Knowing	• Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge. • Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.
Science is a Human Endeavor	• Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Seeing Structure in Expressions	• *Interpret the structure of expressions. • *Write expressions in equivalent forms to solve problems.
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable. • *Summarize, represent, and interpret data on two quantitative variables. • *Interpret linear models.
Making Inferences and Justifying Conclusions	• *Understand and evaluate random processes underlying statistical experiments. • *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). • **RST.9-10.6 –** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
Integration of Knowledge and Ideas	• **RST.9-10.7 –** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • **RST.9-10.8 –** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CCSS: English Language Arts Standards » Writing » Grade 9-10

Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. • **WHST.9-10.2.F –** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Research to Build and Present Knowledge	• **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.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What is the relationship between friction and force?
2. How does friction affect the work a machine can do?
3. How does oil reduce friction?
4. What is the relationship between friction and heat?
5. What are the advantages and disadvantages of different lubricants?
6. How are liquids used to cool machines?
7. How can density be used to determine a percent solution?
8. How are antifreezes used in machines?
9. What is the relationship between temperature and viscosity of oils?
10. What is shear force?
11. What factors determine the terminal velocity of an object?
12. How do you measure viscosity?
13. What is Bernoulli's Principle?
14. How do you use Bernoulli's Principle to design machines?
15. How does an atomizer vaporize a liquid?
16. How do you apply Bernoulli's Principle to windmill design?

Lesson 3.4 Material Management

Concepts	Performance Objectives

Students will know and understand	*Students will learn concepts by doing*
1. Water and land are material that are mechanically managed and conserved.	• Measure the relationship between slope and velocity of water and observe management techniques to control erosion on sloped land. (Activity 3.4.1)
2. Slope has an impact on the mechanics and design of materials.	• Calculate the slope of land between two points using surveying equipment. (Activity 3.4.2)
3. The strength of concrete is dependent upon proper mixing and curing of materials.	• Mix concrete and observe the chemical and physical changes. (Activity 3.4.3) • Test the compression strength of different mixtures of concrete. (Activity 3.4.3)
4. Volume calculations and proportions are used for properly mixing concrete.	• Complete mathematical calculations to mix concrete using proportions and volume calculations. (Activity 3.4.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
• CRP.10.03: Develop relationships with and assimilate input and/or advice from experts (e.g., counselors, mentors, etc.) to plan career and personal goals in a chosen career area.
• CRP.10.04: Identify, prepare, update and improve the tools and skills necessary to pursue a chosen career path.
Agriculture, Food, and Natural Resources Career Cluster
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
• AG 3.1: Examine health risks associated with a particular skill to better form personnel safety guidelines.
6. Analyze the interaction among AFNR systems in the production, processing and management of food, fiber and fuel and the sustainable use of natural resources.
• AG.6.1: Explain foundational cycles and systems of AFNR.
• AG.6.2: Explain the interconnectedness of systems within AFNR.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
4. Plan, build and maintain AFNR structures.
• AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS1: Matter and Its Interactions	
PS1.B: Chemical Reactions	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

PS2: Motion and Stability: Forces and Interactions	
PS2.A: Forces and Motion	• Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved.
PS3: Energy	
PS3.A: Definitions of Energy	• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.
PS3.B: Conservation of Energy and Energy Transfer	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
PS3.C: Relationship Between Energy and Forces	• When two objects interacting through a field change relative position, the energy stored in the field is changed.
PS3.D: Energy in Chemical Processes and Everyday Life	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem.
	• Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

	• Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
Scale, Proportion, and Quantity	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
	• Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
Structure and Function	The way an object is shaped or structured determines many of its properties and functions.
	• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.

Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science disciplines share common rules of evidence used to evaluate explanations about natural systems.
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.
Science is a Human Endeavor	• Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Seeing Structure in Expressions	• *Interpret the structure of expressions. • *Write expressions in equivalent forms to solve problems.
Creating Equations	• *Create equations that describe numbers or relationships.
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations. • *Represent and solve equations and inequalities graphically.
CCSS: Conceptual Category – Geometry	
Similarity, Right Triangles, and Trigonometry	• *Define trigonometric ratios and solve problems involving right triangles.
Geometric Measurement and Dimension	• *Explain volume formulas and use them to solve problems. • Visualize relationships between two-dimensional and three-dimensional objects.
Modeling with Geometry	• *Apply geometric concepts in modeling situations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable. • *Summarize, represent, and interpret data on two categorical and quantitative variables. • *Interpret linear models.
Making Inferences and Justifying Conclusions	• *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). • **RST.9-10.6 –** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

Integration of Knowledge and Ideas	• **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.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **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.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. How is the slope of land calculated?
2. How does slope impact agricultural construction projects?
3. What is the relationship between slope and velocity of water?
4. How is surveying used in agriculture?
5. How is elevation of land measured?
6. How is the grade of land measured?
7. What are the physical and chemical properties of concrete?
8. What are the components of concrete?
9. How does concrete react with water?
10. How do you mix concrete?
11. What math formulas are used to mix concrete and determine volume?
12. What factors determine the strength of concrete?

Lesson 4.1 Making a Plan

Concepts	**Performance Objectives**
Students will know and understand	*Students will learn concepts by doing*
1. Accurate plans and scaled drawings are essential for project success.	• Draw a floor plan of a shop to scale. (Project 4.1.1) • Draw isometric and orthographic depictions of three-dimensional objects. (Activity 4.1.2)
2. A bill of materials accounts for all items needed to complete a project and assists in determining the budget.	• Complete a bill of materials for the construction of a wooden table. (Activity 4.1.3)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
Power, Structural and Technical (AG-PST)

4. Plan, build and maintain AFNR structures.
• AG-PST 4.1: Create sketches and plans of agricultural structures.
• AG-PST 4.2: Apply structural plans, specifications, and building codes.
• AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Creating Equations	• *Create equations that describe numbers or relationships.
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Geometry	
Congruence	• Make geometric constructions.
Geometric Measurement and Dimension	• *Explain volume formulas and use them to solve problems. • Visualize relationships between two-dimensional and three-dimensional objects.
Modeling with Geometry	• *Apply geometric concepts in modeling situations.

CCSS: Conceptual Category – Statistics and Probability	
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
Integration of Knowledge and Ideas	• **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.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **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.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. How are floor plans used to design a building or structure?
2. How do you use ratios and proportions when drawing to scale?
3. When are orthographic drawings used for project planning?
4. What are the advantages and disadvantages of isometric drawings?

5. Why do fabricators need multiple views of an object during the construction process?
6. How do you find dimensions of an object when reading a scale drawing?
7. What are the components of a bill of materials?
8. How are board feet calculated?
9. How do you determine the costs of a project?

Lesson 4.2 Making the Cut

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. A variety of tools are used to process bulk materials into useable parts.	• Identify different types of cutting tools and blades. (Activity 4.2.1) • Fabricate a nut and bolt with a tap and die. (Activity 4.2.3)
2. Proper measurements and efficient use of materials are essential when manufacturing useable parts.	• Demonstrate how the kerf must be considered when cutting material. (Activity 4.2.2)
3. Quality products are produced by following procedural steps.	• Write a prescribed procedure to cut pieces of metal. (Project 4.2.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
2. Operate and maintain mechanical equipment related to AFNR power, structural, and technical systems.
• AG-PST 2.3: Operate machinery and equipment while observing all safety precautions.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.
4. Plan, build and maintain AFNR structures.
• AG-PST 4.1: Create sketches and plans of agricultural structures.
• AG-PST 4.2: Apply structural plans, specifications, and building codes.
• AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Next Generation Science Standards Alignment

Crosscutting Concepts	
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Geometry	
Geometric Measurement and Dimension	• Visualize relationships between two-dimensional and three-dimensional objects.
Modeling with Geometry	• *Apply geometric concepts in modeling situations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
Integration of Knowledge and Ideas	• **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.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Research to Build and Present Knowledge	• **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.

Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What types of tools do you use for cutting material?
2. How are tools designed to cut specific types of material?
3. Why does the kerf need to be considered when cutting material?
4. Where is the cutting blade on a drill bit?
5. What are the features of blades used to cut wood and steel?
6. What safety precautions should you consider when using cutting tools?
7. How are a tap and die used for cutting metal?
8. What are the different types of threads found on bolts?
9. What should be included when writing a procedure for producing a product?
10. Why should you follow procedures when processing material?

Lesson 4.3 Fasten and Fuse

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Torque is a factor considered when fastening material together.	• Observe the effect of torque on fastener performance. (Activity 4.3.1)
2. Fasteners are selected based upon strength and durability when joining machine and structural parts.	• Test the strength and durability of different fasteners and determine where they should be used. (Activity 4.3.2)
3. A variety of welding processes are used to fuse metal.	• Research and present basic techniques for different welding processes. (Project 4.3.3)
4. Metals are welded together for a strong fit using a combination of materials.	• Identify materials used to weld metal together. (Activity 4.3.4) • Design a welding electrode for a specific job. (Activity 4.3.4)
5. Fabrication involves forming and fastening multiple types of materials together to make a useable product.	• Fabricate a doorstop using concrete, metal, and wood. (Problem 4.3.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.

6. Demonstrate creativity and innovation.
• CRP.06.01: Synthesize information, knowledge and experience to generate original ideas and challenge assumptions in the workplace and community.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
2. Operate and maintain mechanical equipment related to AFNR power, structural, and technical systems.
• AG-PST 2.3: Operate machinery and equipment while observing all safety precautions.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.
4. Plan, build and maintain AFNR structures.
• AG-PST 4.1: Create sketches and plans of agricultural structures.
• AG-PST 4.2: Apply structural plans, specifications, and building codes.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. •
ETS1.B: Developing Possible Solutions	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable

	measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
	• Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Engaging in Argument from Evidence	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks.

	• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
Structure and Function	The way an object is shaped or structured determines many of its properties and functions.
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Understandings about the Nature of Science	
Science is a Human Endeavor	• Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Statistics and Probability	
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **RST.9-10.2 –** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • **RST.9-10.3 –** 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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
Integration of Knowledge and Ideas	• **RST.9-10.7 –** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • **RST.9-10.8 –** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the

	research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. How is torque measured?
2. What is the relationship between torque and joint strength?
3. Why are there different types of fasteners used in agriculture?
4. How is an inclined plane used to do work?
5. What are the advantages of using an inclined plane?
6. Where is an inclined plane found on a fastener?
7. How do the threads of a screw affect a joint's resistance to movement?
8. What are the types of welding?
9. What processes are used to weld material together?
10. What factors influence the quality of a weld?
11. Why is filler material important to use when welding?
12. What are the features of a welding electrode?
13. How do you use an electrode to fuse metal?
14. What factors do engineers and welders consider when selecting an electrode to weld metal?
15. How do chemical elements affect the strength of a weld?
16. What factors determine the electrode chosen when welding?
17. What is fabrication?
18. What is the process for fabricating a useable product?

Lesson 5.1 Chemical Energy

Concepts	**Performance Objectives**
Students will know and understand	*Students will learn concepts by doing*
1. Chemical reactions release and absorb thermal energy.	• Make a hand warmer using elements that chemically react. (Activity 5.1.1)
2. Electrical energy can be harnessed and transferred through chemical reactions.	• Design and test a wet cell battery to power an electric motor. (Project 5.1.2)
3. Chemical energy can be converted into mechanical movement.	• Make a steam engine that propels a boat and explain the transfer of energy. (Activity 5.1.3)
4. Agriculture is a producer of renewable forms of fuel.	• Make ethanol from agricultural products. (Activity 5.1.4)
5. Fossil and bio–fuels release energy and chemical bi-products when they combust.	• Model the combustion of hydrocarbons and ethanol. (Activity 5.1.5)

6. Many factors influence the choice of an energy source.	• Compare the advantages and disadvantages of renewable and nonrenewable fuels. (Activity 5.1.6) • Measure the energy output of renewable and nonrenewable fuels. (Activity 5.1.6)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
5. Consider the environmental, social and economic impacts of decisions.
• CRP.05.01: Assess, identify and synthesize the information and resources needed to make decisions that positively impact the workplace and community.
• CRP.05.02: Make, defend and evaluate decisions at work and in the community using information about the potential environmental, social and economic impacts.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.01: Apply reason and logic to evaluate workplace and community situations from multiple perspectives.
Agriculture, Food, and Natural Resources Career Cluster
1. Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Resources Career Cluster.
• AG 1.5: Explain the impact of sustainability on ARNR activities and practices.
• AG.1.7: Demonstrate the application of biotechnology to AFNR activities.
6. Analyze the interaction among AFNR systems in the production, processing and management of food, fiber and fuel and the sustainable use of natural resources.
• AG.6.2: Explain the interconnectedness of systems within AFNR.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.1: Select energy sources for power generation.
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Earth and Space Science	
ESS3: Earth and Human Activity	
ESS3.A: Natural Resources	• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
Physical Science	
PS1: Matter and Its Interactions	
PS1.A: Structure and Properties of Matter	• Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.

	• Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.
PS1.B: Chemical Reactions	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
PS3: Energy	
PS3.A: Definitions of Energy	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.
PS3.C: Relationship Between Energy and Forces	• When two objects interacting through a field change relative position, the energy stored in the field is changed.
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. •
ETS1.B: Developing Possible Solutions	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	

Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
	• Ask questions that arise from careful observation of phenomena, or unexpected results
	  ▪ to determine relationships, including quantitative relationships, between independent and dependent variables.
	  ▪ to clarify and refine a model, an explanation, or an engineering problem.
	• Evaluate a question to determine if it is testable and relevant.
	• Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
	• Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
	• Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.

Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

	• Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
Engaging in Argument from Evidence	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

	• Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect.
Scale, Proportion, and Quantity	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
	• Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems.
Stability and Change	For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.
	• Much of science deals with constructing explanations of how things change and how they remain stable.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science disciplines share common rules of evidence used to evaluate explanations about natural systems. • Science includes the process of coordinating patterns of evidence with current theory.
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent.
Science is a Human Endeavor	• Scientific knowledge is a result of human endeavor, imagination, and creativity. • Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.
Making Inferences and Justifying Conclusions	• *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **RST.9-10.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • **RST.9-10.2 –** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • **RST.9-10.3 –** 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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). • **RST.9-10.6 –** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
Integration of Knowledge and Ideas	• **RST.9-10.7 –** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • **RST.9-10.9 –** Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. • **WHST.9-10.2.F –** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Research to Build and Present Knowledge	• **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. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What types of energy can you harness from a chemical reaction?
2. What are endothermic and exothermic reactions?
3. Where is thermal energy released during machine operation?
4. How is electrochemical energy transferred?
5. How does a battery work?
6. What are the components of a wet cell battery?
7. How can you convert thermal energy into kinetic energy?
8. Where is energy lost as it is converted from one form to another?
9. How do you produce a biofuel?
10. How are fuels produced using fermentation?
11. What are the products of combustion?
12. What are the products of incomplete combustion?
13. When does incomplete combustion occur?
14. What are the advantages and disadvantages of a biofuel?
15. What are the advantages and disadvantages of a fossil fuel?
16. How do you measure the energy efficiency of a fuel source?

Lesson 5.2 Electrical Energy

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Electricity must flow in a complete loop from the source and to the source with no breaks for a circuit to operate correctly.	• Build a complete electrical circuit. (Activity 5.2.1) • Define an open and closed circuit. (Activity 5.2.1)
2. The relationship between amps, volts, and ohms can be defined using Ohm's Law.	• Calculate amps, volts, and ohms in a circuit using Ohm's Law. (Activity 5.2.2)
3. Two types of electrical circuits used in agriculture are series and parallel.	• Construct a parallel and series circuit. (Activity 5.2.3)
4. The use of electricity requires a knowledge and understanding of relationships between voltage, current, and resistance.	• Demonstrate how a resistor affects the electrical current in circuit. (Activity 5.2.4)

5. Circuits are designed to provide electrical power for a specific job or application.	• Design, construct, and test an electrical circuit that meets certain specifications. (Project 5.2.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.1: Select energy sources for power generation.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.6: Service electrical systems by troubleshooting from schematics.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS2: Motion and Stability: Forces and Interactions	
PS2.B: Types of Interactions	• Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
	• “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents.
PS3: Energy	
PS3.A: Definitions of Energy	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
PS3.B: Conservation of Energy and Energy Transfer	• The availability of energy limits what can occur in any system.
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ETS1.B: Developing Possible Solutions	• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem.
	• Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
	• Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

	• Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world.
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
	• Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
	• Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
Scale, Proportion, and Quantity	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
	• Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system..

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science includes the process of coordinating patterns of evidence with current theory. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	• Laws are statements or descriptions of the relationships among observable phenomena. • Scientists often use hypotheses to develop and test theories and explanations.
Science is a Way of Knowing	• Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge.
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent.
Science is a Human Endeavor	• Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.
Making Inferences and Justifying Conclusions	• *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
Integration of Knowledge and Ideas	• **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.
CCSS: English Language Arts Standards » Writing » Grade 9-10	

Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. • **WHST.9-10.2.F –** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Research to Build and Present Knowledge	• **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.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What are the features of electricity?
2. How is electricity used in agriculture?
3. What is an electrical circuit?
4. What is the difference between an open and closed circuit?
5. How are amps, volts, and ohms calculated?
6. What is the relationship between ohms and volts?
7. What increases the resistance to electricity in a circuit?
8. What are parallel and series circuits?
9. How can voltage in a circuit be changed?
10. What is the purpose of a resistor in an electrical circuit?
11. Why do electrical circuits have different amperage and voltage requirements?
12. What is the process for designing a circuit?

Lesson 5.3 Mechanical Energy

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Electromagnetic fields are a source of mechanical energy used to produce rotational movement.	• Construct an electric motor and identify the parts and their functions. (Activity 5.3.1)
2. Mechanical energy can be converted into electrical power.	• Generate electrical energy with a windmill and optimize the power produced. (Activity 5.3.2)

3. The force produced in a fluid power system is measured using Pascal's Law. 4. Controlled movements of fluids under pressure produce mechanical energy.	• Calculate the force of fluids under pressure. (Activity 5.3.3) • Construct a hydraulic lift that can perform a specified amount of work. (Project 5.3.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.1: Select energy sources for power generation.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.6: Service electrical systems by troubleshooting from schematics.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS2: Motion and Stability: Forces and Interactions	
PS2.B: Types of Interactions	• Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
	• "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.
PS3: Energy	
PS3.A: Definitions of Energy	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
PS3.B: Conservation of Energy and Energy Transfer	• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

PS3.D: Energy in Chemical Processes and Everyday Life	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.
Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

	• Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Engaging in Argument from Evidence	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

	• Systems can be designed to cause a desired effect.
Scale, Proportion, and Quantity	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
	• Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science includes the process of coordinating patterns of evidence with current theory. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	• Laws are statements or descriptions of the relationships among observable phenomena. • Scientists often use hypotheses to develop and test theories and explanations.
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent.
Science is a Human Endeavor	• Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations. • *Represent and solve equations and inequalities graphically.

CCSS: Conceptual Category – Functions

Linear, Quadratic, and Exponential Models	• *Construct and compare linear, quadratic, and exponential models and solve problems. • *Interpret expressions for functions in terms of the situation they model.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable. • *Summarize, represent, and interpret data on two categorical and quantitative variables. • *Interpret linear models. • *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **RST.9-10.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • **RST.9-10.2 –** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • **RST.9-10.3 –** 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.
Integration of Knowledge and Ideas	• **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.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. • **WHST.9-10.2.F –** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Research to Build and Present Knowledge	• **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.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What are the properties of an electromagnet?
2. What are the components of an electric motor?

3. How are a generator and electric motor similar?
4. What is the relationship between electric current and magnetism?
5. How does a windmill generate electricity?
6. What is internal resistance?
7. How is electrical load varied in a circuit?
8. How are watts in an electrical machine calculated?
9. What is the relationship between electrical power and resistance in a circuit?
10. How does a hydraulic system work?
11. What are the properties of liquids?
12. What is the relationship between pressure, surface area, and force in a fluid system?
13. How does a hydraulic system provide a mechanical advantage?
14. How are hydraulic systems designed?
15. What factors should you consider when designing a hydraulic system?

Lesson 6.1 Machine Design

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Agricultural machines consist of one or more simple machines that produce linear and/or rotational movement.	• Identify the simple machines and types of motions found in agricultural equipment. (Project 6.1.1)
2. Simple machines provide a mechanical advantage.	• Measure the mechanical advantage of different classes of levers and identify where levers are used in agriculture. (Activity 6.1.2)
3. The amount of work to operate a machine will be greater than the work done by the machine.	• Calculate the efficiency of work completed by a pulley system to lift an object. (Activity 6.1.3)
4. The power and speed of a machine is dependent upon proper design.	• Use ratios to calculate speed and torque of multiple systems of gears. (Activity 6.1.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
Agriculture, Food, and Natural Resources Career Cluster
6. Analyze the interaction among AFNR systems in the production, processing and management of food, fiber and fuel and the sustainable use of natural resources.
• AG.6.1: Explain foundational cycles and systems of AFNR.
• AG.6.2: Explain the interconnectedness of systems within AFNR.

Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.1: Select energy sources for power generation.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.2: Service and repair power transmission systems following manufacturer's guidelines.
• AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.
• AG-PST 3.6: Service electrical systems by troubleshooting from schematics.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS3: Energy	
PS3.A: Definitions of Energy	At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
PS3.B: Conservation of Energy and Energy Transfer	• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
PS3.C: Relationship Between Energy and Forces	• When two objects interacting through a field change relative position, the energy stored in the field is changed.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

	• Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
	• Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect.
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. •
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science includes the process of coordinating patterns of evidence with current theory. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.
Science is a Way of Knowing	• Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review.
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.
Making Inferences and Justifying Conclusions	• *Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
Integration of Knowledge and Ideas	• **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.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **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.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. How do simple machines perform work?

2. What type of machines and equipment do you need to produce an agricultural crop?
3. How does agricultural equipment use simple machines?
4. How do machines produce linear and rotational motions?
5. How are levers used to do work?
6. How are the three classes of levers different?
7. What is a mechanical advantage?
8. How does a lever provide a mechanical advantage?
9. Where are levers used in agriculture?
10. How are pulleys used to increase the mechanical advantage of a machine?
11. Why is a machine not 100% efficient?
12. How does the work input compare to the work output of a machine?
13. What is the relationship between the speed, torque, and size of a gear?
14. What is the importance of a gear ratio in a machine?
15. What factors do you consider when designing a machine?
16. How are gears used to increase the mechanical advantage of a machine?

Lesson 6.2 Machine Management

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Technical reading involves interpreting and applying information from manuals, schematics, diagnostic tools, and measuring tools.	• Read and interpret an operation manual. (Activity 6.2.1)
2. Preventive maintenance requires a systematic periodic schedule.	• Use a technical manual to develop a maintenance schedule for a small engine. (Activity 6.2.1)
3. Troubleshooting includes identifying the problem, researching solutions, and applying the possible solutions.	• Develop a flow chart for solving a problem for a machine and use the chart for troubleshooting. (Activity 6.2.2)
4. Machines are calibrated to perform a specified task.	• Calibrate a water pump to perform a task at a specific rate. (Activity 6.2.3)
	• Design a model of a windmill that produces electricity used to pump water at a specified rate. (Problem 6.2.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.

6. Demonstrate creativity and innovation.
• CRP.06.01: Synthesize information, knowledge and experience to generate original ideas and challenge assumptions in the workplace and community.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.01: Apply reason and logic to evaluate workplace and community situations from multiple perspectives.
• CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
Agriculture, Food, and Natural Resources Career Cluster
6. Analyze the interaction among AFNR systems in the production, processing and management of food, fiber and fuel and the sustainable use of natural resources.
• AG.6.1: Explain foundational cycles and systems of AFNR.
• AG.6.2: Explain the interconnectedness of systems within AFNR.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.1: Select energy sources for power generation.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
2. Operate and maintain mechanical equipment related to AFNR power, structural, and technical systems.
• AG-PST 2.1: Maintain machinery and equipment by performing scheduled service routines.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.2: Service and repair power transmission systems following manufacturer's guidelines.
• AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.
5. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.
• AG-PST 5.1: Execute procedures and techniques for monitoring and controlling electrical systems using basic principles of electricity.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
PS3: Energy	
PS3.A: Definitions of Energy	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
PS3.B: Conservation of Energy and Energy Transfer	• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system.
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

ETS1.B: Developing Possible Solutions	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ ▪ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field with available resources and, when appropriate, frame a hypothesis based on a model or theory.
	• Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

	• Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect.
Scale, Proportion, and Quantity	In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
	• Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

	• Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence.
Science is a Way of Knowing	• Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge.
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.
Science is a Human Endeavor	• Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations. • *Represent and solve equations and inequalities graphically.

CCSS: Conceptual Category – Functions	
Interpreting Functions	• *Interpret functions that arise in applications in terms of the context.
Building Functions	• *Build a function that models a relationship between two quantities.
Linear, Quadratic, and Exponential Models	*Interpret expressions for functions in terms of the situation they model.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable. • *Interpret linear models.
Making Inferences and Justifying Conclusions	*Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems. • *Use probability to evaluate outcomes of decisions.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **RST.9-10.2 –** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • **RST.9-10.3 –** 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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). • **RST.9-10.6 –** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
Integration of Knowledge and Ideas	• **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.
CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. • **WHST.9-10.2.F –** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. What is the purpose of an operation manual?
2. Why do machines need to be maintained?
3. What is the process for developing a maintenance plan?
4. How do you develop a troubleshooting process for a machine?
5. How are problems in a broken machine identified?
6. How is a troubleshooting process planned and followed?
7. What is the purpose of calibrating a machine?

8. How do you calibrate a machine?
9. How are charts and graphs used to calibrate a machine?
10. How are new machines developed?
11. What factors determine the amount of power produced by a machine?

Lesson 6.3 Structural Design

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Requirements of a project need to abide by code, laws, or rules governing such project.	• Identify codes and laws for constructing an agricultural structure. (Activity 6.3.1)
2. Structures provide a controlled environment to protect agricultural commodities and equipment.	• Measure and compare the insulation properties of building materials. (Activity 6.3.2)
3. Agricultural structures contain joints and assemblies that withstand multiple types of forces.	• Construct and test truss designs for strength. (Activity 6.3.3)
4. Agricultural structures need to be well-planned to meet a specific need or purpose.	• Develop a plan for constructing an agricultural building. (Problem 6.3.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
5. Consider the environmental, social and economic impacts of decisions.
• CRP.05.01: Assess, identify and synthesize the information and resources needed to make decisions that positively impact the workplace and community.
• CRP.05.02: Make, defend and evaluate decisions at work and in the community using information about the potential environmental, social and economic impacts.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.01: Apply reason and logic to evaluate workplace and community situations from multiple perspectives.
Agriculture, Food, and Natural Resources Career Cluster
1. Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Resources Career Cluster.
• AG 1.1: Explain how regulations and major laws impact management of AFNR activities.
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
• AG 3.4: Examine required regulations to maintain/improve safety, health and environmental management systems and sustainable business practices.
6. Analyze the interaction among AFNR systems in the production, processing and management of food, fiber and fuel and the sustainable use of natural resources.

• AG.6.2: Explain the interconnectedness of systems within AFNR.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
4. Plan, build and maintain AFNR structures.
• AG-PST 4.1: Create sketches and plans of agricultural structures.
• AG-PST 4.2: Apply structural plans, specifications, and building codes.
• AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS3: Energy	
PS3.A: Definitions of Energy	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
PS3.B: Conservation of Energy and Energy Transfer	• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.

Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
Using Mathematics and Computational Thinking	Mathematical and computational thinking in 9-12 builds on K-8 and experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
Engaging in Argument from Evidence	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.

Crosscutting Concepts	
Patterns	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
	• Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

	• Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect.
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Energy and Matter: Flows, Cycles, and Conservation	Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
Structure and Function	The way an object is shaped or structured determines many of its properties and functions.
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence.
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.
Science is a Way of Knowing	• Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review.
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

Common Core State Standards for High School Mathematics

Modeling standards are indicated by the star symbol (*) throughout other conceptual categories.

CCSS: Conceptual Category – Number and Quantity	
Quantities	• *Reason quantitatively and use units to solve problems.

CCSS: Conceptual Category – Algebra	
Reasoning with Equations and Inequalities	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations.

CCSS: Conceptual Category – Statistics and Probability	
Interpreting Categorical and Quantitative Data	• *Summarize, represent, and interpret data on a single count or measurement variable.
Using Probability to Make Decisions	• *Calculate expected values and use them to solve problems.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 9-10	
Key Ideas and Details	• **RST.9-10.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • **RST.9-10.2 –** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • **RST.9-10.3 –** 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.
Craft and Structure	• **RST.9-10.4 –** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • **RST.9-10.5 –** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
Integration of Knowledge and Ideas	• **RST.9-10.7 –** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • **RST.9-10.8 –** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. • **WHST.9-10.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. Why are building permits required before constructing or remodeling a structure?
2. Where are building codes used and enforced?
3. What are the essential components of a building?
4. How does material selection affect the heat retention of a structure?
5. What determines the R-value of a material?
6. How does material transfer heat?
7. How do you design buildings to control the transfer of heat?

8. What are the properties of insulation materials?
9. What factors determine the types of building codes in your area?
10. How do joint selection and design affect the strength of a structure?
11. What types of loads place force on a structure?
12. What is the purpose of a truss system?
13. What factors influence the strength of a truss design?
14. What factors should you consider when designing a structure?
15. What impact does geographic location have on the design of a structure?
16. How do the contents of an agricultural structure affect its design?

Lesson 7.1 Mechanical Applications

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Communication and writing skills complement the operation of mechanical equipment used in agricultural power and technology careers.	• Complete a final draft of a technical manual for chosen tools and share the operational information about the tools with the class. (Project 1.2.5)
2. Careers in agricultural mechanics require the application of technical skill combined with material knowledge.	• Students will identify technical skills, careers, and knowledge needed in mechanical systems. (Activity 7.1.1)
3. Agricultural mechanics design and calibrate equipment to produce food, fiber, and fuel.	• Design a planter that meets the needs of a specific crop. (Problem 7.1.2)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
4. Communicate clearly, effectively and with reason.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
5. Consider the environmental, social and economic impacts of decisions.
• CRP.05.01: Assess, identify and synthesize the information and resources needed to make decisions that positively impact the workplace and community.
• CRP.05.02: Make, defend and evaluate decisions at work and in the community using information about the potential environmental, social and economic impacts.
6. Demonstrate creativity and innovation.
• CRP.06.01: Synthesize information, knowledge and experience to generate original ideas and challenge assumptions in the workplace and community.
• CRP.06.02: Assess a variety of workplace and community situations to identify ways to add value and improve the efficiency of processes and procedures.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
• CRP.08.01: Apply reason and logic to evaluate workplace and community situations from multiple perspectives.
• CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
• CRP.08.03: Establish plans to solve workplace and community problems and execute them with resiliency.
10. Plan education and career path aligned to personal goals.
• CRP.10.01: Identify career opportunities within a career cluster that match personal interests, talents, goals and preferences.

Agriculture, Food, and Natural Resources Career Cluster
5. Describe career opportunities and means to achieve those opportunities in each of the AFNR career pathways.
• AG.5.1: Locate and identify career opportunities that appeal to personal career goals.
• AG.5.2: Match personal interest and aptitudes to selected careers.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
• AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
• AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.
• AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.
ETS1.B: Developing Possible Solutions	• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from careful observation of phenomena, or unexpected results ▪ to clarify and/or seek additional information. ▪ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ▪ to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ to clarify and refine a model, an explanation, or an engineering problem. • Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

	• Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Crosscutting Concepts	
Systems and System Models	A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Understandings about the Nature of Science	
Science is a Human Endeavor	• Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.
Science Addresses Questions About the Natural and Material World.	• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Writing » Grade 9-10	
Text Types and Purposes	**WHST.9-10.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-10.2.A –** Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.9-10.2.B –** Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.9-10.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. • **WHST.9-10.2.D –** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. • **WHST.9-10.2.E –** Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
Production and Distribution of Writing	• **WHST.9-10.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

	• **WHST.9-10.5 –** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. • **WHST.9-10.6 –** Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
Research to Build and Present Knowledge	• **WHST.9-10.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.9-10.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
Range of Writing	• **WHST.9-10.10 –** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Essential Questions

1. Where are technical skills used?
2. What types of skills are required to be successful in a career?
3. What careers are available in agricultural mechanics?
4. How are communication skills used in agricultural mechanics?
5. How do you develop new machines?
6. Why does agriculture demand new and more efficient machines?