CASE

AEMT Expanded Lesson Review

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

Lesson 1.1 Equipment Systems

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Agricultural equipment used by industry varies based on local crops and geographic location.	• Identify and describe the equipment used in the local area to produce and harvest crops. (Activity 1.1.1)
2. Technicians document plans and processes when servicing equipment.	• Organize notebooks to record coursework and projects. (Activity 1.1.2) • Practice recording assembly and disassembly procedures in a logbook. (Activity 1.1.2)
3. Technicians use tools to make precise measurements.	• Measure components using a dial caliper, dial indicator, torque wrench, and combination square. (Activity 1.1.2) • Use a micrometer to make precise measurements. (Activity 1.1.4)
4. A fastener's strength and size vary based on its purpose.	• Identify bolt size, type, and grade. (Activity 1.1.3)
5. Power take-off (PTO) systems transfer power to agricultural implements.	• Disassemble and identify the components of a universal joint. (Activity 1.1.5)
6. Powertrain systems contain belts, chains, and gears to deliver power for work.	• Identify types of belts, chains, and gears on a piece of equipment. (Activity 1.1.6)
7. Guarding and shielding agricultural equipment prevent injury to an operator.	• Identify the safety hazards found in the internal motions of equipment. (Project 1.1.7)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• 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
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 3.6: 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 1.3: Investigate solutions to AFNR 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.

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. • 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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.7 –** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. • **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Production and Distribution of Writing	• **WHST.11-12.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. • **WHST.11-12.6 –** Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
Research to Build and Present Knowledge	• **WHST.11-12.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.11-12.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

	• **WHST.11-12.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.11-12.10 –** 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. Which agricultural products are grown in your area?
2. What types of equipment do local producers use for growing their crops?
3. What is the purpose of a logbook?
4. How does a logbook keep a technician organized?
5. How are bolts classified?
6. Why do technicians use micrometers when diagnosing problems?
7. What information do you record in a logbook?
8. How is power transferred from a tractor to an implement?
9. What are the advantages and disadvantages of a universal joint?
10. How is power transferred within an implement?
11. Where are belts, chains, gears, and pulleys found?
12. What are the advantages and disadvantages of belts, chains, gears, and pulleys?
13. What are the essential components of all machines and equipment?
14. Where is the risk of injury greatest when working on equipment?
15. How is equipment designed to reduce the risk of injury?

Lesson 1.2 Technician Expectations

Concepts	**Performance Objectives**
Students will know and understand	*Students will learn concepts by doing*
1. Technicians follow a standard diagnostic procedure to inspect a problem, make repairs, and verify operation.	• Identify the parts of the six-step diagnostic process during a guest technician presentation. (Activity 1.2.1)
2. Agricultural equipment dealers prefer technicians with strong interpersonal skills.	• Identify interpersonal skills desired by ag equipment dealers. (Activity 1.2.1)
3. Technicians use digital service procedure manuals to diagnose and repair equipment.	• Create a picklist for equipment repair using a digital service manual. (Activity 1.2.2)
4. Technicians use a digital multimeter to diagnose and repair electrical systems.	• Test for voltage, resistance, and continuity in an electrical component using a digital multimeter. (Activity 1.2.3)
5. Technicians utilize written reports, such as work/repair orders, to communicate services provided to a customer.	• Write a work/repair order using technical writing. (Project 1.2.4) • Write a work/repair order for a universal joint repair. (Project 1.2.5)

6. Component failure analysis allows technicians to analyze root cause failures. 7. Technicians use service manuals to perform diagnostics and repairs on agricultural equipment, leading to a longer life in powertrain systems and reducing operation costs.	• Diagnose a failed universal joint and identify the root cause using the Five Whys method. (Project 1.2.5) • Repair a universal joint and identify steps to verify operation using a manufacturer's service manual. (Project 1.2.5)

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.
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.
• 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.08.02: Investigate, prioritize, and select solutions to solve problems in the workplace and community.
9. Model integrity, ethical leadership, and effective management.
• CRP.09.01: Model characteristics of ethical and effective leaders in the workplace and community (e.g. integrity, self-awareness, self-regulation, etc.).
• CRP.09.02: Implement personal management skills to function effectively and efficiently in the workplace (e.g., time management, planning, prioritizing, etc.).
10. Plan education and career path aligned to personal goals.
• 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.
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
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 2.1: Examine company performance and goals within AFNR organizations and the AFNR industry.
• AG 2.3: Explain the types of industries, organizations, and activities part of AFNR.
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.
Agribusiness Systems Career Pathway (AG-BIZ)

2. Use record keeping to accomplish AFNR business objectives, manage budgets and comply with laws and regulations.
• AG-BIZ 2.2: Prepare and maintain all files as needed for effective record keeping 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.
• AG-PST 2.2: Perform service routines to maintain power units and equipment.
• 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 3.2: Service and repair power transmission systems following manufacturer's guidelines.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS2: Motion and Stability: Forces and Interactions	
PS2.A: Forces and Motion	• Newton's second law accurately predicts changes in the motion of macroscopic objects. • 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. • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the 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.

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.
	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.

Planning and Carrying Out Investigations	• 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. • 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. • 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.
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. • Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. • 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	
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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12

Key Ideas and Details	• **RST.11-12.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. • **RST.11-12.2 –** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics. • **RST.11-12.5 –** Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. • **RST.11-12.6 –** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
Integration of Knowledge and Ideas	• **RST.11-12.7 –** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. • **RST.11-12.8 –** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. • **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Text Types and Purposes	**WHST.11-12.1 –** Write arguments focused on discipline-specific content. • **WHST.11-12.1.C –** Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
Production and Distribution of Writing	• **WHST.11-12.6 –** Use technology, including the internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
Research to Build and Present Knowledge	• **WHST.11-12.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Essential Questions

1. How do technicians diagnose failures in agricultural equipment?
2. What interpersonal skills do technicians need?
3. How are reference numbers used in illustrated parts manuals?
4. What are the advantages of a digital service manual?
5. Why is the work/repair order a critical component of a technician's job?
6. How does a technician communicate services to a customer?
7. How can a technician use a digital multimeter to test electrical circuits?
8. How does questioning help diagnose the root cause?
9. How does a service manual help a technician find the cause, correct the problem, and confirm the repair?

Lesson 1.2 Drive Train Components

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Gears change a drive train's speed and torque.	• Construct a drive train and measure speed. (Activity 2.1.1) • Measure a drive train's torque. (Activity 2.1.3)
2. Clutches engage and disengage torque from the power input to the power output.	• Identify clutch systems & components present on agricultural equipment. (Activity 2.1.2) • Adjust and test the settings for an electromagnetic clutch. (Activity 2.1.2)
3. Bearings reduce friction to increase efficiency in power train systems.	• Identify and select bearing types used in drive train systems. (Activity 2.1.4)
4. Technicians set and adjust gears to work effectively.	• Disassemble a gearbox, identify components and inspect for wear and backlash. (Activity 2.1.5)
5. A drive train uses a combination of components to change the direction and speed of moving parts in a system.	• Construct a drive train modeling agricultural equipment. (Project 2.1.6)

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.
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
• 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.
• AG-PST 2.2: Perform service routines to maintain power units and equipment.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.4: Service and repair steering, suspension, traction, and vehicle performance systems by checking performance parameters.
• AG-PST 3.6: Service electrical systems by troubleshooting from schematics.

Next Generation Science Standards Alignment

Disciplinary Core Ideas

Physical Science	
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. • 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.
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.
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. • 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. • 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.
	• 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. • 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.

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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.7 –** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. • **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Text Types and Purposes	**WHST.11-12.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. • **WHST.11-12.2.A –** Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.11-12.2.B –** Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.11-12.2.E** – Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
Production and Distribution of Writing	• **WHST.11-12.4 –** 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.11-12.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry

	when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.11-12.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.11-12.10 –** 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 motions are in a drive train?
2. How do gears affect the direction, speed, and movement of equipment?
3. How can an operator quickly engage and disengage high-powered equipment?
4. What mechanisms does equipment have to prevent damage to equipment using high torque?
5. How is friction reduced in a machine?
6. What causes friction to occur in equipment?
7. What factors impact wear and damage to gears, bearings, and clutches?
8. How does bearing installation affect performance?
9. Why are precision measurement tools used when repairing equipment?
10. How can a technician determine how a drive train failed?

Lesson 2.2 Final Drives

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Differentials allow implements to maintain equal torque at different speeds.	• Assemble a model of a differential system. (Activity 2.2.1)
2. Planetary gears affect the torque, speed, and direction of a machine.	• Simulate planetary gear settings and observe the input and output speeds. (Activity 2.2.2)
3. Technicians use precision measurement tools to set preload and endplay in a powertrain system.	• Disassemble and adjust tapered bearings on a wheel hub. (Activity 2.2.3)
4. Tire and tracks provide traction in agricultural equipment when proper ground contact is applied.	• Identify and select tires for a tractor. (Activity 2.2.4) • Determine ballast requirements for specific equipment applications. (Activity 2.2.5)
5. Technicians use precision tools to complete a failure analysis and determine the root cause of an equipment failure.	• Troubleshoot and complete a work/repair order for a broken drive train. (Project 2.2.6)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
• 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 1.3: Investigate solutions to AFNR 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 2.2: Perform service routines to maintain power units and equipment.
• 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 3.2: Service and repair power transmission systems following manufacturer's guidelines.

Next Generation Science Standards Alignment

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.

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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Range of Writing	• **WHST.11-12.10 –** 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 advantages of a differential system?
2. Where are differentials found on equipment?

3. What are the advantages of planetary gears?
4. How can a planetary system be used to increase speed or torque?
5. Why are preload and endplay important?
6. How are preload and endplay adjusted on a final drive?
7. How are tires measured?
8. What factors does a technician consider when selecting a tire?
9. How does a technician measure wheel slippage?
10. What is the purpose of ballasting?

Lesson 3.1 Precision Systems

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Equipment calibration increases the efficiency of outputs and limits overlaps and skips in a field.	• Calibrate a hand sprayer and fertilizer spreader. (Activity 3.1.1)
2. Precision systems require a wireless connection with satellites to find a geographic location.	• Locate satellites and determine signal quality for a global positioning system. (Activity 3.1.2)
3. Controller systems in precision agriculture include guidance systems, yield monitors, sensors, and automated outputs.	• Draw a flow chart explaining the relationship between precision agricultural components found on a combine. (Project 3.1.3) • Operate a simulated tractor and guidance system. (Activity 3.1.4)
4. Precision agriculture increases production efficiencies that reduce application costs while improving yields.	• Calculate the potential savings for using an autosteer tractor and a piece of tillage equipment. (Activity.3.1.5)
5. Agricultural producers use sensors and automated controls to increase production efficiencies.	• Set up a control system for activating an irrigator. (Activity 3.1.6) • Construct a control system modeling a tractor's autosteer system. (Project 3.1.7)

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.04.01: Speak using strategies that ensure clarity, logic, purpose and professionalism in formal and informal settings.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
• CRP.04.03: Model active listening strategies when interacting with others 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.

• 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.
• CRP.06.03: Create and execute a plan of action to act upon new ideas and introduce innovations to workplace and community organizations.
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.
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.
12. Work productively in teams while using cultural/global competence.
• CRP.12.01: Contribute to team-oriented projects and builds consensus to accomplish results using cultural global competence in the workplace and community.
• CRP.12.02: Create and implement strategies to engage team members to work toward team and organizational goals in a variety of workplace and community situations (e.g., meetings, presentations, etc.).
Agriculture, Food, and Natural Resources Career Cluster
Agribusiness Systems Career Pathway (AG-BIZ)
4. Develop a business plan for an AFNR enterprise or business unit.
• AG-BIZ 4.3: Develop an operation and/or production plan to provide required levels of product or service.
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 3.6: Service electrical systems by troubleshooting from schematics.
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.
• AG-PST 5.2 Design control systems by referencing electrical drawings.
• AG-PST 5.3 Use geospatial technologies in AFNR applications.

Next Generation Science Standards Alignment

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.
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	
Seeing Structure in Expressions	*Interpret the structure of expressions. *Write expressions in equivalent forms to solve problems.

CCSS: Conceptual Category – Geometry	
Modeling with Geometry	*Apply geometric concepts in modeling situations.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Research to Build and Present Knowledge	• **WHST.11-12.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
Range of Writing	• **WHST.11-12.10 –** 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 do technicians calibrate equipment?
2. How does equipment calibration reduce input costs?
3. How do GPS receivers work?
4. What causes poor satellite signals?
5. How does a guidance system work on a mobile machine?
6. What information does a precision agricultural system collect during crop production?
7. What are the advantages of producers using a precision agriculture system?
8. How does an operator set up a guidance system?
9. What types of electrical circuits does a precision agriculture system use?
10. How does a programmable logic controller work?
11. Why are sensors an essential component of precision agriculture systems?

Lesson 3.2 Precision Applications

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Geographic information systems display vectors, features, and attributes.	• Use GIS to make field boundaries and display a soil sampling grid. (Activity 3.2.1)
2. A producer can predict a field's productivity by collecting data from specific locations.	• Use interpolation to display GIS data. (Activity 3.2.2)
3. Variable-rate application systems reduce producer costs while protecting the environment.	• Analyze data using GIS and recommend a seeding application based on soil type. (Activity 3.2.3) • Compare flat-rate and variable-rate applications by creating basic fertilizer recommendations for each scenario. (Project 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.
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.
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.
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
Plant Systems (AG-PL)
1. Develop and implement a crop management plan for a given production goal that accounts for environmental factors.
• AG-PL 1.1: Develop a fertilization plan using the results of an analysis and evaluation of nutritional requirements and environmental conditions.
3. Propagate, culture, and harvest plants and plant products based on current industry standards.
• AG-PL 3.1: Develop a production plan that applies the fundamentals of plant management.
Power, Structural and Technical (AG-PST)
5. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.
• AG-PST 5.3 Use geospatial technologies in AFNR applications.

Next Generation Science Standards Alignment

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.
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 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. • 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. • 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. • 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. • 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 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. • 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.

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.

	• 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.

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. *Summarize, represent, and interpret data on two categorical and quantitative variables.
Conditional Probability and the Rules of Probability	*Use the rules of probability to compute probabilities of compound events in a uniform probability model.
Using Probability to Make Decisions	*Use probability to evaluate outcomes of decisions.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Production and Distribution of Writing	• **WHST.11-12.4 –** 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.11-12.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
Range of Writing	• **WHST.11-12.10 –** 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 information displayed on a GIS map?
2. How are GIS features different from an attribute?
3. How are data points used to predict unknown values on a map?
4. How is GIS used to save producer input costs?
5. What is a variable rate application?
6. Why does a technician need to understand GIS software applications?

Lesson 3.3 The Data Advantage

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Agricultural producers use remote sensing devices to collect data for making production decisions. 2. Technicians use data to predict future repairs and maintenance.	• Use machine learning software to simulate remote sensing and data analysis. (Activity 3.3.1) • Interpret GIS data and identify machine failure. (Activity 3.3.2)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
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)
5. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.
• AG-PST 5.3 Use geospatial technologies in AFNR applications.

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. • 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	
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.

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. • 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. • 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.).

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.
	• 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.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	• New technologies advance scientific knowledge.

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	
Making Inferences and Justifying 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 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Production and Distribution of Writing	• **WHST.11-12.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Range of Writing	• **WHST.11-12.10 –** 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 agricultural producers use aerial pictures to increase production?
2. Why do farmers use drones?
3. How can machines use data to make decisions?
4. How do technicians use GIS to identify mechanical failures?
5. What is the relationship between sensors on equipment and GIS data?

Lesson 4.1 Electrical Systems

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Agricultural equipment uses series, parallel, and series-parallel circuits.	• Construct series, parallel, and series-parallel circuits. (Activity 4.1.1) • Calculate total resistance in series, parallel, and series-parallel circuits. (Activity 4.1.1)
2. Diodes protect electrical equipment by allowing power to flow in one direction.	• Test a diode using a digital multimeter. (Activity 4.1.2) • Construct circuits using silicon diodes. (Activity 4.1.2) • Construct circuits using Zener diodes. (Activity 4.1.3)
3. Electrical systems use alternating and direct current.	• Rectify AC voltage to power an LED. (Activity 4.1.3) • Troubleshoot a tractor's charging system using a digital multimeter. (Activity 4.1.4)
4. Rheostats and potentiometers vary the resistance in an electrical circuit.	• Model a rheostat using a graphite pencil. (Activity 4.1.5) • Use a potentiometer to change the voltage in a circuit. (Activity 4.1.5)

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.
2. Apply appropriate academic and technical skills.
• 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.
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	
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.
PS3: Energy	
PS3.A: Definitions of Energy	• "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.

Science and Engineering Practices	
Planning and Carrying Out Investigations	• Select appropriate tools to collect, record, analyze, and evaluate data.
Analyzing and Interpreting 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.

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. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
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 Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

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 11-12	
Key Ideas and Details	• **RST.11-12.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Text Types and Purposes	**WHST.11-12.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. • **WHST.11-12.2.E** – Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
Research to Build and Present Knowledge	• **WHST.11-12.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.11-12.10 –** 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 parallel, series, and series-parallel circuits?
2. How does resistance change in parallel, series, and series-parallel circuits?
3. What is the relationship between ohms and volts?
4. How are amps, volts, and ohms calculated?
5. How is current controled in a circuit?
6. How can a diode regulate voltage in a circuit?
7. How is alternating current changed into direct current?
8. How does a technician check for diode leakage in a charging system?
9. What increases the resistance to electricity in a circuit?
10. How can voltage in a circuit be changed?
11. How can amperage in a circuit be changed?

Lesson 4.2 Electrical Controls

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Technicians read schematics when designing, constructing, and troubleshooting electrical circuits.	• Describe a cranking system using an electrical schematic. (Activity 4.2.1)
2. Electrical systems control how engine systems operate and function.	• Test the continuity of an ignition key switch. (Activity 4.2.2) • Assemble a shutdown circuit using a wiring schematic. (Project 4.2.3)
3. Agricultural equipment uses relays to control high amperage circuits that power specific components.	• Identify common terminals used on relays. (Activity 4.2.4) • Assemble a circuit using a relay. (Activity 4.2.4)
4. Electrical systems use resistors, diodes, potentiometers, relays, and solenoids to control equipment components.	• Design and construct a circuit to control motor speed and direction. (Project 4.2.5)
5. Technicians manage and troubleshoot controller systems used in precision agriculture.	• Construct and troubleshoot a transducer. (Project 4.2.6)

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.
2. Apply appropriate academic and technical skills.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
Environmental Service Systems Pathway (AG-ENV)
1. Use analytical procedures and instruments to manage environmental service systems.
• AG-ENV 1.3: Calibrate and service field equipment and instruments according to manufacturer's specifications.
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.
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.
• AG-PST 5.2 Design control systems by referencing electrical drawings.
• AG-PST 5.3 Use geospatial technologies in AFNR applications.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
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.
PS3: Energy	
PS3.A: Definitions of Energy	• "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.

Science and Engineering Practices	
Planning and Carrying Out Investigations	• Select appropriate tools to collect, record, analyze, and evaluate data.
Analyzing and Interpreting 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.

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. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
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 Knowledge is Based on Empirical Evidence	• Science knowledge is based on empirical evidence. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

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 11-12	
Key Ideas and Details	• **RST.11-12.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Text Types and Purposes	**WHST.11-12.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. • **WHST.11-12.2.E** – Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
Research to Build and Present Knowledge	• **WHST.11-12.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.11-12.10 –** 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 a relay?
2. How does a relay work?
3. How can technicians use a digital multimeter to diagnose faulty relays?
4. How are relays, potentiometers, switches, and diodes used as electrical controls?
5. What is the role of a solenoid in the starting circuit?
6. How does a technician diagnose electrical circuit failure?
7. How are safety switches used in agricultural equipment?
8. Why are safety switches built into the circuitry of tractors or harvesting equipment?
9. How does a transducer send a signal?

Lesson 4.3 Electrical Analysis

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Technicians use diagnostic tools and Ohm's law as part of a systematic troubleshooting process.	• Calculate voltage drop in a circuit. (Activity 4.3.1) • Troubleshoot voltage drops with a digital multimeter. (Project 4.3.2)

	• Diagnose parasitic battery drain with a digital multimeter. (Activity 4.3.3)
2. Technicians maintain and troubleshoot systems directing electrical current between components.	• Construct an ignition/shutdown circuit using cables and connectors. (Project 4.3.4) • Troubleshoot an ignition/shutdown circuit using a digital multimeter and a schematic. (Project 4.3.4)
3. Technicians use tools to troubleshoot and maintain GPS/GIS equipment.	• Modify a sprayer to include electrical and GPS controls. (Problem 4.3.5) • Develop a troubleshooting and maintenance plan for a GPS sprayer. (Problem 4.3.5)

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.
2. Apply appropriate academic and technical skills.
• CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
Environmental Service Systems Pathway (AG-ENV)
1. Use analytical procedures and instruments to manage environmental service systems.
• AG-ENV 1.3: Calibrate and service field equipment and instruments according to manufacturer's specifications.
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.
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.
• AG-PST 5.2 Design control systems by referencing electrical drawings.
• AG-PST 5.3 Use geospatial technologies in AFNR applications.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS3: Energy	
PS3.A: Definitions of Energy	• "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.

Science and Engineering Practices	
Planning and Carrying Out Investigations	• Select appropriate tools to collect, record, analyze, and evaluate data.

Analyzing and Interpreting 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.

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. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
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.

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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.1 –** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

Essential Questions

1. What is the relationship between resistance and voltage drop?
2. What factors contribute to voltage drop?
3. How does a technician measure the current draw with a DMM?
4. What is a parasitic battery drain?
5. How are connectors used within a circuit?
6. How do technicians limit a faulted connection?
7. How are electrical systems and GPS systems used to control agricultural equipment?

Lesson 5.1 Diesel Components

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. There are functional differences between diesel and gasoline engines.	• Identify similarities and differences between small gasoline and diesel engines. (Activity 5.1.1)
2. Mechanical diesel injection systems have several components with specific functions.	• Identify the high and low-pressure components of a fuel system. (Activity 5.1.2) • Flare and assemble a fuel line. (Activity 5.1.2) • Inspect a fuel injector for faults. (Activity 5.1.2)
3. Diesel engines have systems that clean and pressurize the air and clean the exhaust.	• Inspect and identify the components of a turbocharger and air filter. (Activity 5.1.3) • Measure the urea content in diesel exhaust fluid samples. (Activity 5.1.3)
4. Diesel engine systems have a variety of lubrication and liquid cooling systems.	• Change oil and oil filter using OEM specifications. (Activity 5.1.4) • Inspect a cooling system using industry equipment. (Activity 5.1.4 and Project 5.1.5) • Model a cooling system to cool the engine coolant. (Project 5.1.5)
5. Technicians use customer complaints combined with an inspection to determine the cause of engine failure.	• Determine the cause of broken engine components and complete a work repair order. (Project 5.1.6)

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.
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.
4. Communicate clearly, effectively and with reason.
• CRP.04.01: Speak using strategies that ensure clarity, logic, purpose and professionalism in formal and informal settings.
• 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.
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 3.1: Service and repair the components of internal combustion engines using procedures for troubleshooting and evaluating performance.

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. • 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	
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.
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.
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. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

Common Core State Standards for High School Mathematics

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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12

Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Research to Build and Present Knowledge	• **WHST.11-12.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Essential Questions

1. How are the subsystems of a diesel and gasoline engine different?
2. What components of each engine system are similar, and which are specialized?
3. How do diesel fuel system components work together?
4. What skills do technicians need to service a fuel system?
5. What faults can impact a diesel intake system?
6. How does the wastegate impact air intake?
7. How does an injection pump with a fixed speed regulate the fuel injection?

Lesson 5.2 Diesel and Electrical

Concepts	**Performance Objectives**
Students will know and understand	*Students will learn concepts by doing*
1. Diesel engines control connected systems using Controller Area Network (CAN) bus systems with Electronic Control Units (ECU) to monitor and control the engine.	• Diagnose faults in a CAN bus model using a DMM. (Activity 5.2.1) • Identify how a circuit fault in CAN bus impacts an 8-bit signal. (Activity 5.2.1)
2. A CAN bus allows a system of microcontrollers to control agricultural equipment.	• Simulate CAN bus data in response to sensor data. (Activity 5.2.2) • Inspect an oil pressure transducer for faults. (Activity 5.2.2)
3. High-pressure common rail diesel fuel systems have essential components with specific functions.	• Develop a flowchart of CAN bus operations within fuel and intake systems. (Project 5.2.3)

National AFNR Common Career Technical Core Standards Alignment

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
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.
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.
• AG-PST 5.2 Design control systems by referencing electrical drawings.

Next Generation Science Standards Alignment

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, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
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. • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Research to Build and Present Knowledge	• **WHST.11-12.9 –** Draw evidence from informational texts to support analysis, reflection, and research.

Essential Questions

1. How does a technician check a CAN bus system using a digital multimeter?
2. How does a CAN bus system translate sensor data?
3. How do ECUs respond to 8-bit signals?
4. How does a CAN bus system communicate faults?
5. How do technicians use codes to isolate root causes?

Lesson 6.1 Hydraulic Principles

Concepts	**Performance Objectives**
Students will know and understand	*Students will learn concepts by doing*
1. A hydraulic system has a pump, control valves, actuators, fluid, and hoses.	• Virtually assemble a fluid power system. (Activity 6.1.1)
2. Technicians use schematics to identify fluid power components and systems.	• Draw and identify the components found in a hydraulic system schematic. (Activity 6.1.2)
3. The hydraulic systems can be closed or open-loop systems using positive or non-positive pumps.	• Construct example models of hydraulic systems (Activity 6.1.3)
4. A technician can control the fluid flow and pressure in a hydraulic system.	• Add flow and pressure gauges and adjust the fluid pressure and flow in a hydraulic system. (Activity 6.1.4)

5. Pascal's Law determines the system pressure and components a machine needs to operate.	• Calculate pressure drop in a hydraulic system. (Activity 6.1.4) • Find the force exerted by hydraulic cylinders. (Activity 6.1.5) • Use Pascal's Law to find equipment's needed pressure and cylinder size. (Activity 6.1.5)

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.
Agriculture, Food, and Natural Resources Career Cluster
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.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.3: Service and repair hydraulic systems by evaluating performance using maintenance manuals.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
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). • 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. • 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. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
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	• Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
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.
	• 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.
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	
Science Addresses Questions About the Natural and Material World.	• Not all questions can be answered by science.

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	
Circles	Understand and apply theorems about circles.
Modeling with Geometry	*Apply geometric concepts in modeling situations.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.7 –** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Production and Distribution of Writing	• **WHST.11-12.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Range of Writing	• **WHST.11-12.10 –** 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 hydraulic systems work?
2. How do technicians diagnose problems within a hydraulic system?
3. How are hydraulic theory and mathematics related?
4. What are the major components of a fluid power system?
5. What is an actuator?
6. What are the energy input and outputs of a hydraulic system?
7. How do technicians use schematics to assemble and maintain hydraulic systems?
8. Which rules do all schematic drawings follow?
9. How does pump selection impact hydraulic system operations?
10. How is fluid pressure different from fluid flow?
11. How can math be used to solve customer complaints?
12. What causes pressure to occur in a fluid system?

Lesson 6.2 Hydraulic Systems and Safety

Concepts	**Performance Objectives**
Students will know and understand	*Students will learn concepts by doing*

1. Hydraulic fluids have specifications and properties that meet industry standards.	• Read an SDS and identify the ISO Standards for hydraulic fluids. (Activity 6.2.1) • Compare the physical properties of hydraulic fluids. (Activity 6.2.1)
2. Technicians need to be aware of the potential safety hazards when working with hydraulic equipment.	• Inspect a hydraulic system for safety hazards. (Activity 6.2.2) • Record and practice the steps to place a hydraulic system in a zero energy state. (Activity 6.2.2)
3. Hydrostatic transmissions use variable displacement pumps to transfer energy in a power train.	• Model and calculate the advantage of variable displacement pumps. (Activity 6.2.3)
4. Electro-hydraulic systems control cylinders in agricultural implements.	• Evaluate a solenoid and relay for functionality on electro-hydraulic components. (Activity 6.2.4) • Construct an electro-hydraulic system. (Project 6.2.5)
5. Hydraulics provide power in agricultural equipment for steering, braking, drivetrains, and axillary equipment.	• Inspect and document the physical characteristics of fluid power systems found on a tractor. (Activity 6.2.6)

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.
4. Communicate clearly, effectively and with reason.
• CRP.04.01: Speak using strategies that ensure clarity, logic, purpose and professionalism in formal and informal settings.
• CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
• CRP.04.03: Model active listening strategies when interacting with others in formal and informal settings.
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.
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.
• 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)
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.3: Service and repair hydraulic systems by evaluating performance using maintenance manuals.
• AG-PST 3.4: Service and repair steering, suspension, traction, and vehicle performance systems by checking performance parameters.

Next Generation Science Standards Alignment

Disciplinary Core Ideas
Engineering, Technology, and the Application of Science
ETS1: Engineering Design

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). • 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.
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 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. • 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.

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. • 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. • 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. • Energy drives the cycling of matter within and between systems.

Common Core State Standards for High School Mathematics

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

CCSS: Conceptual Category – Functions	
Interpreting Functions	*Interpret functions that arise in applications in terms of the context.
Linear, Quadratic, and Exponential Models	*Interpret expressions for functions in terms of the situation they model.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.7 –** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. • **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Text Types and Purposes	**WHST.11-12.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. • **WHST.11-12.2.A –** Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
Production and Distribution of Writing	• **WHST.11-12.4 –** 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.11-12.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
Range of Writing	• **WHST.11-12.10 –** 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 a Safety Data Sheet (SDS)?
2. What are the physical and chemical properties of hydraulic fluid?
3. How do technicians work with hydraulic systems safely?
4. What are the potential injuries caused by hydraulic systems?
5. What are the advantages of a variable displacement pump?
6. Why are piston pumps used in hydrostatic systems?
7. How are hydraulics controlled with electrical circuits?
8. How is a relay different from a solenoid?

9. What systems in a tractor use fluid power?
10. What should a technician know about the fluid power systems in an agricultural implement?

Lesson 6.3 Hydraulic Maintenance

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Hydraulic components must seal correctly and be free of air and contaminants to prevent wear and damage.	• Disassemble a hydraulic cylinder and valve to inspect for wear and damage. (Activity 6.3.1) • Disassemble a hydraulic pump and complete a work/repair order. (Project 6.3.2)
2. Technicians select fittings based on design and purpose.	• Identify the fittings needed for a hydraulic system. (Activity 6.3.3)
3. Routine repair of a hydraulic system includes flushing a system and inspecting for particulate matter.	• Inspect used hydraulic oil for potential causes of contamination. (Project 6.3.4) • Fill out a work/repair order for hydraulic parts damaged by contaminated oil. (Project 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.
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
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
• AG 3.6: Demonstrate methods to correct common hazards.
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.
• AG-PST 2.2: Perform service routines to maintain power units and equipment.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
• AG-PST 3.3: Service and repair hydraulic systems by evaluating performance using maintenance manuals.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Science and Engineering Practices	
	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.

Planning and Carrying Out Investigations	• 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. • 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.
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. • 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. • 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.

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. • 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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics. •
Integration of Knowledge and Ideas	• **RST.11-12.7 –** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. • **RST.11-12.9 –** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Text Types and Purposes	**WHST.11-12.2 –** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. • **WHST.11-12.2.A –** Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. • **WHST.11-12.2.B –** Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. • **WHST.11-12.2.C –** Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. • **WHST.11-12.2.D –** Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. • **WHST.11-12.2.E** – Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
Production and Distribution of Writing	• **WHST.11-12.4 –** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. • **WHST.11-12.6 –** Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
Research to Build and Present Knowledge	• **WHST.11-12.7 –** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. • **WHST.11-12.8 –** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. • **WHST.11-12.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.11-12.10 –** 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 cylinder and valve leaks prevented?
2. Why doing hydraulic fittings vary in size and shape?
3. What are some common causes of hydraulic system failure?
4. What are the internal components in a cylinder?
5. How does a hydraulic valve divert oil to specific ports?
6. What can cause a hydraulic pump to break?
7. How is hydraulic fluid kept clean?
8. What are the common contaminants found in hydraulic fluid?

Lesson 7.1 Practical Evaluation

Concepts	Performance Objectives
Students will know and understand	*Students will learn concepts by doing*
1. Technicians work with producers to periodically maintain equipment for optimum agricultural production.	• Assess the mechanical systems of a tractor and implement and write a work/repair order for recommended maintenance. (Project 7.1.1)
2. Troubleshooting and service procedures are essential for long-term equipment performance.	• Complete service procedures for hydraulic, electrical, and power train systems. (Activity 7.1.2)
3. Practical experiences are essential when preparing for a technical career.	• Compile a work portfolio of technical skill competencies. (Foundational SAE Checklist)

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.08.01: 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.
10. Plan education and career path aligned to personal goals.
• CRP.10.04: Identify, prepare, update and improve the tools and skills necessary to pursue a chosen career path.
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
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.
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 2.2: Perform service routines to maintain power units and equipment.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.

• AG-PST 3.1: Service and repair the components of internal combustion engines using procedures for troubleshooting and evaluating performance.
• AG-PST 3.2: Service and repair power transmission systems following manufacturer's guidelines.
• AG-PST 3.3: Service and repair hydraulic systems by evaluating performance using maintenance manuals.
• AG-PST 3.4: Service and repair steering, suspension, traction, and vehicle performance systems by checking performance parameters.
• AG-PST 3.6: Service electrical systems by troubleshooting from schematics.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	• **RST.11-12.3 –** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure	• **RST.11-12.4 –** 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 11-12 texts and topics.
Integration of Knowledge and Ideas	• **RST.11-12.7 –** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
Range of Reading and Level of Text Complexity	• **RST.11-12.10 –** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

CCSS: English Language Arts Standards » Writing » Grade 11-12	
Production and Distribution of Writing	• **WHST.11-12.4 –** 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.11-12.9 –** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	• **WHST.11-12.10 –** 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 does a technician determine if equipment is ready to use?
2. What technical skills does a technician need to move into the workforce?
3. How has Technical Applications in Agriculture prepared you for technical careers?