

Mechanical Systems in Agriculture Expanded Lesson Review

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

Lesson 1.1 Engineering Systems

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> 1. Agricultural systems utilize multiple types of engineering disciplines and skills. 2. Engineers use engineering notebooks to document problem statements, criteria, constraints, design solutions, and results. 3. Engineering involves a team of engineers, technicians, and tradespeople. 4. Knowing the location of safety equipment is essential when working in a mechanical shop. 5. Working in a mechanical shop requires diligence when following safety procedures and expectations. 6. Agricultural employees need to work efficiently and communicate effectively in the workplace. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Assemble an agriscience notebook and identify how engineering is used in agriculture. (Activity 1.1.1) • Prepare an engineering notebook and investigate an engineering design problem for planting soybeans. (Activity 1.1.2) • Work in a team consisting of an engineer, a technician, and a tradesperson to construct a prototype and model. (Project 1.1.3) • Diagram and describe where emergency equipment and safety hazards are located in the laboratory and shop. (Activity 1.1.4) • Review the <i>MSA Safety Manual</i> and determine safe practices for the mechanical shop. (Activity 1.1.4) • Identify near misses and complete an example near miss report. (Activity 1.1.5) • Describe and identify employability skills industry employers expect of employees. (Activity 1.1.6)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
<p>1. Act as a responsible and contributing citizen and employee.</p> <ul style="list-style-type: none"> • 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.
<p>2. Apply appropriate academic and technical skills.</p> <ul style="list-style-type: none"> • 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.
<p>8. Utilize critical thinking to make sense of problems and persevere in solving them.</p> <ul style="list-style-type: none"> • CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
<p>9. Model integrity, ethical leadership and effective management.</p>

<ul style="list-style-type: none"> • CRP.09.01: Model characteristics of ethical and effective leaders in the workplace and community (e.g. integrity, self-awareness, self-regulation, etc.).
<ul style="list-style-type: none"> • CRP.09.02: Implement personal management skills to function effectively and efficiently in the workplace (e.g., time management, planning, prioritizing, etc.).
<ul style="list-style-type: none"> • CRP.09.03: Demonstrate behaviors that contribute to a positive morale and culture in the workplace and community (e.g., positively influencing others, effectively communicating, etc.).
12. Work productively in teams while using cultural/global competence.
<ul style="list-style-type: none"> • CRP.12.01: Contribute to team-oriented projects and builds consensus to accomplish results using cultural global competence 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.
<ul style="list-style-type: none"> • AG 3.1: Examine health risks associated with a particular skill to better form personnel safety guidelines.
<ul style="list-style-type: none"> • 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.

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	<ul style="list-style-type: none"> • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	<ul style="list-style-type: none"> • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.
Science and Engineering Practices	
Asking Questions and Defining Problems	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. <ul style="list-style-type: none"> • 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). <ul style="list-style-type: none"> • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system.
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. <ul style="list-style-type: none"> • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
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	<ul style="list-style-type: none"> 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.
Obtaining, Evaluating, and Communicating Information	<p>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.</p> <ul style="list-style-type: none"> 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> Systems can be designed to do specific tasks. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Understandings about the Nature of Science	
Science is a Human Endeavor	<ul style="list-style-type: none"> Technological advances have influenced the progress of science and science has influenced advances in technology. Science and engineering are influenced by society and society is influenced by science and engineering.
Science Addresses Questions About the Natural and Material World.	<ul style="list-style-type: none"> Not all questions can be answered by science. Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> WHST.11-12.4 – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 will you use your *Agriscience Notebook*?
2. How are machines and structures used in agriculture?
3. What types of engineering are needed in agriculture?
4. What skills do you need to work in the engineering field?
5. What careers can you have in engineering?
6. What is an *Engineering Notebook*?
7. How are engineering notebooks used in the agricultural industry?
8. Why do engineering problems require a team of individuals to design a solution?
9. What are proper safety procedures when working in a shop?
10. Where is the emergency equipment located in a shop?
11. What guidelines are you expected to follow when working in a shop?

Lesson 1.2 Agricultural Production

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> 1. Technicians increase the efficiency of agricultural equipment through proper calibration and settings. 2. GIS uses vectors, features, and attributes to display georeferenced data. 3. Agricultural producers use GPS/GIS to collect and analyze data and make production decisions. 4. Global positioning systems interact with equipment to improve efficiencies related to production cost and yield. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Calibrate a handheld broadcast spreader and sprayer for a lawn application. (Activity 1.2.1) • Use GIS to make field boundaries and display a soil sampling grid. (Activity 1.2.2) • Analyze data using GIS and make a recommendation for a fertilizer application based upon analysis. (Activity 1.2.3) • Use GIS data to develop an application plan for liming and fertilizing a field. (Project 1.2.5) • Calculate the cost savings of using a guidance system for tilling a field. (Activity 1.2.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.

<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • 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
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
<ul style="list-style-type: none"> • AG.3.7: Demonstrate application of personal and group health and safety practices.
Plant Systems (AG-PL)
1. Develop and implement a crop management plan for a given production goal that accounts for environmental factors.
<ul style="list-style-type: none"> • AG-PL 1.1: Develop a fertilization plan using the results of an analysis and evaluation of nutritional requirements and environmental conditions. • AG-PL 1.2: Evaluate soil/media nutrients using tests of appropriate materials and/or by examining data.
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.
<ul style="list-style-type: none"> • AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
2. Operate and maintain mechanical equipment related to AFNR power, structural, and technical systems.
<ul style="list-style-type: none"> • AG-PST 2.3: Operate machinery and equipment while observing all safety precautions.
5. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.
<ul style="list-style-type: none"> • AG-PST 5.3 Use geospatial technologies in AFNR applications.

Next Generation Science Standards Alignment

Crosscutting Concepts	
Patterns	<p>Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</p> <ul style="list-style-type: none"> • 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> • 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 – Algebra	
Seeing Structure in Expressions	*Interpret the structure of expressions.
Creating Equations	*Write expressions in equivalent forms to solve problems.
Reasoning with Equations and Inequalities	*Create equations that describe numbers or relationships. Understand solving equations as a process of reasoning and explain the reasoning.

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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 is equipment calibrated for applying fertilizer and herbicides?
2. What is the process for calibrating equipment?
3. How can application skips and overlaps be prevented?
4. What are the components of a GIS map with georeferenced data?
5. What type of data can you display using geographic information systems?
6. How are queries and interpolation used to find information about a geographic area?
7. How do global positioning systems control machines?
8. How are GPS and GIS used together to manage agricultural production?
9. How do guidance systems save agricultural input costs?
10. How can a producer use GIS data to increase efficiency?
11. What are the advantages of using GPS and GIS for agricultural production?
12. How does agricultural equipment make site specific applications?

13. What types of agricultural equipment improve the productive efficiency of a farmer?

Lesson 1.3 Designing Solutions

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> Design software is an integral component of the design process. Engineers consider trade-offs when selecting a solution to an engineering design problem. Technicians use detail drawings to read and interpret designs. Engineers use computer modeling to display a complex system of components. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> Use CAD software to design structural beams. (Activity 1.3.1) Use a trade-off matrix to select a solution to an engineering design problem. (Activity 1.3.2) Develop a detail drawing for a prototype. (Project 1.3.3) Use CAD software to design complex parts. (Activity 1.3.4) Design and virtually assemble parts using CAD software. (Activity 1.3.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
<p>11. Use technology to enhance productivity.</p> <ul style="list-style-type: none"> 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)
<p>4. Plan, build and maintain AFNR structures.</p> <ul style="list-style-type: none"> AG-PST 4.1: Create sketches and plans of agricultural structures.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
<p>ETS1.A: Defining and Delimiting Engineering Problems</p>	<ul style="list-style-type: none"> 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.
<p>ETS1.B: Developing Possible Solutions</p>	<ul style="list-style-type: none"> 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.
<p>ETS1.C: Optimizing the Design Solution</p>	<ul style="list-style-type: none"> Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices

Asking Questions and Defining Problems	<p>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.</p> <ul style="list-style-type: none"> • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
Developing and Using Models	<p>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).</p> <ul style="list-style-type: none"> • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	<p>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.</p> <ul style="list-style-type: none"> • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation’s design to ensure variables are controlled. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
Analyzing and Interpreting Data	<p>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.</p> <ul style="list-style-type: none"> • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
Constructing Explanations and Designing Solutions	<p>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.</p> <ul style="list-style-type: none"> • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Crosscutting Concepts

Systems and System Models	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Structure and Function	<p>The way an object is shaped or structured determines many of its properties and functions.</p> <ul style="list-style-type: none"> • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
Stability and Change	<p>For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</p> <ul style="list-style-type: none"> • Much of science deals with constructing explanations of how things change and how they remain stable. • Systems can be designed for greater or lesser stability.

Understandings about the Nature of Science

Scientific Investigations Use a Variety of Methods	<ul style="list-style-type: none"> • The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use. • Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
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Common Core State Standards for High School Mathematics

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

CCSS: Conceptual Category – Number and Quantity	
Quantities	*Reason quantitatively and use units to solve problems.
CCSS: Conceptual Category – Geometry	
Geometric Measurement and Dimension	Visualize relationships between two-dimensional and three-dimensional objects.
Modeling with Geometry	*Apply geometric concepts in modeling situations.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 computer-aided design?
2. Where is computer-aided design used?
3. What are the features in computer-aided design software?
4. How do engineers make design decisions?
5. How does economic cost affect design decisions?
6. Why is experimental research used to select a design?
7. What is a detail drawing?
8. How do you use dimensional lines in a detail drawing?
9. How is CAD used to assemble machines?
10. Why are CAD assemblies used before constructing an actual machine?

Lesson 2.1 Structural Systems

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <p>1. Technicians interpret detailed drawings when making a materials list and constructing an agricultural structure.</p>	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Construct model walls of a building and prepare a materials list by reading detail drawings. (Activity 2.1.1)

<p>2. Engineers use mathematical calculations and measurements to improve the functionality of an agricultural structure.</p> <p>3. Environmental conditions affect the design and management of structural systems used in agriculture.</p>	<ul style="list-style-type: none"> • Design a truss system meeting specified criteria for a model structure. (Project 2.1.2) • Test greenhouse coverings for heat conversion. (Project 2.1.3) • Select a greenhouse covering based upon material and operation costs. (Project 2.1.3)
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National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
<ul style="list-style-type: none"> • CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community. • CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
Power, Structural and Technical (AG-PST)
1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
<ul style="list-style-type: none"> • AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
4. Plan, build and maintain AFNR structures.
<ul style="list-style-type: none"> • AG-PST 4.1: Create sketches and plans of agricultural structures. • AG-PST 4.2: Apply structural plans, specifications, and building codes. • AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures. • AG-PST 4.4: Follow architectural and mechanical plans to construct AFNR structures.

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	<ul style="list-style-type: none"> • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	<p>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.</p> <ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none"> • Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	<p>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).</p> <ul style="list-style-type: none"> • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system.
Planning and Carrying Out Investigations	<p>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.</p> <ul style="list-style-type: none"> • 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.
	<ul style="list-style-type: none"> • Select appropriate tools to collect, record, analyze, and evaluate data.
Analyzing and Interpreting Data	<p>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.</p> <ul style="list-style-type: none"> • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
Using Mathematics and Computational Thinking	<p>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.</p> <ul style="list-style-type: none"> • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m³, acre-feet, etc.).
Constructing Explanations and Designing Solutions	<p>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.</p> <ul style="list-style-type: none"> • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Obtaining, Evaluating, and Communicating Information	<p>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.</p> <ul style="list-style-type: none"> • 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.

- 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> • 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.
Structure and Function	<p>The way an object is shaped or structured determines many of its properties and functions.</p> <ul style="list-style-type: none"> • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Stability and Change	<p>For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</p> <ul style="list-style-type: none"> • Systems can be designed for greater or lesser stability.

Understandings about the Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	<ul style="list-style-type: none"> • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.
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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.
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CCSS: Conceptual Category – Algebra

Seeing Structure in Expressions	*Interpret the structure of expressions. *Write expressions in equivalent forms to solve problems.
Arithmetic with Polynomials and Rational Expressions	Perform arithmetic operations on polynomials.
Reasoning with Equations and Inequalities	Solve equations and inequalities in one variable.

CCSS: Conceptual Category – Geometry

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

Common Core State Standards for English Language Arts

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

Key Ideas and Details	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> • 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.
Production and Distribution of Writing	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 detail drawings read?
2. How is an architect's scale used to read a detail print?
3. What are the parts of a framing wall?
4. What factors are considered when designing a roof?
5. How does pitch impact rafter design?
6. What factors impact the stability of a truss system?
7. What types of covering are used on a greenhouse?
8. What environmental factors are considered when designing a greenhouse?

Lesson 2.2 Electrical Systems

Preface

Many systems within a building operate out of sight. A system of electrical wires throughout a building provides electricity to power other systems, such as heating, cooling, and plumbing. Sensors and switches can control the electrical power within those systems.

Technicians design electrical circuits to power the systems in a building by developing a circuit map and drawing electrical schematics. Circuit maps and schematics are used to ensure a circuit does not become

overloaded by drawing too much current. If appliances draw too much current through a circuit, the wires could overheat and start a fire. Technicians calculate the current in a circuit, called amperage, by dividing the watts, by the total electrical pressure in the circuit.

When circuits fail, technicians use their knowledge of electrical principles, a digital multimeter, and the troubleshooting process to solve the problem. A digital multimeter measures resistance, voltage, and current within a circuit. A technician uses measurement data to calculate information, such as total resistance and total current, and then uses that information to troubleshoot problems within the system. The troubleshooting process has systematic steps used to efficiently solve the problems.

Programmable logic controllers (PLC) operate electrically powered devices in agricultural systems. PLCs consist of inputs, controls, and outputs. PLC inputs are sensors collecting data. A controller interprets the data and controls the outputs. Technicians program PLCs to control systems, such as grain handlers, food storage facilities, and greenhouses used in agriculture.

During this lesson, students read and design electrical schematics for a greenhouse. Then they program a PLC to interpret data from a temperature sensor. Next, they practice using a digital multimeter and explain how to use the troubleshooting process to identify electrical system failures. Students finish the lesson designing and testing a PLC program for monitoring and controlling the temperature in a greenhouse.

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> 1. Technicians use schematics to install electrical systems and calculate electrical load requirements in agricultural structures. 2. Programmable logic controllers (PLCs) enable mechanical systems to interact and work together to produce agricultural goods. 3. Technicians use digital multimeters to troubleshoot agricultural systems. 4. Troubleshooting is a step-by-step process providing a clear definite outline for solving a problem 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Read a schematic and calculate amps and ohms in a circuit. (Activity 2.2.1) • Break down a schematic to meet the load requirements of the circuit. (Project 2.2.2) • Use a digital control unit to operate a motor at different temperatures. (Activity 2.2.3) • Design and implement cooling, heating, and alarm systems for a production greenhouse. (Project 2.2.5) • Use a digital multimeter to measure amps, volts, and ohms in an electrical system. (Activity 2.2.4) • Record the troubleshooting steps for solving example electrical problems. (Activity 2.2.4) • Develop a troubleshooting procedure for a cooling, heating, and alarm system in a greenhouse. (Project 2.2.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
<ul style="list-style-type: none"> • CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
Power, Structural and Technical (AG-PST)

1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.
<ul style="list-style-type: none"> • AG-PST 1.1: Select energy sources for power generation. • AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems. • AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • 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

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	<p>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.</p> <ul style="list-style-type: none"> • Ask questions that arise from careful observation of phenomena, or unexpected results <ul style="list-style-type: none"> · to clarify and/or seek additional information. · that arise from examining models or a theory, to clarify and/or seek additional information and relationships. · to determine relationships, including quantitative relationships, between independent and dependent variables. · to clarify and refine a model, an explanation, or an engineering problem. • Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	<p>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).</p> <ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none"> • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
<p>Planning and Carrying Out Investigations</p>	<p>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.</p> <ul style="list-style-type: none"> • 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.
<p>Analyzing and Interpreting Data</p>	<p>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.</p> <ul style="list-style-type: none"> • 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.
<p>Using Mathematics and Computational Thinking</p>	<p>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.</p> <ul style="list-style-type: none"> • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m³, acre-feet, etc.).
<p>Constructing Explanations and Designing Solutions</p>	<p>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.</p> <ul style="list-style-type: none"> • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the

	<p>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.</p> <ul style="list-style-type: none"> • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Obtaining, Evaluating, and Communicating Information	<p>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.</p> <ul style="list-style-type: none"> • 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	
Patterns	<p>Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</p> <ul style="list-style-type: none"> • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. • 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	<p>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.</p> <ul style="list-style-type: none"> • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.
Scale, Proportion, and Quantity	<p>In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</p> <ul style="list-style-type: none"> • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales. • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Systems and System Models	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none"> 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.
	<ul style="list-style-type: none"> 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. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Understandings about the Nature of Science	
Scientific Investigations Use a Variety of Methods	<ul style="list-style-type: none"> Science investigations use diverse methods and do not always use the same set of procedures to obtain data. New technologies advance scientific knowledge. Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use. Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Scientific Knowledge is Based on Empirical Evidence	<ul style="list-style-type: none"> Science knowledge is based on empirical evidence. Science disciplines share common rules of evidence used to evaluate explanations about natural systems. Science includes the process of coordinating patterns of evidence with current theory. Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
Scientific Knowledge is Open to Revision in Light of New Evidence	<ul style="list-style-type: none"> Scientific explanations can be probabilistic. Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	<ul style="list-style-type: none"> Theories and laws provide explanations in science, but theories do not with time become laws or facts. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that has been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. Laws are statements or descriptions of the relationships among observable phenomena. Scientists often use hypotheses to develop and test theories and explanations.

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.
Arithmetic with Polynomials and Rational Expressions	Perform arithmetic operations on polynomials.
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

Key Ideas and Details	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> • 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.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	<ul style="list-style-type: none"> • WHST.11-12.4 – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. • WHST.11-12.7 – 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.
Research to Build and Present Knowledge	<ul style="list-style-type: none"> • WHST.11-12.9 – Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	<ul style="list-style-type: none"> • 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 schematics used to analyze an electrical system?
2. What factors affect the number of appliances on a circuit?
3. What electrical principles are used when planning an electrical circuit?
4. How do you calculate electrical requirements for a circuit?
5. How is a digital multimeter used for solving electrical problems?
6. Why is troubleshooting a step-by-step process?
7. How are problems in an electrical circuit identified and solved?
8. What is the purpose of a programmable logic controller?
9. How are logic statements used to control output devices?
10. How does a thermostat work?
11. Where are PLCs used in agriculture?

Lesson 3.1 Engine Operation

Concepts	Performance Objectives
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<i>Students will know and understand</i>	<i>Students will learn concepts by doing</i>
<p>1. Four-stroke cycle engines systematically process energy inputs and produce energy outputs.</p> <p>2. A small engine consists of a series of systems converting energy from one form to another in a controlled manner.</p> <p>3. Technicians use troubleshooting steps to solve mechanical problems caused by improper design or product failure.</p> <p>4. Engine operators use safe practices to protect themselves and those around them.</p> <p>5. Safety Data Sheets (SDS) contain important information related to the proper use and cleanup of chemical materials.</p>	<ul style="list-style-type: none"> • Develop a flowchart to identify inputs, processes, and outputs in a four-stroke cycle small engine. (Activity 3.1.1) • Use the flow chart with the leakdown tester to identify the current stroke of an engine. (Activity 3.1.4) • Define the systems found in a small engine and record the inputs, processes, and outputs of each system. (Activity 3.1.2) • Record the energies transferred throughout the systems in an engine. (Activity 3.1.2) • Measure the thermal energy transferred in an engine. (Activity 3.1.6) • Test the electrical and compression system of an engine to ensure proper working order. (Activity 3.1.4) • Write a troubleshooting procedure for finding an ignition or compression problem in an engine. (Activity 3.1.4) • Complete a <i>Tool Operation Template</i> and <i>Tool Safety Checklist</i> for a small engine. (Activity 3.1.3) • Safely operate an engine. (Activity 3.1.6) • Use SDS forms to determine the proper use and cleanup of chemicals used in the course. (Activity 3.1.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
9. Model integrity, ethical leadership and effective management.
<ul style="list-style-type: none"> • 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.). • CRP.09.03: Demonstrate behaviors that contribute to a positive morale and culture in the workplace and community (e.g., positively influencing others, effectively communicating, etc.).
Agriculture, Food, and Natural Resources Career Cluster
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
<ul style="list-style-type: none"> • AG 3.1: Examine health risks associated with a particular skill to better form personnel safety guidelines. • AG 3.3: Identify hazards and acquire first aid skills to promote environmental safety.
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.
<ul style="list-style-type: none"> • 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 3.1: Service and repair the components of internal combustion engines using procedures for troubleshooting and evaluating performance.
- AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Physical Science	
PS3: Energy	
PS3.B: Conservation of Energy and Energy Transfer	<ul style="list-style-type: none"> • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • The availability of energy limits what can occur in any system.
Crosscutting Concepts	
Cause and Effect: Mechanism and Prediction	<p>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.</p> <ul style="list-style-type: none"> • 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> • 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.
Energy and Matter: Flows, Cycles, and Conservation	<p>Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.</p> <ul style="list-style-type: none"> • 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.

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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.

<p>Integration of Knowledge and Ideas</p>	<ul style="list-style-type: none"> • 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. • 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.
<p>Range of Reading and Level of Text Complexity</p>	<ul style="list-style-type: none"> • 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.
<p>CCSS: English Language Arts Standards » Writing » Grade 11-12</p>	
<p>Text Types and Purposes</p>	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> • 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.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).
<p>Production and Distribution of Writing</p>	<p>WHST.11-12.4 – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.</p>
<p>Research to Build and Present Knowledge</p>	<p>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.</p> <p>WHST.11-12.9 – Draw evidence from informational texts to support analysis, reflection, and research.</p>
<p>Range of Writing</p>	<p>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.</p>

Essential Questions

1. What are inputs, outputs, and processes in a mechanical system?
2. How are flow charts used to understand how an engine works?
3. How can flow charts be used to improve a system or identify a problem?
4. How are systems in a machine connected?
5. How is energy converted in a small engine?
6. What types of systems are found in an engine?
7. How do mechanical systems transfer energy?
8. What tools can a technician use to troubleshoot a small engine?
9. How can the troubleshooting process be applied to a small engine?
10. What practices are used to be safe when operating a machine?
11. How do you select PPE to wear when operating a machine?
12. How do you safely operate a small engine?
13. What are Safety Data Sheets?
14. How are Safety Data Sheets used in a shop setting?

Lesson 3.2 Disassembly Required

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> 1. Machine disassembly requires a systematic process that is sequential and organized. 2. A small engine carburetor has a series of parts used to increase fuel efficiency. 3. Governor controls and electrical systems in an engine are used to manage the fuel input and energy output. 4. Tolerances and specifications guide how small engine components are assembled together to function effectively. 5. Engine components are designed for a specific application or function. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Document and organize the disassembly of a small engine. (Activity 3.2.1, Activity 3.2.3, Activity 3.2.4, Activity 3.2.5) • Make a prototype of a carburetor producing the optimum air-fuel ratio. (Project 3.2.2) • Diagram how the governor adjusts small engine speed. (Activity 3.2.3) • Draw a schematic of the electrical system in small engine. (Activity 3.2.3) • Measure and adjust valve clearances for a small engine. (Activity 3.2.4) • Identify types of metals found in an engine and the purpose of each. (Activity 3.2.5) • Diagram and calculate the gear ratios and speeds in a small engine. (Activity 3.2.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
<ul style="list-style-type: none"> • 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.
9. Model integrity, ethical leadership and effective management.
<ul style="list-style-type: none"> • CRP.09.01: Model characteristics of ethical and effective leaders in the workplace and community (e.g. integrity, self-awareness, self-regulation, etc.). • CRP.09.03: Demonstrate behaviors that contribute to a positive morale and culture in the workplace and community (e.g., positively influencing others, effectively communicating, etc.).
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.
<ul style="list-style-type: none"> • AG-PST 1.1: Select energy sources for power generation. • AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems • AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems. • AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
<ul style="list-style-type: none"> • AG-PST 3.1: Service and repair the components of internal combustion engines using procedures for troubleshooting and evaluating performance. • AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.

Next Generation Science Standards Alignment

Disciplinary Core Ideas

Engineering, Technology, and the Application of Science

ETS1: Engineering Design

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ETS1.B: Developing Possible Solutions

- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Ask questions that arise from careful observation of phenomena, or unexpected results
 - that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
 - to determine relationships, including quantitative relationships, between independent and dependent variables.
 - to clarify and refine a model, an explanation, or an engineering problem.

- Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

- Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.

Developing and Using Models

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

- 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 an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
- Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
- Select appropriate tools to collect, record, analyze, and evaluate data.
- Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
- Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

	<ul style="list-style-type: none"> • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
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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.
	<ul style="list-style-type: none"> • 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.
	<ul style="list-style-type: none"> • 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.
Structure and Function	The way an object is shaped or structured determines many of its properties and functions.
	<ul style="list-style-type: none"> • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Common Core State Standards for High School Mathematics

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Common Core State Standards for English Language Arts

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Craft and Structure	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • WHST.11-12.4 – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. • WHST.11-12.5 – Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
Research to Build and Present Knowledge	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 process for reverse engineering a machine?
2. How should you organize parts when removing them from an engine?
3. How will you use your *Engineering Notebook* when taking apart an engine?
4. How do the components of a carburetor work?
5. How are mechanical and electrical controls used in an engine?
6. Why do technicians adjust mechanical controls?
7. How can mechanical controls be used for safety purposes?
8. What is a machine specification or tolerance?
9. Why do machines need to be assembled with precision?
10. How is clearance measured between two machine parts?
11. Why are machine components made of different materials?
12. Why are components marked or stamped?
13. How do gears control the operation of machine systems?

Lesson 3.3 Machine Assembly

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> Part specifications are used to ensure mechanical components fit together and not malfunction. Lubrication and bearings reduce wear on an engine. Proper assembly prevents malfunctions in a small engine. Technicians monitor and adjust engines for power and speed. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> Design and print a tool to measure the wear of journals on an engine. (Project 3.3.1) Measure the wear on a crankshaft and find the specification for replacement. (Activity 3.3.2) Identify wear points in an engine. (Activity 3.3.2) Describe the systems in place to reduce wear. (Activity 3.3.2) Reassemble a small engine using correct torque and sequencing of bolts, spacing of valves, and spacing of armature. (Activity 3.3.2, Activity 3.3.3) Set the governed speed of a small engine. (Activity 3.3.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
1. Act as a responsible and contributing citizen and employee.
<ul style="list-style-type: none"> CRP.01.01: Model personal responsibility in the workplace and community.
2. Apply appropriate academic and technical skills.
<ul style="list-style-type: none"> 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.
<ul style="list-style-type: none"> CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
9. Model integrity, ethical leadership and effective management.
<ul style="list-style-type: none"> 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.). CRP.09.03: Demonstrate behaviors that contribute to a positive morale and culture in the workplace and community (e.g., positively influencing others, effectively communicating, etc.).
Agriculture, Food, and Natural Resources Career Cluster
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
<ul style="list-style-type: none"> 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.
<ul style="list-style-type: none"> AG-PST 1.1: Select energy sources for power generation. AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems
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 3.1: Service and repair the components of internal combustion engines using procedures for troubleshooting and evaluating performance.
• AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	<ul style="list-style-type: none"> Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	<ul style="list-style-type: none"> 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	<p>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.</p> <ul style="list-style-type: none"> Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	<p>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).</p> <ul style="list-style-type: none"> Design a test of a model to ascertain its reliability. Develop a complex model that allows for manipulation and testing of a proposed process or system.
Analyzing and Interpreting Data	<p>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.</p> <ul style="list-style-type: none"> 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	<p>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.</p> <ul style="list-style-type: none"> 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> 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.
Structure and Function	<p>The way an object is shaped or structured determines many of its properties and functions.</p>

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • WHST.11-12.4 – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. • WHST.11-12.7 – 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.
Research to Build and Present Knowledge	<ul style="list-style-type: none"> • WHST.11-12.9 – Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	<ul style="list-style-type: none"> • 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 are engine components manufactured with precision?
2. How can you determine if a part does not fit within the correct specification?
3. How are engines designed to lubricate and cool moving parts?
4. What types of bearings are used in a machine?
5. What are the features of antifriction and friction bearings?
6. Why do bearings and journals wear out?
7. Why are machines assembled in a specific order?
8. How does assembly sequence affect machine function?
9. Why is torque considered when fastening engine components?
10. How do you set the speed of an engine?
11. How are governor systems adjusted on an engine?

Lesson 3.4 Engine Problems

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> 1. Technicians use troubleshooting and part identification to determine engine maintenance and repair costs. 2. Design criteria are based on market needs or identified problems. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Use a database to find and identify part numbers and costs. (Activity 3.4.1) • Use the troubleshooting process to identify and fix a faulty small engine. (Problem 3.4.2) • Identify parts to replace for a small engine. (Problem 3.4.2) • Measure and design a replacement part for a small engine. (Project 3.4.3)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
<p>1. Act as a responsible and contributing citizen and employee.</p> <ul style="list-style-type: none"> • CRP.01.01: Model personal responsibility in the workplace and community.
<p>2. Apply appropriate academic and technical skills.</p> <ul style="list-style-type: none"> • 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.
<p>4. Communicate clearly, effectively and with reason.</p> <ul style="list-style-type: none"> • 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.
<p>8. Utilize critical thinking to make sense of problems and persevere in solving them.</p> <ul style="list-style-type: none"> • 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.
<p>Agriculture, Food, and Natural Resources Career Cluster</p>

3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
<ul style="list-style-type: none"> • AG 3.5: Enact procedures that demonstrate the importance of safety, health, and environmental responsibilities in the workplace. • 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.
<ul style="list-style-type: none"> • AG-PST 1.2: Use hand and power tools commonly required in 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.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • AG-PST 3.1: Service and repair the components of internal combustion engines using procedures for troubleshooting and evaluating performance. • AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace.
4. Plan, build and maintain AFNR structures.
<ul style="list-style-type: none"> • AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Next Generation Science Standards Alignment

Crosscutting Concepts	
Patterns	<p>Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</p> <ul style="list-style-type: none"> • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
Cause and Effect: Mechanism and Prediction	<p>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.</p> <ul style="list-style-type: none"> • 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 High School Mathematics

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

CCSS: Conceptual Category – Number and Quantity	
Quantities	*Reason quantitatively and use units to solve problems.
CCSS: Conceptual Category – Statistics and Probability	
Using Probability to Make Decisions	*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	<ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● WHST.11-12.4 – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. ● WHST.11-12.7 – 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.
Research to Build and Present Knowledge	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● 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 process for identifying and ordering new parts for an engine or machine?
2. Why do machine parts have identification numbers?
3. What is the role of a service technician?
4. How are troubleshooting and failure analysis similar?
5. Why are machine parts redesigned?
6. What factors are considered when redesigning a machine part?

Lesson 4.1 Mobile Systems

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <p>3. Systems of gears and pulleys transfer energy in a mechanical system.</p> <p>4. A system's function can be improved with proper selection of machine power and speed.</p> <p>5. Agricultural machines consist of structural, drivetrain, control, and manipulator systems.</p> <p>6. Tractors are designed to meet the needs of a mechanical load.</p>	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Calculate speed ratios in a compound pulley system (Activity 4.1.1) • Construct a gearbox with compound gears and then calculate ratios and speed. (Activity 4.1.2) • Compare torque and speed of compound gear combinations. (Activity 4.1.3) • Construct a model tractor chassis and transmission system using robotic parts. (Activity 4.1.4) • Measure the energy draw and work of a model tractor pulling equipment. (Project 4.1.5) • Design a transmission and structural system in a model tractor to increase power, work, and stability. (Project 4.1.5)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
<p>1. Act as a responsible and contributing citizen and employee.</p>
<ul style="list-style-type: none"> • CRP.01.01: Model personal responsibility in the workplace and community.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • CRP.01.03: Identify and act upon opportunities for professional and civic service at work and in the community.
<p>2. Apply appropriate academic and technical skills.</p>
<ul style="list-style-type: none"> • CRP.02.01: Use strategic thinking to connect and apply academic learning, knowledge and skills to solve problems in the workplace and community.
<ul style="list-style-type: none"> • CRP.02.02: Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.
<p>6. Demonstrate creativity and innovation.</p>
<ul style="list-style-type: none"> • CRP.06.01: Synthesize information, knowledge and experience to generate original ideas and challenge assumptions in the workplace and community.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • CRP.06.03: Create and execute a plan of action to act upon new ideas and introduce innovations to workplace and community organizations.
<p>8. Utilize critical thinking to make sense of problems and persevere in solving them.</p>
<ul style="list-style-type: none"> • CRP.08.01: Apply reason and logic to evaluate workplace and community situations from multiple perspectives.
<ul style="list-style-type: none"> • CRP.08.02: Investigate, prioritize and select solutions to solve problems in the workplace and community.
<ul style="list-style-type: none"> • CRP.08.03: Establish plans to solve workplace and community problems and execute them with resiliency.
<p>9. Model integrity, ethical leadership and effective management.</p>
<ul style="list-style-type: none"> • CRP.09.01: Model characteristics of ethical and effective leaders in the workplace and community (e.g. integrity, self-awareness, self-regulation, etc.).
<ul style="list-style-type: none"> • CRP.09.02: Implement personal management skills to function effectively and efficiently in the workplace (e.g., time management, planning, prioritizing, etc.).
<ul style="list-style-type: none"> • CRP.09.03: Demonstrate behaviors that contribute to a positive morale and culture in the workplace and community (e.g., positively influencing others, effectively communicating, etc.).

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.	
<ul style="list-style-type: none"> • AG-PST 1.1: Select energy sources for power generation. • AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems • AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems. • AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit. 	
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.	
<ul style="list-style-type: none"> • AG-PST 3.2: Service and repair power transmission systems following manufacturer's guidelines. • AG-PST 3.4: Service and repair steering, suspension, traction, and vehicle performance systems by checking performance parameters. • AG-PST 3.5: Execute the safe and proper use of construction/fabrication hand tools in the workplace. 	
5. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.	
<ul style="list-style-type: none"> • AG-PST 5.1: Execute procedures and techniques for monitoring and controlling electrical systems using basic principles of electricity. 	

Next Generation Science Standards Alignment

Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	<ul style="list-style-type: none"> • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	<ul style="list-style-type: none"> • 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	<p>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.</p> <ul style="list-style-type: none"> • Ask questions that arise from careful observation of phenomena, or unexpected results <ul style="list-style-type: none"> · to determine relationships, including quantitative relationships, between independent and dependent variables. · to clarify and refine a model, an explanation, or an engineering problem. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	<p>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).</p> <ul style="list-style-type: none"> • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system.
Planning and Carrying Out Investigations	<p>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.</p> <ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none"> 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.
Constructing Explanations and Designing Solutions	<p>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.</p> <ul style="list-style-type: none"> Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Crosscutting Concepts	
Cause and Effect: Mechanism and Prediction	<p>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.</p> <ul style="list-style-type: none"> 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> 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.
Stability and Change	<p>For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</p> <ul style="list-style-type: none"> Systems can be designed for greater or lesser stability.

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.
Creating Equations	*Write expressions in equivalent forms to solve problems.
Reasoning with Equations and Inequalities	*Create equations that describe numbers or relationships.
	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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 a drivetrain?
2. How do drivetrains transfer energy?
3. How do pulley sizes affect a drivetrain?
4. Why is pulley selection important when designing a drivetrain?
5. How does a gearbox work?
6. How are ratios in compound gear systems calculated?
7. What is a gear reduction?
8. What is the relationship between power and speed?
9. How is rpm converted into linear speed?
10. How is torque measured?
11. What is the relationship between gear ratios and torque?

12. How can torque and speed be increased in a mechanical system?
13. What are the systems in an agricultural machine or tractor?
14. How are tractor drivetrains designed and controlled?
15. How does drawbar placement and hitching of equipment affect the stability of a tractor?

Lesson 4.2 Control Systems

Concepts	Performance Objectives
<i>Students will know and understand</i>	<i>Students will learn concepts by doing</i>
<ol style="list-style-type: none"> 1. Engineers program agricultural system controls using pseudocode, flow charts, and computer language. 2. Conducting background research is important to identify what is already known in a subject area. 3. Programmers use Boolean logic to program PLCs for machine operation. 4. Anticipating and solving potential problems is an essential part of the troubleshooting process. 	<ul style="list-style-type: none"> • Develop a behavioral plan and write pseudocode for an automated model tractor. (Project 4.2.1) • Use computer language to operate a virtual robot and model tractor. (Activity 4.2.3) • Make a flow chart showing the decision-making process of a robot. (Activity 4.2.4 and Activity 4.2.5) • Research robotic/drone applications in the agricultural field. (Project 4.2.2) • Write an annotated bibliography using valid resources and citations. (Project 4.2.2) • Use Boolean logic to program a virtual robot to navigate boundaries and obstacles. (Activity 4.2.4 and Activity 4.2.5) • Research and design an automated tractor for an orchard. (Problem 4.2.6) • Develop a troubleshooting chart for checking sensors and circuits for functionality. (Problem 4.2.6)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • CRP.04.02: Produce clear, reasoned and coherent written and visual communication in formal and informal settings.
6. Demonstrate creativity and innovation.
<ul style="list-style-type: none"> • 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.
7. Employ valid and reliable research strategies.
<ul style="list-style-type: none"> • CRP.07.01: Select and implement reliable research processes and methods to generate data for decision-making in the workplace and community. • CRP.07.02: Evaluate the validity of sources and data used when considering the adoption of new technologies, practices and ideas in the workplace and community.

8. Utilize critical thinking to make sense of problems and persevere in solving them.
<ul style="list-style-type: none"> • 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.
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.
<ul style="list-style-type: none"> • AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems. • AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.
<ul style="list-style-type: none"> • AG-PST 3.2: Service and repair power transmission systems following manufacturer's guidelines.
5. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.
<ul style="list-style-type: none"> • AG-PST 5.1: Execute procedures and techniques for monitoring and controlling electrical systems using basic principles of electricity.

Next Generation Science Standards Alignment

Physical Science	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	<ul style="list-style-type: none"> • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	<ul style="list-style-type: none"> • 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	<p>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.</p> <ul style="list-style-type: none"> • Ask questions that arise from careful observation of phenomena, or unexpected results <ul style="list-style-type: none"> · to clarify and refine a model, an explanation, or an engineering problem. • Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	<p>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).</p> <ul style="list-style-type: none"> • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system.
Planning and Carrying Out Investigations	<p>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.</p> <ul style="list-style-type: none"> • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

	<ul style="list-style-type: none"> • 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	<p>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.</p> <ul style="list-style-type: none"> • 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. • 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.
Constructing Explanations and Designing Solutions	<p>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.</p> <ul style="list-style-type: none"> • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Obtaining, Evaluating, and Communicating Information	<p>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.</p> <ul style="list-style-type: none"> • 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	<p>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.</p> <ul style="list-style-type: none"> • 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> • 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 – 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.

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
Key Ideas and Details	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none"> • 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.
Production and Distribution of Writing	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none"> • WHST.11-12.9 – Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing	<ul style="list-style-type: none"> • 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 process for writing a program for a robot or machine?
2. Why is pseudocode used to write a computer program?
3. How do I conduct valid background research?
4. Why is research important?
5. How do researchers choose and use resources for information?
6. How do I avoid plagiarizing?
7. How is computer language different from ours?
8. What grammatical rules do I use with computer languages?
9. How is testing a prototype in a virtual world different from testing a prototype in a physical?
10. What types of sensors can a robot use to collect data?
11. How does a PLC analyze data using Boolean logic?
12. How is Boolean logic used to program a robot?
13. How are control structures used when writing program code?
14. How is an automated machine programmed to repeat behaviors?
15. How do I program a robot to sense and react to its surroundings?
16. Why are flow charts used when planning an automated machine's behaviors?
17. How can I program a machine for an unpredictable environment?
18. What safety mechanisms on a machine use electronic sensors?

Lesson 4.3 Agricultural Processing

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> 1. Engineers choose components based upon the direction, speed, and motion needed in a mechanical system. 2. Technicians use schematics to design, construct, and test fluid power systems. 3. Valves control flow and pressure in fluid power systems. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Use gears and sprockets to simulate a threshing system in a combine. (Project 4.3.1) • Use pneumatic symbols to design and test virtual pneumatic systems. (Activity 4.3.2) • Construct a pneumatic system with a solenoid valve controlling a double acting cylinder. (Activity 4.3.3) • Determine the relationship between fluid pressure and fluid flow using a regulator and flow control valve. (Activity 4.3.4)

4. Mechatronic systems use a combination of machine and computer technology to process agricultural goods.

• Design and construct a conveyor system modeling the processing of a product. (Project 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.02.01: 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.
- 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.

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.).
- CRP.09.03: Demonstrate behaviors that contribute to a positive morale and culture in the workplace and community (e.g., positively influencing others, effectively communicating, etc.).

11. Use technology to enhance productivity.

- CRP.11.01: Research, select and use new technologies, tools and applications to maximize productivity in the workplace and community.

Power, Structural and Technical (AG-PST)

1. Apply physical science principles and engineering applications related to mechanical equipment, structures, and biological systems to solve problems and improve performance in AFNR power, structural, and technical systems.

- AG-PST 1.1: Select energy sources for power generation.
- AG-PST 1.2: Use hand and power tools commonly required in power, structural, and technical systems

AG-PST 1.3: Investigate solutions to AFNR power, structural, and technical systems.

AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.

3. Service and repair mechanical equipment and power systems used in AFNR power, structural and technical systems.

- AG-PST 3.2: Service and repair power transmission systems following manufacturer's guidelines.
- AG-PST 3.3: Service and repair hydraulic systems by evaluating performance using maintenance manuals.

5. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.

- AG-PST 5.1: Execute procedures and techniques for monitoring and controlling electrical systems using basic principles of electricity.

Next Generation Science Standards Alignment

Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	<ul style="list-style-type: none"> Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices	
Asking Questions and Defining Problems	<p>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.</p> <ul style="list-style-type: none"> Ask questions that arise from careful observation of phenomena, or unexpected results <ul style="list-style-type: none"> to clarify and refine a model, an explanation, or an engineering problem. Evaluate a question to determine if it is testable and relevant. Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.
Developing and Using Models	<p>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).</p> <ul style="list-style-type: none"> Design a test of a model to ascertain its reliability. Develop a complex model that allows for manipulation and testing of a proposed process or system. Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Planning and Carrying Out Investigations	<p>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.</p> <ul style="list-style-type: none"> Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. Select appropriate tools to collect, record, analyze, and evaluate data. Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
Analyzing and Interpreting Data	<p>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.</p> <ul style="list-style-type: none"> Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

	<ul style="list-style-type: none"> 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	<p>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.</p> <ul style="list-style-type: none"> Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. 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	<p>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.</p> <ul style="list-style-type: none"> Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. 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	<p>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.</p> <ul style="list-style-type: none"> 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	<p>A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <ul style="list-style-type: none"> 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 – Algebra	
Seeing Structure in Expressions	*Write expressions in equivalent forms to solve problems.
Creating Equations	*Create equations that describe numbers or relationships.

Common Core State Standards for English Language Arts

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

Key Ideas and Details	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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 gears designed to change direction and rotation in mechanical systems?
2. What are the advantages and disadvantages of using sprockets in a mechanical system?
3. How is pressurized fluid converted into linear power?
4. What are the essential components of a pneumatic system?
5. What is the purpose of a schematic?
6. How do pneumatic symbols represent the physical components?
7. How does a pneumatic valve control direction and flow of a fluid?
8. How are valves adjusted and controlled?
9. What is a solenoid valve?
10. How are solenoids programmed?
11. How is pressure different from flow in a fluid power system?

12. What are the components of a mechatronics system?
13. What is the process for designing an assembly line?
14. Where is mechatronics used in agriculture?

Lesson 5.1 Independent Engineers

Concepts	Performance Objectives
<p><i>Students will know and understand</i></p> <ol style="list-style-type: none"> 1. Intellectual product protection includes patents, trademarks, and copyrights. 2. Engineers design agricultural equipment to improve efficiencies. 3. Results of engineering projects include interpretation of data in the form of posters, papers, or oral presentations. 4. Regulatory agencies monitor research and development, production, and use of engineered products to ensure safety for consumers and the environment. 	<p><i>Students will learn concepts by doing</i></p> <ul style="list-style-type: none"> • Collect and summarize research about similar problems with patented, copyrighted, or trademarked solutions. (Activity 5.1.1) • Design new agricultural equipment improving agricultural production or processing. (Project 5.1.2) • Write a technical report summarizing an engineering design. (Project 5.1.3) • Prepare a research poster to present to the class and at local science and engineering fairs. (Project 5.1.3) • Research organizations that regulate new product designs. (Project 5.1.4) • Write a user manual for a new product design. (Project 5.1.4)

National AFNR Common Career Technical Core Standards Alignment

Career Ready Practices
2. Apply appropriate academic and technical skills.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • 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.
6. Demonstrate creativity and innovation.
<ul style="list-style-type: none"> • 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.
<ul style="list-style-type: none"> • 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

1. Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Resources Career Cluster.
<ul style="list-style-type: none"> • AG 1.1: Explain how regulations and major laws impact management of AFNR activities.
3. Examine and summarize importance of health, safety, and environmental management systems in AFNR organizations.
<ul style="list-style-type: none"> • 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.
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.
AG-PST 1.4: Design or modify equipment, structures, or biological systems to improve performance of an AFNR enterprise or business unit.
4. Plan, build and maintain AFNR structures.
<ul style="list-style-type: none"> • AG-PST 4.1: Create sketches and plans of agricultural structures. • AG-PST 4.2: Apply structural plans, specifications, and building codes. • AG-PST 4.3: Determine requirements and estimate costs for construction materials and procedures.

Next Generation Science Standards Alignment

Disciplinary Core Ideas	
Engineering, Technology, and the Application of Science	
ETS1: Engineering Design	
ETS1.A: Defining and Delimiting Engineering Problems	<ul style="list-style-type: none"> • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
ETS1.B: Developing Possible Solutions	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.
Science and Engineering Practices	
Asking Questions and Defining Problems	<p>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.</p> <ul style="list-style-type: none"> • Ask questions that arise from careful observation of phenomena, or unexpected results <ul style="list-style-type: none"> · to clarify and/or seek additional information. · that arise from examining models or a theory, to clarify and/or seek additional information and relationships. · to determine relationships, including quantitative relationships, between independent and dependent variables. · to clarify and refine a model, an explanation, or an engineering problem. • Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.

<p>Developing and Using Models</p>	<p>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).</p> <ul style="list-style-type: none"> • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
<p>Planning and Carrying Out Investigations</p>	<p>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.</p> <ul style="list-style-type: none"> • 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. • 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.
<p>Analyzing and Interpreting Data</p>	<p>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.</p> <ul style="list-style-type: none"> • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
<p>Constructing Explanations and Designing Solutions</p>	<p>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.</p> <ul style="list-style-type: none"> • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. <ul style="list-style-type: none"> • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
<p>Obtaining, Evaluating, and Communicating Information</p>	<p>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.</p> <ul style="list-style-type: none"> • 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).

Common Core State Standards for English Language Arts

CCSS: English Language Arts Standards » Science & Technical Subjects » Grade 11-12	
<p>Key Ideas and Details</p>	<ul style="list-style-type: none"> • 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.

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	<p>WHST.11-12.2 – Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</p> <ul style="list-style-type: none">• 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.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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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 intellectual property protected?
2. How do I select an engineering project that interests me?
3. How do I write an engineering problem statement?
4. What materials need to be included in an engineering proposal?
5. How do I write a technical report?
6. Why is the quality background research important when designing a product?
7. What is an abstract?
8. How do I prepare a presentation poster?
9. How do engineers communicate their ideas with others?