Minnesota Department of Education

Agriculture, Food & Natural Resources

Agriculture, Food, and Natural Resources Frameworks

Power, Structural, and Technical Systems Pathway

Power, Structural, and Technical Systems Pathway

The power structural and technical systems pathway encompasses the study of agricultural equipment, power systems, alternative fuel sources, precision technology, as well as woodworking, metalworking, welding, and project planning for agricultural structures. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of power, structural, and technical systems in Agriculture, Food, and Natural Resource (AFNR) settings.

Experiential Learning

Experiential Learning consists of Supervised Agriculture Experience (SAE), Work-based Learning (WBL), Apprenticeship, Job Shadow, and Service Learning experiences. Experiential Learning is a required component of a total agricultural education program and intended for every student. Through their involvement in Experiential Learning activities, students are able to consider multiple careers and occupations, learn expected workplace behavior, develop specific skills within an industry, and are given opportunities to apply academic and occupational skills in the workplace or a simulated workplace environment. Through these strategies, students learn how to apply what they are learning in the classroom as they prepare to transition into the world of college and career opportunities. Table 1 contains example Supervised Agricultural Experiences defined by the National Future Farmers of America (FFA) Organization.

Table 1. Supervised Agricultural Experiences

• Agricultural Mechanics Design and Fabrication • Agri-Science Integrated Systems Research-Power	• Agricultural Mechanics Repair and Maintenance • Structural, and Technical Systems Research

National FFA Organization

The FFA Organization is dedicated to making a positive difference in the lives of students by developing their potential for premier leadership, personal growth, and career success through agricultural education. FFA award and degree programs recognize students for excellence in academics, career development, leadership, and community service. Career and leadership development activities encompass the entire AFNR Career Cluster and each AFNR Pathway and are available at the local chapter, regional, state, and national levels. See Table 2 for example FFA activities of Career and Leadership Development Events related to the Power, Structural, and Technical Systems pathway.

Table 2. FFA Activities

Career Development Events (CDE's)	Leadership Development Events (LDE's)
• Agricultural Technology and Mechanical Systems • Agricultural Sales • Soils • Agriscience Fair: Power, Structure, and Technical Systems	• Agricultural Issues Forum • Marketing Plan • Prepared Public Speaking • Extemporaneous Speaking

Recommended Courses

Introductory Courses Number and Name	**Intermediate Courses** Number and Name	**Advanced Courses** Number and Name
• 26/27 Agricultural Exploration I/II • 52/53 Agricultural Technology I/II • 30/31 Agribusiness Management I/II	• 42/43 Small Gasoline Engines I/II • 54/55 Ag Welding Technology I/II/Metals I/II • 50/51 Ag Construction, Building and Structures I/II	• 57 Agricultural Engineering • 36/37 Computer Applications in Ag I/II (CAD) • 44/45 Ag Power Mechanics I/II/Large Gas Engines I/II

Minnesota Power, Structural, and Technical Systems Standards

Minnesota Framework: MN.PST.01. Apply physical science principles and engineering applications to solve problems and improve performance in AFNR power, structural and technical systems.

Performance Indicator: MN.PST.01.01: Apply physical science and engineering principles to design, implement and improve safe and efficient mechanical systems in AFNR situations.

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.

MN.PST.01.01 Intro Course Benchmarks	**MN.PST.01.01 Intermediate Course Benchmarks**	**MN.PST.01.01 Advanced Course Benchmarks**
PST.01.01.01.a. Compare and contrast applications of simple machines in AFNR related mechanical systems.	PST.01.01.01.b. Perform mathematical calculations to determine the mechanical advantage of simple machines in AFNR related mechanical systems.	PST.01.01.01.c. Apply the scientific method to devise strategies to improve the efficiency of operation of AFNR related mechanical systems.
PST.01.01.02.a. Identify the tools, machines and equipment needed to construct and/or fabricate a project in AFNR.	PST.01.01.02.b. Calculate the maintenance and purchase cost of tools, machines and equipment used in AFNR.	PST.01.01.02.c. Devise and document processes to safely implement and evaluate the safe use of AFNR related tools, machinery, and equipment.
PST.01.01.03.a. Examine owner's manuals to classify the types of safety hazards associated with different mechanical systems used in AFNR (e.g., caution, warning, danger, etc.).	PST.01.01.03.b. Select, maintain, and demonstrate the proper use of tools, machines and equipment used in different AFNR related mechanical systems.	PST.01.01.03.c. Conduct a safety inspection of tools, machines and equipment used in different AFNR related mechanical systems.

Continued from Minnesota Framework: MN.PST.01

Performance Indicator: MN.PST.01.02. Apply physical science principles to metal fabrication using a variety of welding and cutting processes (e.g., SMAW, GMAW, GTAW, fuel-oxygen and plasma arc torch, etc.).

Minnesota Academic Science Standards

- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.1.1 The structure of the atom determines chemical properties of elements.
- 9.2.1.2 Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.
- 9P.2.3.2 Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.
- 9P.2.3.3 Magnetic and electric fields interact to produce electromagnetic waves.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

MN.PST.01.02 Intro Course Benchmarks	MN.PST.01.02 Intermediate Course Benchmarks	MN.PST.01.02 Advanced Course Benchmarks
PST.01.02.01.a. Compare and contrast the principles and procedures of different welding and cutting processes (e.g., SMAW, GMAW, GTAW, fuel-oxygen and plasma arc torch, etc.).	PST.01.02.01.b. Analyze the situation and determine the best welding and cutting process to be used in metal fabrication.	PST.01.02.01.c. Evaluate the quality of metal fabrication procedures (e.g., SMAW, GMAW, GTAW, fuel-oxygen and plasma arc torch, etc.).
PST.01.02.02.a. Compare and contrast the properties of different metals used in AFNR power, structural and technical systems (e.g., malleability, conductivity, optical properties, chemical composition, etc.).	PST.01.02.02.b. Assess and select the proper electrode for use in various shielded metal arc welding situations.	PST.01.02.02.c. Construct and/or repair metal structures and equipment using metal fabrication procedures.

Minnesota Framework: MN.PST.02. Operate, maintain, and repair AFNR mechanical equipment and power systems.

Performance Indicator: MN.PST.02.01. Use hand and power (portable and stationary) tools commonly required in power, structural, and technical systems.

Minnesota Academic Science Standards

- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.

MN.PST.02.01 Intro Course Benchmarks	MN.PST.02.01 Intermediate Course Benchmarks	MN.PST.02.01 Advanced Course Benchmarks
MN.PST.02.01.01.a. Identify common tools used in AFNR setting.	MN.PST.02.01.01.b. Demonstrate proper use of common tools used in AFNR setting.	MN.PST.02.01.01.c. Effectively use common tools in AFNR setting to complete an assigned task.
MN.PST.02.01.02.a. Utilize English and standard units of measurement.	MN.PST.02.01.02.b. Demonstrate proficiency in the use of precision measurement tools.	MN.PST.02.01.02.c. Utilize precision measuring equipment to perform common AFNR problem solving calculations (e.g. engine displacement, land area, CFM's moved).

Performance Indicator: MN.PST.02.02. Perform preventative maintenance and scheduled service to maintain equipment, machinery and power units used in AFNR settings.

Minnesota Academic Science Standards

- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.

MN.PST.02.02 Intro Course Benchmarks	MN.PST.02.02 Intermediate Course Benchmarks	MN.PST.02.02 Advanced Course Benchmarks
PST.02.02.01.a. Maintain the cleanliness and appearance of equipment, machinery and power units used in AFNR power, structural and technical systems to assure proper functionality.	PST.02.02.01.b. Develop a preventative maintenance schedule for equipment, machinery and power units used in AFNR power, structural and technical systems.	PST.02.02.01.c. Devise a strategy to communicate to different audiences, preventative maintenance and service schedule for equipment, machinery and power units used in AFNR power, structural and technical systems.
PST.02.02.02.a. Examine operator's manuals to determine recommendations for servicing filtration systems and maintaining fluid levels on equipment, machinery and power units used in AFNR power, structural and technical systems.	PST.02.02.02.b. Service filtration systems and maintain fluid levels on equipment, machinery and power units in accordance with operator's manuals.	PST.02.02.02.c. Assess and adjust equipment (e.g., belts and drives, chains, sprockets, etc.) and maintain fluid conveyance components (e.g., hoses, lines, nozzles, etc.) to ensure proper functioning.

Continued from Minnesota Framework: MN.PST.02

Performance Indicator: MN.PST.02.03. Operate machinery and equipment while observing all safety precautions in AFNR settings.

Minnesota Academic Science Standards

- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.

MN.PST.02.03 Intro Course Benchmarks	MN.PST.02.03 Intermediate Course Benchmarks	MN.PST.02.03 Advanced Course Benchmarks
PST.02.03.01.a. Research and summarize the use of equipment, machinery and power units for AFNR power, structural and technical systems.	PST.02.03.01.b. Analyze and calculate the cost of using equipment, machinery, and power units for AFNR power, structural and technical systems.	PST.02.03.01.c. Perform pre-operation inspections, start-up and shut-down procedures on equipment, machinery and power units as specified in owner's manuals.
PST.02.03.02.a. Examine and identify safety hazards associated with equipment, machinery and power units used in AFNR power, structural, and technical systems (e.g., caution, warning, danger, etc.).	PST.02.03.02.b. Apply safety principles and applicable regulations to operate equipment, machinery and power units used in AFNR power, structural and technical systems.	PST.02.03.02.c. Adjust equipment, machinery and power units for safe and efficient operation in AFNR power, structural and technical systems.

Minnesota Framework: MN.PST.03. Service and repair AFNR mechanical equipment and power systems.

Performance Indicator: MN.PST.03.01. Troubleshoot, service and repair components of internal combustion engines using manufacturers' guidelines.

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.2.1.2 Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.
- 9.2.2.2 An object's mass and the forces on it affect the motion of an object.
- 9.2.3.2 Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
- 9.2.4.1 There are benefits, costs and risks to different means of generating and using energy.
- 9P.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9P.2.2.1 Forces and inertia determine the motion of objects.
- 9P.2.2.2 When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.
- 9P.2.3.2 Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.
- 9P.2.3.3 Magnetic and electric fields interact to produce electromagnetic waves.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

MN.PST.03.01 Intro Course Benchmarks	MN.PST.03.01 Intermediate Course Benchmarks	MN.PST.03.01 Advanced Course Benchmarks
PST.03.01.01.a. Identify and classify components of internal combustion engines used in AFNR power, structural and technical systems.	PST.03.01.01.b. Analyze and explain how the components of internal combustion engines interrelate during operation.	PST.03.01.01.c. Evaluate service and repair needs for internal combustion engines using a variety of performance tests (e.g., manuals, computer-based diagnostics, etc.).
PST.03.01.02.a. Distinguish the characteristics of spark-and-compression internal combustion engines used in AFNR power, structural and technical systems.	PST.03.01.02.b. Utilize technical manuals and diagnostic tools to determine service and repair needs of spark-and-compression internal combustion engines used in AFNR power, structural and technical systems.	PST.03.01.02.c. Inspect, analyze and repair spark-and-compression internal combustion engines used in AFNR power, structural and technical systems.

Continued from Minnesota Framework: MN.PST.03

Performance Indicator: MN.PST.03.02. Service electrical systems and components of mechanical equipment and power systems using a variety of troubleshooting and/or diagnostic methods.

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.2.2 An object's mass and the forces on it affect the motion of an object.
- 9.2.3.2 Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
- 9P.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9P.2.2.2 When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.
- 9P.2.3.2 Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.
- 9P.2.3.3 Magnetic and electric fields interact to produce electromagnetic waves.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

MN.PST.03.02 Intro Course Benchmarks	MN.PST.03.02 Intermediate Course Benchmarks	MN.PST.03.02 Advanced Course Benchmarks
PST.03.02.01.a. Compare and contrast basic units of electricity (e.g., volts, amps, watts, and ohms) and the principles that describe their relationship (e.g., Ohm's Law, Power Law, etc.).	PST.03.02.01.b. Assess the tools used to measure the basic units of electrical circuits in AFNR power, structural and technical systems, and perform the measurements.	PST.03.02.01.c. Analyze and design electrical circuits for AFNR power, structural and technical systems using knowledge of the basic units of electricity.
PST.03.02.02.a. Compare and contrast the characteristics of electronic components used in AFNR power, structural and technical systems (e.g., battery, resistor, diode, transistor, capacitor, etc.).	PST.03.02.02.b. Analyze and interpret electrical system symbols and diagrams.	PST.03.02.02.c. Conduct testing procedures to evaluate and repair malfunctioning electrical components and systems used in AFNR power, structural and technical systems.
PST.03.02.03.a. Classify the uses of electrical sensors and controls in AFNR power, structural and technical systems.	PST.03.02.03.b. Distinguish and select materials and tools used in electrical control circuit installation.	PST.03.02.03.c. Plan and install electrical control circuits and/or circuit boards to assure proper operation within AFNR power, structural and technical systems.

Continued from Minnesota Framework: MN.PST.03

Performance Indicator: MN.PST.03.03. Utilize manufacturers' guidelines to diagnose and troubleshoot malfunctions in machinery, equipment and power source systems (e.g., hydraulic, pneumatic, transmission, steering, suspension, etc.).

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.2.2 An object's mass and the forces on it affect the motion of an object.
- 9.2.3.2 Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
- 9.2.4.1 There are benefits, costs and risks to different means of generating and using energy.
- 9P.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9P.2.2.1 Forces and inertia determine the motion of objects.
- 9P.2.2.2 When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

MN.PST.03.03 Intro Course Benchmarks	MN.PST.03.03 Intermediate Course Benchmarks	MN.PST.03.03 Advanced Course Benchmarks
PST.03.03.01.a. Research and summarize the applications of common types of hydraulic and pneumatic systems used in AFNR power, structural and technical systems.	PST.03.03.01.b. Analyze and interpret hydraulic and pneumatic system symbols and diagrams used in AFNR power, structural and technical systems.	PST.03.03.01.c. Inspect, analyze and repair hydraulic and pneumatic system components used in AFNR power, structural and technical systems.
PST.03.03.02.a. Compare and contrast operation principles and features of mechanical transmission systems used in AFNR power, structural and technical systems (e.g., belts, chains, gears, bearings, seals, universals, drive shafts, etc.).	PST.03.03.02.b. Utilize speed, torque and power measurements to calculate efficiency in power transmission systems used in AFNR power, structural and technical systems.	PST.03.03.02.c. Inspect, analyze and repair the components of power transmission systems used in AFNR power, structural and technical systems.
PST.03.03.03.a. Identify and examine the components of suspension and steering systems used in AFNR power, structural and technical systems.	PST.03.03.03.b. Assess and analyze vehicle and machinery performance related to suspension and steering systems used in AFNR power, structural and technical systems.	PST.03.03.03.c. Inspect, analyze and repair vehicle suspension and steering systems used in AFNR power, structural and technical systems.

Minnesota Framework: MN.PST.04. Plan, build and maintain AFNR structures and/or manufactured products.

Performance Indicator: MN.PST.04.01. Create sketches and plans for AFNR structures and/or manufactured products.

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.4.1 There are benefits, costs and risks to different means of generating and using energy.
- 9P.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9P.2.3.1 Sound waves are generated from mechanical oscillations of objects and travel through a medium.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

MN.PST.04.01 Intro Course Benchmarks	MN.PST.04.01 Intermediate Course Benchmarks	MN.PST.04.01 Advanced Course Benchmarks
PST.04.01.01.a. Interpret and explain the meaning of symbols used in sketches of agricultural structures and/or manufactured products.	PST.04.01.01.b. Apply scale measurement and dimension to develop sketches of agricultural structures and/or manufactured products.	PST.04.01.01.c. Create sketches of an agricultural structure and/or manufactured products by applying principles of design.
PST.04.01.02.a. Read and interpret the parts and/or views of plans for agricultural structures and/or manufactured products.	PST.04.04.02.b. Construct plans for agricultural structures and/or manufactured products using current technology (e.g., drafting software, computer-aided design, etc.).	PST.04.01.02.c. Evaluate, plan and design functional and efficient facilities and/or products for use in AFNR power, structural and technical systems.

Continued from Minnesota Framework: MN.PST.04

Performance Indicator: MN.PST.04.02. Determine requirements, specifications and estimate costs for AFNR structures and/or manufactured products.

Minnesota Academic Science Standards

- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9P1.3.3 Developments in physics affect society and societal concerns affect the field of physics.
- 9P1.3.4 Physical and mathematical models are used to describe physical systems.

MN.PST.04.02 Intro Course Benchmarks	MN.PST.04.02 Intermediate Course Benchmarks	MN.PST.04.02 Advanced Course Benchmarks
PST.04.02.01.a. Summarize and categorize the information needed to complete a bill of materials and cost estimate for an AFNR structure and/or manufactured products.	PST.04.02.01.b. Analyze a project plan to prepare a bill of materials and an estimate of material costs.	PST.04.02.01.c. Create a project cost estimate, including materials, labor and management for an AFNR structure and/or manufactured products.
PST.04.02.02.a. Research and summarize sources of industry construction and materials standards and their importance (e.g., American National Standards Institute, ANSI, Underwriters' Laboratories, UL, etc.).	PST.04.02.02.b. Assess and analyze local building code requirements for agriculture structures and/or manufactured products.	PST.04.02.02.c. Design and conduct a functionality and safety assessment on an agricultural structure and/or manufactured products using knowledge of industry standards and local code requirements.

Continued from Minnesota Framework: MN.PST.04

Performance Indicator: MN.PST.04.03. Follow architectural, engineering, and/or mechanical plans/schematics to construct, maintain and/or repair AFNR structures and/or manufactured products (e.g., material selection, site preparation and/or layout, plumbing, concrete/masonry, electrical, bend allowances, hole tolerances, etc.).

Minnesota Academic Science Standards

- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.2.2 An object's mass and the forces on it affect the motion of an object.
- 9P.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9P.2.2.1 Forces and inertia determine the motion of objects.
- 9P.2.2.2 When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

MN.PST.04.03 Intro Course Benchmarks	MN.PST.04.03 Intermediate Course Benchmarks	MN.PST.04.03 Advanced Course Benchmarks
PST.04.03.01.a. Examine the criteria in selecting materials for constructing, maintaining, and/or repairing AFNR structures and/or manufactured products.	PST.04.03.01.b. Analyze and assess samples of materials or products for quality and efficiency of workmanship.	PST.04.03.01.c. Select materials for a project based upon an analysis of the project and the quality of the materials.
PST.04.03.02.a. Summarize the characteristics needed for an ideal building site.	PST.04.03.02.b. Complete a building site analysis checklist to select an ideal building site.	PST.04.03.02.c. Assess site characteristics, identify adjustments, and demonstrate procedures for preparing a building site.
PST.04.03.03.a. Compare and contrast the characteristics of wood and/or metal products used in AFNR structures and/or manufactured products.	PST.04.04.03.b. Calculate costs associated with the repair and replacement of wood and/or metal components an AFNR structure and/or manufactured products.	PST.04.03.03.c. Construct AFNR structures using wood and/or metal materials.
PST.04.03.04.a. Compare and contrast the characteristics of materials used in plumbing and water systems (e.g., copper, PVC, PEX, etc.).	PST.04.04.04.b. Calculate costs associated with the repair and replacement of wood and/or metal components an AFNR structure.	PST.04.03.04.c. Install and/or repair pipes and plumbing equipment and fixtures in AFNR structures.
PST.04.03.05.a. Summarize the characteristics of the components found in concrete.	PST.04.03.05.b. Calculate volume for concrete projects.	PST.04.03.05.c. Construct, maintain and/or repair AFNR structures with concrete, brick, stone or masonry.

MN.PST.04.03 Intro Course Benchmarks	MN.PST.04.03 Intermediate Course Benchmarks	MN.PST.04.03 Advanced Course Benchmarks
PST.04.03.06.a. Compare and contrast direct and alternating current.	PST.04.03.06.b. Assess and analyze the electrical requirements of an AFNR structure and/or manufactured products.	PST.04.03.06.c. Install and/or repair fixtures following appropriate codes and standards.
PST.04.03.07.a. Distinguish electrical circuits and the components of each.	PST.04.03.07.b. Calculate the cost of operating an electrical motor.	PST.04.03.07.c. Plan and wire electrical circuits (i.e., single pole switch, three-way switch, duplex outlet, etc.).

Minnesota Framework: MN.PST.05. Use control, monitoring, geospatial and other technologies in AFNR power, structural and technical systems.

Performance Indicator: MN.PST.05.01. Apply computer and other technologies (e.g., robotics, CNC, UAS, etc.) to solve problems and increase the efficiency of AFNR systems.

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.2.2 An object's mass and the forces on it affect the motion of an object.
- 9.2.3.2 Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
- 9.2.4.1 There are benefits, costs and risks to different means of generating and using energy.
- 9P.2.2.1 Forces and inertia determine the motion of objects.
- 9P.2.2.2 When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.
- 9P.2.3.2 Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.
- 9P.2.3.3 Magnetic and electric fields interact to produce electromagnetic waves.

MN.PST.05.01 Intro Course Benchmarks	MN.PST.05.01 Intermediate Course Benchmarks	MN.PST.05.01 Advanced Course Benchmarks
PST.05.01.01.a. Research and categorize computer technologies used to solve problems and increase efficiency in AFNR systems.	PST.05.01.01.b. Analyze data using computer programs and other current technologies used in AFNR systems.	PST.05.01.01.c. Solve problems and calculate changes in efficiency using computer technologies for AFNR systems.
PST.05.03.02.a. Examine and summarize the specific intent of technologies used to solve problems and increase the efficiency of AFNR systems (e.g., robotics, UAS, CNC, etc.).	PST.05.03.02.b. Calculate the change in efficiency after using technologies in AFNR systems.	PST.05.03.02.c. Solve problems and evaluate changes in efficiency and create recommendations for the use of technologies in AFNR systems. (e.g., robotics, UAS, CNC, etc.).

Continued from Minnesota Framework: MN.PST.05

Performance Indicator: MN.PST.05.02. Prepare and/or use electrical drawings to design, install and troubleshoot electronic control systems in AFNR settings.

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.3.2 Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
- 9.2.4.1 There are benefits, costs and risks to different means of generating and using energy.
- 9P.1.3.3 Developments in physics affect society and societal concerns affect the field of physics.
- 9P.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9P.2.3.2 Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.
- 9P.2.3.3 Magnetic and electric fields interact to produce electromagnetic waves.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

MN.PST.05.02 Intro Course Benchmarks	MN.PST.05.02 Intermediate Course Benchmarks	MN.PST.05.02 Advanced Course Benchmarks
PST.05.02.01.a. Examine and categorize electrical control system components used in AFNR systems (e.g., transistors, relays, HVAC, logic controllers, etc.).	PST.05.02.01.b. Analyze schematic drawings for electrical control systems used in AFNR systems.	PST.05.02.01.c. Design schematic drawings for electrical control systems used in AFNR systems.
PST.05.02.02.a. Differentiate between the purpose of electrical sensors and controls used in AFNR power, structural and technical systems.	PST.05.02.02.b. Interpret maintenance schedules for electrical control systems used in AFNR power, structural and technical systems.	PST.05.02.02.c. Troubleshoot electrical control system performance problems found in AFNR power, structural and technical systems.
PST.05.02.03.a. Research and summarize the importance of AFNR power, structural and technical control systems using programmable logic controllers (PLC) and/or other computer-based systems.	PST.05.02.03.b. Assess the functions of AFNR power, structural and technical control systems using programmable logic controllers (PLC) in agricultural production and manufacturing.	PST.05.02.03.c. Develop and implement AFNR power, structural and technical control systems using programmable logic controllers (PLC) and/or other computer-based systems.

Continued from Minnesota Framework: MN.PST.05

Performance Indicator: MN.PST.05.03. Apply geospatial technologies to solve problems and increase the efficiency of AFNR systems.

Minnesota Academic Science Standards

- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9P.1.3.3 Developments in physics affect society and societal concerns affect the field of physics.

MN.PST.05.03 Intro Course Benchmarks	MN.PST.05.03 Intermediate Course Benchmarks	MN.PST.05.03 Advanced Course Benchmarks
PST.05.03.01.a. Research and summarize the impact of utilizing geospatial technologies (i.e., GPS, GIS, remote sensing, telematics, etc.) in AFNR systems.	PST.05.03.01.b. Analyze and interpret trends in data collected utilizing geospatial technologies.	PST.05.03.01.c. Collect data and create maps utilizing geospatial technologies.
PST.05.03.02.a. Examine the components of precision technologies used in AFNR systems.	PST.05.03.02.b. Analyze and calculate the economic impact of utilizing precision technologies (e.g., GPS/GIS) in AFNR systems.	PST.05.03.02.c. Install, maintain and service instrumentation and equipment used for precision technologies (i.e., GPS receivers, yield monitors, remote sensors, etc.) used in AFNR systems.

Minnesota Framework: MN.PST.06. Demonstrate the application of biotechnology and alternative energy to solve problems in AFNR systems.

Performance Indicator: MN.PST.06.01. Apply biotechnology principles, techniques, and processes to produce biofuels renewable energy sources (e.g., fermentation, transesterification, methanogenesis, wind energy, solar power, geothermal etc.).

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.2 Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.
- 9.2.1.2 Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.
- 9.2.3.2 Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
- 9.2.4.1 There are benefits, costs and risks to different means of generating and using energy.
- 9C.1.3.3 Developments in chemistry affect society and societal concerns affect the field of chemistry.
- 9C.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9C.2.1.2 Chemical and physical properties of matter result from the ability of atoms to form bonds.
- 9C.2.1.3 Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.
- 9C.2.1.4 States of matter can be described in terms of motion of molecules and that the properties and behavior of gases can be explained using the kinetic molecular theory.
- 9P.1.3.4 Physical and mathematical models are used to describe physical systems.
- 9P.2.2.1 Forces and inertia determine the motion of objects.
- 9P.2.2.2 When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.
- 9P.2.3.2 Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.
- 9P.2.3.3 Magnetic and electric fields interact to produce electromagnetic waves.
- 9P.2.3.4 Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.

Continued from Minnesota Framework: MN.PST.06

MN.PST.06.01 Intro Course Benchmarks	MN.PST.06.01 Intermediate Course Benchmarks	MN.PST.06.01 Advanced Course Benchmarks
PST.06.01.01.a. Examine and synthesize the need for biofuels (e.g., cellulosic bioenergy, etc.).	PST.06.01.01.b. Analyze the impact of the production and use of biofuels on the environment.	PST.06.01.01.c. Evaluate and support how biofuels could solve a global issue (e.g., environmental, agricultural, etc.).
PST.06.01.02.a. Differentiate between biomass and sources of biomass.	PST.06.01.02.b. Assess the characteristics of biomass that make it useful for biofuels production.	PST.06.01.02.c. Conduct a review of the technologies used to create biofuels from biomass and weigh the pros and cons of each method.
PST.06.01.03.a. Research and explain the process of fermentation and its potential applications.	PST.06.01.03.b. Correlate the relationship between fermentation and the process used to produce alcohol from biomass.	PST.06.01.03.c. Produce alcohol and co-products from biomass.
PST.06.01.04.a. Define and summarize the process of transesterification and its potential applications.	PST.06.01.04.b. Analyze and document the process used to produce biodiesel from biomass.	PST.06.01.04.c. Produce biodiesel and co-products from biomass.
PST.06.01.05.a. Examine the process of methanogenesis and its potential applications.	PST.06.01.05.b. Analyze and describe the process used to produce methane from biomass.	PST.06.01.05.c. Produce methane and co-products from biomass.
PST.06.01.06.a. Research and identify renewable and nonrenewable energy sources used in AFNR.	PST.06.01.06.b. Assess the environmental impacts of renewable and nonrenewable energy sources used in AFNR.	PST.06.06.06.c. Design and implement methods to evaluate the efficiency of renewable and nonrenewable energy sources used in AFNR.
PST.06.01.07.a. Compare and contrast the pathways of delivery for renewable and nonrenewable energy sources in an AFNR enterprise or business.	PST.06.01.07.b. Calculate the costs of using renewable and nonrenewable energy sources in an AFNR enterprise or business.	PST.06.01.07.c. Devise a strategy to incorporate the use of selected energy sources in an ANFR enterprise or business.
PST.06.01.08.a. Summarize methods and compare and contrast units used to benchmark energy use of AFNR structures (e.g., EUIs, BTUs, etc.).	*PST.06.01.08.b. Convert energy utilized in an AFNR structure to an energy utilization index (e.g., convert CCF, KWH, etc. to Btu consumption per square foot, etc.).*	*PST.06.01.08.c. Apply energy benchmarking data to examine and select methods to conserve energy in AFNR structures.*