Power, Structural, and Technical Systems (PST) Pathway; AFNR Field/Cluster

The Power, Structural, and Technical Systems (PST) 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 AFNR settings.

Recommended Power, Structural, and Technical (PST) Courses and Pathway Sequence

Agriculture Combined Program (019901)

| Introductory (Intro.) Courses | Intermediate (Interm.) Courses | Advanced (Adv.) Courses |
| --- | --- | --- |
| Number and Name | Number and Name | Number and Name |
| * 01 Principles of Ag., Food, and Natural Resources
* 02 Advanced Principles of Ag., Food, and Natural Resources
* 03 Principles of AFNR Biology (Science-Elective Credit)
* 04 Advanced Principles of AFNR Biology (Science-Elective Credit)
* 60 Agricultural Power Systems Technology
 | * 61 Agricultural Physics (Physics or Math Credit)
* 62 Agricultural Manufacturing
* 63 Advanced Agricultural Manufacturing
* 64 Agricultural Construction
* 65 Advanced Agricultural Construction
* 66 Agricultural Electricity and Plumbing
* 67 Agricultural Transportation and Operations
* 68 Advanced Agricultural Transportation and Operations
* 69 Agricultural Small Engines
* 70 Agricultural Engineering
* 71 Agricultural Engineering and Physics (Physics or Math Credit)
 | * 13 Agricultural Education, Research, and Development
* 72 Creative Power Systems Design (Art Credit)
* 73 Ag. Fabrication and Repair Operations (Simulated WBL: School Business)
* 74 Specialty and Emerging Power Systems Topics
* 93 Extended/ Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
* 94 Agricultural Leadership Development
* 95 Agricultural Career Seminar
* 96 Advanced Agricultural Career Seminar
* 97 AFNR Work Experience: Immersion SAE (Adv. Internship/Placement, Entrepreneurship, Research)
 |

Work-Based Learning and Supervised Agricultural Experiences

Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Rule 3505). Table 1 contains example SAE opportunities, as defined by the National Council for Agricultural Education, Perkins V federal legislation, and the Minnesota Department of Education.

Table 1.

Examples of WBL/SAE Curricula and Programs that Relate to Power, Structural, and Technical Systems, Non-Exhaustive.

| Experiential Learning (Foundational SAE; Pre-WBL) | None |
| --- | --- |
| * Job shadow
* Service learning
* Field trips
* Career exploration
 | * Job shadowing in the fabrication industry
* Ag issues in the alternative fuels industry
* Field trip to a local equipment dealer
* Community learning experiences
 |

| Internship (Placement SAE; Immersion WBL) | Entrepreneurship (Entrepreneurship SAE; Immersion WBL) |
| --- | --- |
| * Working at a custom fabrication business
* Working for a renewable energy company
* Placement with a local agricultural construction company
 | * Custom trailer fabrication
* Equipment repair business
* Wind energy business
 |
| Research (Research SAE; Immersion WBL) | School-Based Enterprise (SBE; SBE SAE; Simulated WBL) |
| * Hydraulic pressure of varies lubricants
* Emission control effects of diesel engines
* Ethanol fuel impacts on small engines
* Structural integrity of various materials used in construction
 | * Power Systems SBE WBL
* Metal Fabrication SBE WBL
* Animal Production/School Farm Operations SBE WBL
 |
| Apprenticeship (Adv. Placement SAE; Immersion WBL) | FFA Work-Based Learning and SAE Proficiency Award Areas |
| * More than 450 hours in an internship, combined with coursework. Contact MDE for support.
 | * Agricultural Mechanics Design and Fabrication
* Agricultural Mechanics Repair and Maintenance
* Agricultural Services
 |

Leadership Development and National FFA Organization

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral (necessary to comprise the whole) component of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Rule 3505). Table 2 contains example FFA opportunities, as defined by the National Council for Agricultural Education, Perkins V federal legislation, the Minnesota Department of Education, and the Minnesota FFA Association.

Table 2.

Examples of Leadership/FFA Curricula and Programs that Relate to Power, Structural, and Technical Systems, Non-Exhaustive.

| Student Development Programs (Growing Leaders) | Community Development/ Service (Building Communities) |
| --- | --- |
| * Agriscience or SAE Fair
* Career Day/guest speakers
* Facility tours
 | * Build benches/planters for community spaces
* Servicing lawn mowers/generators for the community
* Build community recreation options (e.g., disc golf course)
* Build little community libraries
* Building garages and storage building for community
 |
| Literacy, Advocacy, and Safety (Strengthening Agriculture) | Conferences, Conventions, and Banquets |
| * Lawn mower safety demonstrations
* Farm/ATV/Electrical Safety Demonstrations
* Alternative Energy Education
 | * InTENse
* Horizon conference
 |
| Career Development Events (CDE) | Leadership Development Events (LDE) |
| * Ag Mechanical and Technical Systems
 | * Agricultural Issues Forum
* Marketing Plan
* Prepared Public Speaking
* Extemporaneous Speaking
 |

Minnesota AFNR: Power, Structural, and Technical Systems Standards

| [MN.PST.01. Apply physical science principles and engineering applications to solve problems and improve performance in AFNR power, structural, and technical systems.](#pst1) |
| --- |
| MN.PST.01.01. Apply physical science and engineering principles to design, implement, and improve safe and efficient mechanical systems in AFNR situations. |
| 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, plasma arc torch). |

| [MN.PST.02. Operate, maintain, and repair AFNR mechanical equipment and power systems.](#pst2) |
| --- |
| MN.PST.02.01. Use hand and power (portable and stationary) tools commonly required in power, structural, and technical systems. |
| MN.PST.02.02. Perform preventative maintenance and scheduled service to maintain equipment, machinery, and power units used in AFNR settings. |
| MN.PST.02.03. Operate machinery and equipment while observing all safety precautions in AFNR settings. |

| [MN.PST.03. Service and repair AFNR mechanical equipment and power systems.](#pst3) |
| --- |
| MN.PST.03.01. Troubleshoot, service, and repair components of internal combustion engines using manufacturers’ guidelines. |
| MN.PST.03.02. Service electrical systems and components of mechanical equipment and power systems using a variety of troubleshooting and diagnostic methods. |
| 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). |

| [MN.PST.04. Plan, build, and maintain AFNR structures or manufactured products.](#pst4) |
| --- |
| MN.PST.04.01. Create sketches and plans for AFNR structures or manufactured products. |
| MN.PST.04.02. Determine requirements, specifications, and estimate costs for AFNR structures or manufactured products. |
| MN.PST.04.03. Follow architectural, engineering, and mechanical plans/schematics to construct, maintain, or repair AFNR structures or products (e.g., material selection, site preparation/layout, plumbing, masonry, electrical). |

| [MN.PST.05. Use control, monitoring, geospatial, and other technologies in AFNR power, structural, and technical systems.](#pst5) |
| --- |
| MN.PST.05.01. Apply computer and other technologies (e.g., robotics, CNC, UAS) to solve problems and increase the efficiency of AFNR systems. |
| MN.PST.05.02. Prepare and use electrical drawings to design, install, and troubleshoot electronic control systems in AFNR settings. |
| MN.PST.05.03. Apply geospatial technologies to solve problems and increase the efficiency of AFNR systems. |

| [MN.PST.06. Demonstrate the application of biotechnology and alternative energy to solve problems in AFNR systems.](#pst6) |
| --- |
| 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). |

| 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. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.01.01. Adv. 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 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). | 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. |

| 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.01.02. Apply physical science principles to metal fabrication using a variety of welding and cutting processes (e.g., SMAW, GMAW, GTAW, fuel-oxygen, plasma arc torch). |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.01.02. Adv. 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, plasma arc torch, CNC plasma cutting). | PST.01.02.01.b. Analyze the situation and determine the best welding and cutting process to be used in AFNR metal fabrication. | PST.01.02.01.c. Evaluate the quality of AFNR metal fabrication procedures (e.g., SMAW, GMAW, GTAW, fuel-oxygen, plasma arc torch). |
| 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). | 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 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. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.02.01. Adv. Course Benchmarks |
| --- | --- | --- |
| MN.PST.02.01.01.a. Identify common tools used in AFNR settings. | MN.PST.02.01.01.b. Demonstrate proper use of common tools used in AFNR settings. | MN.PST.02.01.01.c. Effectively use common tools in AFNR settings to complete an assigned task. |
| MN.PST.02.01.02.a. Utilize Metric and Standard (i.e., SAE) 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, CFMs moved). |

| Minnesota Framework: MN.PST.02. Operate, maintain, and repair AFNR mechanical equipment and power systems. |
| --- |
| Performance Indicator: MN.PST.02.02. Perform preventative maintenance and scheduled service to maintain equipment, machinery, and power units used in AFNR settings. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.02.02. Adv. 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) and maintain fluid conveyance components (e.g., hoses, lines, nozzles) to ensure proper functioning. |

| Minnesota Framework: MN.PST.02. Operate, maintain, and repair AFNR mechanical equipment and power systems. |
| --- |
| Performance Indicator: MN.PST.02.03. Operate machinery and equipment while observing all safety precautions in AFNR settings. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.02.03. Adv. 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). | 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. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.03.01. Adv. 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). |
| 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. |

| Minnesota Framework: MN.PST.03. Service and repair AFNR mechanical equipment and power systems. |
| --- |
| Performance Indicator: MN.PST.03.02. Service electrical systems and components of mechanical equipment and power systems using a variety of troubleshooting and diagnostic methods. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.03.02. Adv. Course Benchmarks |
| --- | --- | --- |
| PST.03.02.01.a. Compare, and contrast, basic units of electricity (i.e., volts, amps, watts, ohms) and the principles that describe their relationship (i.e., Ohm’s Law, Power Law). | 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). | 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 circuit boards to assure proper operation within AFNR power, structural, and technical systems. |

| Minnesota Framework: MN.PST.03. Service and repair AFNR mechanical equipment and power systems. |
| --- |
| Performance Indicator: MN.PST.03.03. Utilize manufacturers’ guidelines to diagnose and troubleshoot malfunctions in machinery, equipment, and power source systems (e.g., hydraulic, pneumatic, transmission, steering, suspension). |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.03.03. Adv. 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). | 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 or manufactured products. |
| --- |
| Performance Indicator: MN.PST.04.01. Create sketches and plans for AFNR structures or manufactured products. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.04.01. Adv. Course Benchmarks |
| --- | --- | --- |
| PST.04.01.01.a. Interpret and explain the meaning of symbols used in sketches of agricultural structures or manufactured products. | PST.04.01.01.b. Apply scale measurement and dimension to develop sketches of agricultural structures or manufactured products. | PST.04.01.01.c. Create sketches of an agricultural structure or manufactured products by applying principles of design (e.g., drafting software, computer-aided design). |
| PST.04.01.02.a. Read and interpret the parts and views of plans for agricultural structures or manufactured products. | PST.04.04.02.b. Construct plans for agricultural structures or manufactured products using current technology (e.g., drafting software, computer-aided design). | PST.04.01.02.c. Evaluate, plan, and design functional and efficient facilities or products for use in AFNR power, structural, and technical systems. |

| Minnesota Framework: MN.PST.04. Plan, build, and maintain AFNR structures or manufactured products. |
| --- |
| Performance Indicator: MN.PST.04.02. Determine requirements, specifications, and estimate costs for AFNR structures or manufactured products. |
| MN Academic Science Standards (2009)* 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.
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| MN.PST.04.02. Intro. Course Benchmarks | MN.PST.04.02. Interm. Course Benchmarks | MN.PST.04.02. Adv. Course Benchmarks |
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| PST.04.02.01.a. Summarize and categorize the information needed to complete a bill of materials and cost estimate for an AFNR structure 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 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). | PST.04.02.02.b. Assess and analyze local building code requirements for agriculture structures or manufactured products. | PST.04.02.02.c. Design and conduct a functionality and safety assessment on an agricultural structure or manufactured products using knowledge of industry standards and local code requirements. |

| Minnesota Framework: MN.PST.04. Plan, build, and maintain AFNR structures or manufactured products. |
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| Performance Indicator: MN.PST.04.03. Follow architectural, engineering, and mechanical plans/schematics to construct, maintain, or repair AFNR structures or products (e.g., material selection, site preparation/layout, plumbing, masonry, electrical). |
| MN Academic Science Standards (2009)* 9.1.2.1 Engineering is a way of addressing human needs by applying science and mathematical to develop 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 energy remains constant.
* 9P.2.3.4 Energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction, and radiation.
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| MN.PST.04.03. Intro. Course Benchmarks | MN.PST.04.03. Interm. Course Benchmarks | MN.PST.04.03. Adv. Course Benchmarks |
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| PST.04.03.01.a. Examine the criteria in selecting materials for constructing, maintaining, and repairing AFNR structures 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 or metal products used in AFNR structures or manufactured products. | PST.04.03.03.b. Calculate costs associated with the repair and replacement of wood or metal components an AFNR structure or manufactured products. | PST.04.03.03.c. Construct AFNR structures using wood 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). | PST.04.03.04.b. Calculate costs associated with the repair and replacement of wood or metal components an AFNR structure. | PST.04.03.04.c. Install 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 repair AFNR structures with concrete, brick, stone, or masonry. |
| 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 or manufactured products. | PST.04.03.06.c. Install 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). |

| Minnesota Framework: MN.PST.05. Use control, monitoring, geospatial, and other technologies in AFNR power, structural, and technical systems. |
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| Performance Indicator: MN.PST.05.01. Apply computer and other technologies (e.g., robotics, CNC, UAS) to solve problems and increase the efficiency of AFNR systems. |
| MN Academic Science Standards (2009)* 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.
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| MN.PST.05.01. Intro. Course Benchmarks | MN.PST.05.01. Interm. Course Benchmarks | MN.PST.05.01. Adv. Course Benchmarks |
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| 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.05.01.02.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). | PST.05.01.02.b. Calculate the change in efficiency after using technologies in AFNR systems. | PST.05.01.02.c. Solve problems and evaluate changes in efficiency and create recommendations for the use of technologies in AFNR systems (e.g., robotics, UAS, CNC). |

| Minnesota Framework: MN.PST.05. Use control, monitoring, geospatial, and other technologies in AFNR power, structural, and technical systems. |
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| Performance Indicator: MN.PST.05.02. Prepare and use electrical drawings to design, install, and troubleshoot electronic control systems in AFNR settings. |
| MN Academic Science Standards (2009)* 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.
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| MN.PST.05.02. Intro. Course Benchmarks | MN.PST.05.02. Interm. Course Benchmarks | MN.PST.05.02. Adv. Course Benchmarks |
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| PST.05.02.01.a. Examine and categorize electrical control system components used in AFNR systems (e.g., transistors, relays, HVAC, logic controllers). | 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) 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) or, sensor-based technologies, other computer-based systems. |

| Minnesota Framework: MN.PST.05. Use control, monitoring, geospatial, and other technologies in AFNR power, structural, and technical systems. |
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| Performance Indicator: MN.PST.05.03. Apply geospatial technologies to solve problems and increase the efficiency of AFNR systems. |
| MN Academic Science Standards (2009)* 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. Interm. Course Benchmarks | MN.PST.05.03. Adv. Course Benchmarks |
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| PST.05.03.01.a. Research and summarize the impact of utilizing geospatial technologies (i.e., GPS, GIS, remote sensing, telematics ) 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) used in AFNR systems. |

| Minnesota Framework: MN.PST.06. Demonstrate the application of biotechnology and alternative energy to solve problems in AFNR systems. |
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| 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). |
| MN Academic Science Standards (2009)* 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.
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| Minnesota Framework: MN.PST.06. Demonstrate the application of biotechnology and alternative energy to solve problems in AFNR systems. |
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| 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). Continued. |

| MN.PST.06.01. Intro. Course Benchmarks | MN.PST.06.01. Interm. Course Benchmarks | MN.PST.06.01. Adv. Course Benchmarks |
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| PST.06.01.01.a. Examine and synthesize the need for biofuels (e.g., cellulosic bioenergy). | 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). |
| 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.06.01.06.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). | PST.06.01.08.b. Convert energy utilized in an AFNR structure to an energy utilization index (e.g., convert CCF, KWH to Btu consumption per square foot). | PST.06.01.08.c. Apply energy benchmarking data to examine and select methods to conserve energy in AFNR structures. |
| PST.06.01.09.a. Identify the basic mechanical components of a photovoltaic, wind turbine, or geothermal system. | PST.06.01.09.b. Measure and test energy output generated from solar power and wind energy systems.  | PST.06.01.09.c. Design solar and wind energy systems to meet stand alone and off grid energy use applications.  |

**Secondary/Interdisciplinary AFNR Pathways that Align with Power, Structural, and Technical Systems**

* [**Agribusiness Systems (ABS)**](#ABS_Standards)—a secondary or multidisciplinary AFNR pathway, often integrating standards or cumulating from coursework from the AFNR animal, plant, natural resources, and power systems pathways—encompassing the study of agribusinesses and their management including, but not limited to, record keeping, budget management (cash and credit), business planning, and sales and marketing. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the planning, development, application, and management of agribusiness systems in AFNR settings.