



Manufacturing Careers

Trade and Industry Frameworks



Minnesota Department of Education

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Contents

Program Area Description..... 4

How to Use This Document.....4

 Basic Manufacturing Technical Skills..... 4

Experiential Learning and Work-Based Learning.....5

Career Technical Student Organization: SkillsUSA.....5

 CTSO Competitive Events:..... 5

Suggested Technical Skill Assessments (TSA) or Industry-Recognized Credentials:..... 6

Program Area Courses.....7

Employability Skills Framework.....10

Health, Safety, Security, and Environment Framework..... 11

Career Exploration Framework..... 16

Career Pathway: Basic Manufacturing..... 18

 Basic Manufacturing Courses..... 18

 Basic Manufacturing Technical Skills..... 19

Career Pathway: Manufacturing Welding.....30

 Manufacturing Welding Courses..... 30

 Manufacturing Welding Technical Skills..... 31

Career Pathway: Manufacturing Machining	37
Manufacturing Machining Courses.....	37
Manufacturing Machining Technical Skills.....	37
Career Pathway: Manufacturing Fabrication	41
Manufacturing Fabrication Courses.....	41
Manufacturing Fabrication Technical Skills.....	42
Career Pathway: Manufacturing Technology	48
Manufacturing Technology Courses.....	48
Manufacturing Technology Technical Skills.....	50
Career Pathway: Air Conditioning, Heating, and Refrigeration Services	60
Air Conditioning, Heating, and Refrigeration Services Courses.....	60
Air Conditioning, Heating, and Refrigeration Services Technical Skills.....	61
Career Pathway: Manufacturing Capstone	64
Capstone Course.....	64
Capstone Technical Skills.....	64
Appendix – Sources and Resources	71
Sources Material.....	71
Online Resources.....	71

Program Area Description

“Producing Products which people use in their lives”

The Manufacturing Cluster includes the study of planning, managing, and performing the processing of materials into intermediate or final products and related professional and technical support activities such as production planning and control, maintenance and manufacturing/process engineering. Student develop skills in working with products and equipment, installing or repairing products, designing a new product, deciding how the product will be made, or making a product and apply them in classroom, simulated, and real-world settings. Students completing a program of study related to careers in this cluster will be prepared for careers in equipment operators, millwrights, assemblers and warehouse workers.

How to Use This Document

Purpose: The Minnesota Trade and Industry Education Framework is designed to be used as a guide as teachers develop new courses or modify existing courses in the content area of Manufacturing. This framework will serve as a guide for several different courses that can be taught in the manufacturing area. This framework was developed from several sources including several national standards, other state framework/standards, the Minnesota Technical Skills Attainment (TSA) work, and the States’ Career Cluster Initiative. The work was reviewed by Trade and Industry teachers, higher education partners, trade and teacher associations, and industry specialists. A list of reviewers is listed in the Introduction document.

What this framework is not—is a lesson plan! The framework includes course guides that capture the essential Learning Targets as well as the Performance Indicators and Measure/Benchmarks:

- **Performance Indicators** - used to help identify and develop the major units of study
A method to confirm the most important learning is addressed for each of the units in a course.
- **Measures and Benchmarks** - guide development of formative and summative assessments to align with course Indicators
Attainment of the knowledge and skills outlined in the performance indicators is intended to demonstrate an acceptable level of proficiency with the related performance element at the conclusion of a program of study in this area.
- **Learning Targets** - suggested as examples of daily student learning objectives
Learning Targets are not intended to be an all-encompassing list; the samples are provided as examples to demonstrate a logical progression of knowledge and skill development pertaining to one or more content areas related to the performance indicator.

Example:

Basic Manufacturing Technical Skills

Performance Indicator/Standard

Measures/Benchmarks	Learning Targets
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Experiential Learning and Work-Based Learning

Experiential Learning opportunities **could include industry tours, job shadowing experiences, service learning experiences, and simulated business.** Work-Based Learning (WBL) includes internship and Youth Apprenticeship opportunities for approved WBL programs with licensed WBL coordinators. Experiential Learning is a required component of the total trade and industry education program, with the intention that opportunities will be available for every student. Through 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 career and college opportunities.

Career Technical Student Organization: SkillsUSA

SkillsUSA is a partnership of students, teachers and industry representatives working together to ensure America has a skilled workforce. SkillsUSA helps each student excel. SkillsUSA is a national organization which serves teachers and high school, middle school and college students. Students are preparing for careers in technical, skilled, and service occupations, including health occupations, as well as preparing for further education.

CTSO Competitive Events:

SkillsUSA:

- Automated Manufacturing Technology
- CNC Milling Specialist
- CNC Technician
- CNC Turning Specialist
- Heating, Ventilation, AC, Refrigeration
- Industrial Motor Control
- Mechatronics
- Power Equipment Technology
- Sheet Metal
- Technical Drafting
- Welding
- Welding Fabrication
- Welding Sculpture

Suggested Technical Skill Assessments (TSA) or Industry-Recognized Credentials:

[Autodesk](#)

AutoCAD Certified Associate
Fusion 360 Certified Associate
Inventor Certified Associate
Revit Certified Associate

[AWS \(American Welding Society\)](#)

Certified Welder

[AWS SENSE \(Schools Excelling through National Skills Standards Education\)](#)

SENSE Level 1 - Entry Welder
SENSE Level 2 - Advanced Welder

[MSSC \(Manufacturing Skill Standards Council\)](#)

Certified Production Technician – Safety
Certified Production Technician – Quality Practices and Measurements
Certified Production Technician – Processes and Production
Certified Production Technician – Maintenance Awareness

[NIMS \(National Institute for Metalworking Skills\)](#)

Machine Level 1 – Measurement, Materials, and Safety

Machine Level 1 – CNC Mill Operations

[NOCTI \(National Occupational Competency Testing Institute\) Exams](#)

Manufacturing Technology
Precision Manufacturing
Welding

[Onshape](#)

Certified Onshape Associate

[OSHA Education Center/American Safety Council](#)

OSHA 10-hour

[Precision Exams](#)

Welding Technician Entry
Welding Technician Intermediate
Welding Technician Advanced

[SACA \(Smart Automation Certification Alliance\)](#)

Certified Industry 4.0 Associate – Basic Operations
Certified Industry 4.0 Associate – Advanced Operations
Certified Industry 4.0 Associate – Robotic System Operations
Certified Industry 4.0 Associate – IIOT, Networking, and Data Analytics

[SME \(Society of Manufacturing Engineer\)](#)

Certified Manufacturing Associate

[Solidworks](#)

Mechanical Design (CSWA–Mechanical Design)

Program Area Courses

In Minnesota, engineering and STEM courses are foundational to the Trade and Industry program areas. Being able to design and create objects or structures is essential to any of the Trade and Industry program areas. By learning the engineering design process and the practical relationship with math and science, students build problem-solving skills that transfer to all of the Trade and Industry program areas.

Many programs will also provide a broad overview of industrial technology and emerging technologies or innovations as an introduction to Trade and Industry. This introduction will often start in middle school programs, but can also begin or continue into the first years of a high school program.

The following chart provides a matrix of how courses can align into certain pathways. Full descriptions for the Intro to Industrial Technology can be found in the Introduction to Industrial Technology document.

Intro to Industrial Technology

"Producing Products"

Engineering/STEM courses

- Engineering Essentials
- Introduction to Engineering Design
- Principles of Engineering
- Digital Electronics
- Computer Integrated Manufacturing
- Engineering Design and Development
- Environmental Sustainability
- Civil Engineering and Architecture

Industrial Technology courses

- Introduction to Industrial Technology
- Emerging Technologies
- Technology Innovation and Assessment

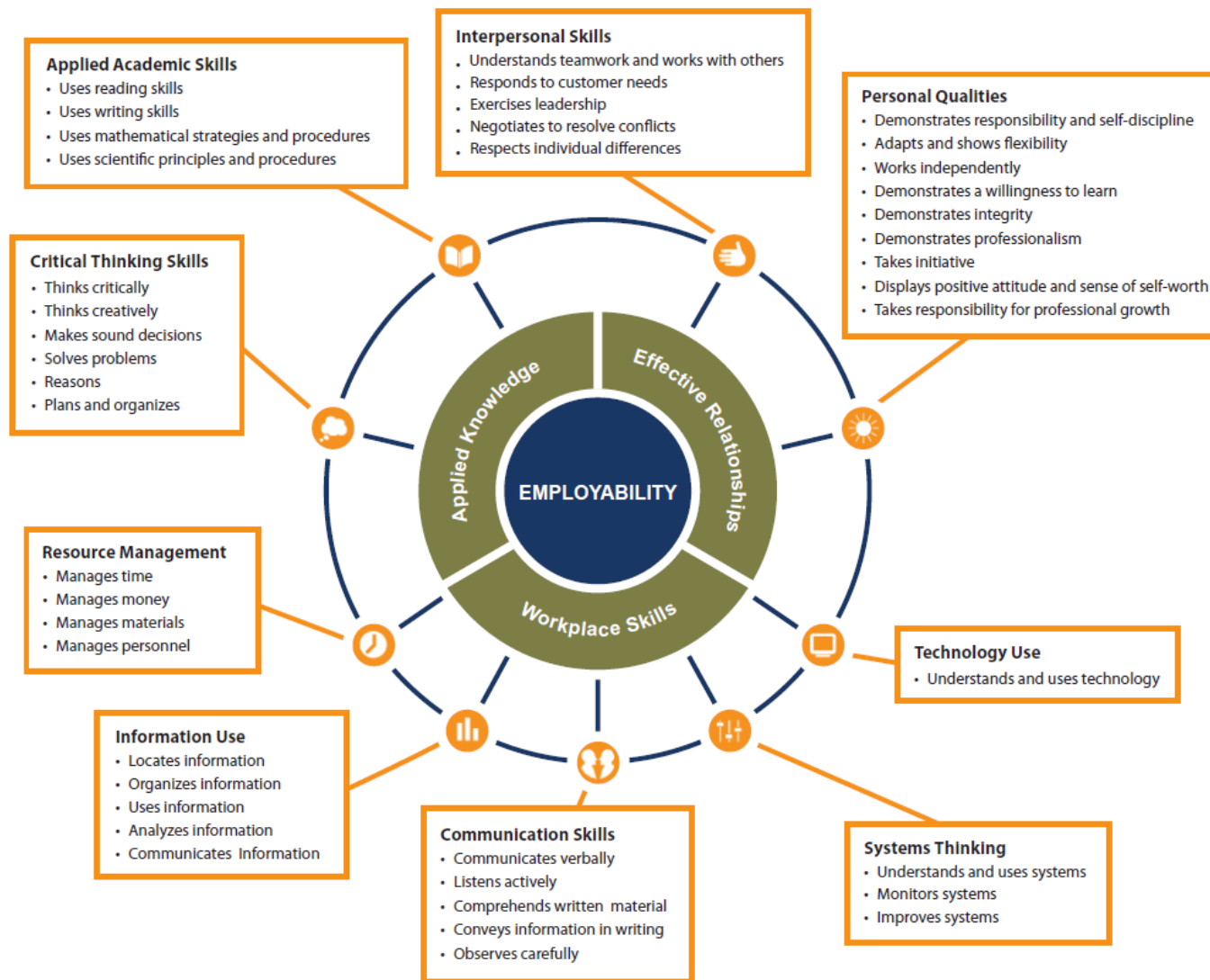
Manufacturing – Basic courses

- Product Development
- Production Systems
- Drafting
- CAD
- Mechanical Drafting
- Career Investigation

Manufacturing Careers

Welding courses	Machining courses	Fabrication courses	Technology courses	Air Conditioning, Heating, and Refrigeration Service courses
• Basic Welding • Intermediate Welding • Advance Welding • Specialty Welding	• Basic Machining • Advanced Machining	• Metals Fabrication • Metal and Wood Processing/ Production • Materials Processing • Basic Non-Metals Fabrication • Advanced Non-Metals Fabrication	• Basic Electro-Mechanical Systems • Advanced Electro-Mechanical Systems • Basic Mechatronics • Advanced Mechatronics • Basic Robotics • Advanced Robotics • Engineering Applications • Power and Energy • Basic Super Mileage • Advanced Super Mileage	• Heating, Vent, and Air Conditioning • Refrigeration
• Capstone – Simulated School Business				

Employability Skills Framework



From the [Perkins Collaborative Resource Network \(PCRN\)](#)

Employability Framework (continued)

In the modern workplace, well-developed employability skills are as important as expert technical skills. The national framework above outlines the essential skills that should be embedded in every Trade and Industry course. In separate document is a helpful tool for determining and accessing how employability skills are included in a Trade and Industry curriculum. Go to the [Perkins Collaborative Resource Network website](#), supported by the U.S. Department of Education, for more information about the Framework.

An Employability Skills Lesson Planning Checklist can be found on the [Trade and Industry section](#) of the Minnesota Department of Education (MDE) website. Teachers are encourage to use the checklist in determining how to embed employability skills in each of their lesson plans.

[Return to the beginning of the document](#)

Health, Safety, Security, and Environment Framework

Safety is an essential element of any Trade and Industry program. The following are a list of basic safety best practices and standards to be embedded in every Trade and Industry course. Teachers should consider how these practices inform the development of their local Career and Technical (CTE) Standards and how to adapt them to the particular needs of each course.

Additional detailed benchmarks can be developed with use of national standards in a particular program area. Check the [Trade and Industry Program](#) page on the Minnesota Department of Education (MDE) website for a list of the appropriate national standards.

HS.01 Maintain a healthy and safe environment

Measures/Benchmarks	Learning Targets
HS.01.01 Take actions to ensure the safety of self and others, in accordance with established personal and jobsite safety practices	1.1.1 Describe general shop safety rules and procedures 1.1.2 Understand the safety vision for the lab or worksite 1.1.3 Identify marked safety areas and safety equipment
HS.01.02 Anticipate and prevent work-related injuries and illnesses	1.2.1 Analyze possible jobsite hazards 1.2.2 Understand and apply appropriate risk management 1.2.3 Conduct proper safety inspections and work observations 1.2.4 Undertake leadership accountability, in addition to personal accountability, for safety
HS.01.03 Comply with federal, state, and local regulations, and school health and safety policies	1.3.1 Describe the roles of OSHA and EPA in workplace safety 1.3.2 Operate lab equipment according to safety guidelines

Measures/Benchmarks	Learning Targets
HS.01.04 Recognize common hazards and unsafe conditions that can occur on worksite, their risks, and appropriate controls to address them	1.4.1 Utilize safe procedures for handling of tools and equipment 1.4.2 Utilize proper ventilation procedures for working within the lab/shop area 1.4.3 Identify the location and the types of fire extinguishers and other fire safety equipment 1.4.4 Identify the location of eye wash stations
HS.01.05 Maintain a sanitary and clutter-free work environment	1.5.1 Perform housekeeping duties for lab or worksite 1.5.2 Demonstrate proper cleaning, storage, and maintenance of tools and equipment
HS.01.06 Administer first aid or CPR if trained and summon assistance as needed	1.6.1 Demonstrate knowledge of lab or worksite medical emergency procedures 1.6.2 Locate first aid kit and other safety equipment in lab or on the workplace 1.6.3 Report any missing equipment or items from the safety kit
HS.01.07 Properly handle and dispose of hazardous materials	1.7.1 Locate safety data sheets (SDS) 1.7.2 Locate hazardous material storage cabinets 1.7.3 Locate chemical spill alarm

HS.02 Foster personal safety

Measures/Benchmarks	Learning Targets
HS.02.01 Understand the legal rights of workers regarding workplace safety and protection from hazards	2.1.1 Identify OSHA regulations and specific laws and regulations governing Minnesota workplaces 2.1.2 Identify the process for reporting worksite hazards and incidents
HS.02.02 Contribute to culture of safety in the workplace, making suggestions, and reporting injuries, incidents, and hazards as appropriate	2.2.1 Understand individual safety responsibilities 2.2.2 Understand leadership component to enforce safety practices and procedures 2.2.3 Identify the elements of safety reporting procedure 2.2.4 Prepare time or job cards, reports, or records
HS.02.03 Know effects of and how to deal with temperature extremes and weather conditions	2.3.1 Identify proper clothing used in certain temperature extremes 2.3.2 Identify procedures used to mitigate temperature extremes 2.3.3 Understand procedures to reach safety during sudden changes in the weather
HS.02.04 Know how to safely work in confined spaces or at heights	2.4.1 Identify the hazards that might exist in confined spaces or at height 2.4.2 Identify proper personal protective equipment (PPE) used for the certain situation 2.4.3 Ensure that others are monitoring situation

Measures/Benchmarks	Learning Targets
HS.02.05 Engage in safety training	2.5.1 Identify and use proper lifting procedures and proper use of support equipment 2.5.2 Identify and wear appropriate clothing for lab/shop activities 2.5.3 Secure hair and jewelry for lab/shop activities 2.5.4 Demonstrate knowledge and proper use of all tools and equipment
HS.02.06 Select, inspect, and use personal protective equipment (PPE)	2.6.1 Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab/shop activities (e.g., hard hats, safety vests, personal protective equipment [PPE]) 2.6.2 Use appropriate protective equipment for specific tasks (e.g. welding apron and visor, scaffold safety belt and lanyards)

HS.03 Demonstrate digital citizenship

Measures/Benchmarks	Learning Targets
HS.03.01 Cultivate and manage digital identity and reputation and are aware of the permanence of actions in the digital world	3.1.1 Demonstrate knowledge of how online data impacts digital identity 3.1.2 Demonstrate knowledge of how online behavior impacts digital identity 3.1.3 Maintain a positive digital footprint
HS.03.04 Manage personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online	3.2.1 Identify digital access challenges and their privacy and security implications 3.2.2 Identify digital commerce practices and how they impact privacy and security issues
HS.03.03 Engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices	3.3.1 Identify the impacts online interaction in interpersonal relationship and on the community 3.3.2 Understand and utilize digital etiquette in online interactions 3.3.3 Identify the legal and ethical issues related to technology use and social interactions
HS.03.04 Demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property	3.4.1 Explain legal and ethical issues for project development 3.4.2 Explain the legal and ethical use of content 3.4.3 Explain legal and ethical issues as it relates to workplace environment

HS.04 Observe and follow proper safety procedures

Measures/Benchmarks	Learning Targets
HS.04.01 Follow organizational procedures and protocols for workplace emergencies, including safe evacuation, and emergency response	4.1.1 Describe the procedures for addressing safety emergencies in lab or on worksite 4.1.2 Identify the location of the posted evacuation routes
HS.04.02 Understand lab and worksite safety, fire safety, electrical safety, and chemical safety	4.2.1 Demonstrate knowledge of the procedures for using fire extinguishers and other fire safety equipment 4.2.2 Demonstrate knowledge for use of eye wash stations 4.2.3 Utilize proper ventilation procedures for working within the lab/shop area 4.2.4 Demonstrate knowledge of the safety aspects of low and high voltage circuits 4.2.5 Research safety aspects of supplemental restraint systems (SRS), electronic brake control systems, and hybrid vehicle high voltage circuits 4.2.6 Identify and use proper placement of floor jacks and jack stands 4.2.7 Identify and use proper procedures for safe vehicle lift operation
HS.04.03 Demonstrate knowledge of hazardous properties of materials such as radiation, toxicity, flammability, reactivity, corrosivity, and limits of fire resistance exposure	4.3.1 Demonstrate knowledge of proper PPE used in dealing with hazardous or toxic materials 4.3.2 Identify materials and situations which may prove to be hazardous 4.3.3 Demonstrate proper procedures to address or mitigate hazardous situations
HS.04.04 Use Safety Data Sheets (SDS) information to manage, use, and dispose of hazardous materials	4.4.1 Understand the move from material safety data sheets (MSDS) to safety data sheets (SDS) 4.4.2 Locate safety data sheets (SDS) in lab or on the worksite 4.4.3 Interpret safety data sheets (SDS)
HS.04.05 Uses equipment and tools safely. Completes safety training on pertinent equipment and applies safe operating procedures	4.5.1 Follow verbal and written instructions to complete work assignments 4.5.2 Identify tools and their appropriate usage 4.5.3 Identify equipment and their appropriate usage 4.5.4 Identify standard and metric designation 4.5.5 Demonstrate the proper techniques when using tools and equipment 4.5.6 Demonstrate proper use of precision measuring tools (i.e., micrometer, dial-indicator, dial-caliper)

Measures/Benchmarks	Learning Targets
HS.04.06 Explain the importance of lockout/tagout and describe basic procedures	4.6.1 Describe and demonstrate the importance of lockout/tagout (LOTO) 4.6.2 Prepare for the shutdown 4.6.3 Notify affected classmates 4.6.4 Shut down the equipment properly 4.6.5 Isolate energy sources 4.6.6 Apply LOTO devices to energy sources 4.6.7 Release/control all stored energy 4.6.8 Verify the lockout 4.6.9 Maintain the lockout
HS.04.07 Follow ladder and scaffold safety procedures	4.7.1 Remove, if possible, hazards found in confined spaces or at height 4.7.2 Select and use proper PPE for the certain situation 4.7.3 Properly use correct equipment for each situation

[Return to the beginning of the document](#)

Career Exploration Framework

Students need to have opportunities to explore careers and participate in experiential learning to better understand future career options. Every Trade and Industry program needs to provide these experiences and every course should embed activities for students to become aware of the range of options available to them.

The following are a list of basic career exploration standards to be addressed in every Trade and Industry program. For more detailed information, a [Career and College \(CCR\) Readiness Guide](#) is available on the Minnesota Department of Education (MDE) website. The Domains and Competencies section provides specific advice and activities that can be developed to address these standards.

CE.01 Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans

Measures/Benchmarks	Learning Targets
CE.01.01 Identify personal interests, aptitudes, information, and skills necessary for informed career decision making	1.1.1 Review individual capabilities and aptitudes 1.1.2 Identify individual interests and knowledge base 1.1.3 Connect interests and abilities to future career and postsecondary choices
CE.01.02 Evaluate personal character traits such as trust, respect, and responsibility and understand the impact they can have on career success	1.2.1 Identify and prioritize personal values 1.2.2 Determine how core values align with chosen career fields 1.2.3 Recognize alternative career pathways that might better align with core values
CE.01.03 Explore how information and communication technologies are used in career planning and decision making	1.3.1 Identify various sources of career information 1.3.2 Use analytical strategies to find and assess the quality of career information and identify potential bias 1.3.3 Determine best sources of career information based on analysis
CE.01.04 Research the scope of career opportunities available and the requirements for education, training, certification, and licensure	1.4.1 Assess various career options including training costs, starting and average pay, and advancement opportunities 1.4.2 Determine career preparation level required for each option 1.4.3 Compare best options aligned with career talents and values
CE.01.05 Integrate changing employment trends, societal needs, and economic conditions into career planning	1.5.1 Research future employment trends to determine career opportunities 1.5.2 Research changes and advancement in technology and its impact on future employment 1.5.3 Identify how societal changes might affect career planning and decisions 1.5.4 Identify flexible options for career plan in face of disruptive change

Measures/Benchmarks	Learning Targets
CE.01.06 Recognize the role and function of professional organizations, industry associations, and organized labor in a productive society	1.6.1 Research and identify professional organizations and industry associations related to career interests 1.6.2 Identify activities and events that provide additional career exploration opportunities
CE.01.07 Recognize the importance of small business in Minnesota and global economies	1.7.1 Identify the impact and extensiveness of small business on the economy 1.7.2 Investigate the entrepreneurial opportunities available in a particular career field
CE.01.08 Understand how digital media are used by potential employers and postsecondary agencies to evaluate candidates	1.8.1 Identify how employers recruit, collect information, and screen candidates using digital media 1.8.2 Identify the importance of personal digital identity in candidate vetting process
CE.01.09 Develop a career plan that reflects career interests, pathways, and postsecondary options	1.9.1 Review individual career goals and chart next steps to achieve them 1.9.2 Establish a schedule to pursue action items 1.9.3 Revisit and revise plan as necessary

[Return to the beginning of the document](#)

Career Pathway: Basic Manufacturing

Cluster: Manufacturing

Program: 171710

Basic Manufacturing Courses

Cours e Code	Recommended Course Title	Course Description
20	Product Development	Product Development courses provide students with the opportunity to focus on one or more areas of industrial technology to design or redesign a product to solve a problem. Students may build prototypes, including use of 3D printing, and working models and may evaluate the product and process according to industry standards.
21	Production Systems	Production Systems courses provide students with knowledge and skills related to manufacturing technologies from conception through production. Although courses vary, students typically analyze markets, design and develop prototypes, plan a marketing or sales strategy, employ testing and quality assurance practices, manage a production plan, and manufacture useful products. These courses may also explore the evolution and impact of technology on society's social, cultural, and economic systems and institutions.
22	Drafting	Drafting—General courses introduce students to the technical craft of drawing illustrations to represent and/or analyze design specifications and then refine the skills necessary for this craft. Drafting—General courses use exercises from a variety of applications to provide to students the knowledge and experience to develop the ability to perform freehand sketching, lettering, geometric construction, and multi-view projections and to produce various types of drawings (working, detail, assembly, schematic, perspective, and so on). Computer-aided drafting (CAD) systems (if available) are typically introduced and used to fulfill course objectives.
23	CAD	Frequently offered as an intermediary step to more advanced drafting courses (or as a concurrent course), CAD Design and Software courses introduce students to the computer-aided drafting systems available in the industry.

Cours e Code	Recommended Course Title	Course Description
24	Mechanical Drafting	Drafting—Technical/Mechanical courses introduce students to and help them refine the technical craft of drawing illustrations to represent and/or analyze design specifications, using examples drawn from industrial applications. These courses are intended to help students develop general drafting skills, but place a particular emphasis on sectioning, auxiliary views, revolutions, and surface development. In these courses, students typically learn basic machining and fabrication processes as they draw schematic diagrams featuring cams, gears, linkages, levers, pulleys, and so on.
25	Career Investigation	Exploration of Manufacturing Occupations courses introduce and expose students to the career opportunities pertaining to the processing and production of goods. Course topics vary and may include (but are not limited to) systems pertinent to the manufacturing process, properties of various raw materials, and the methods used to transform materials into consumer products. Course activities depend upon the careers being explored; course topics may include entrepreneurship, labor laws, economic impact, and customer service.

Basic Manufacturing Technical Skills

MB 01 Recognize the impact of financial, technical, environmental, and labor trends on the past and future of the manufacturing industry

Measures/Benchmarks	Learning Targets
MB.01.01 Understand significant historical trends in the manufacturing industry	1.1.1 Research and compare manufacturing techniques used throughout history 1.1.2 Explain how historical innovations have impacted today's society
MB.01.02 Understand that regulations influence manufacturing design and execution	1.2.1 Describe the significant impacts manufacturing has on the environment 1.2.2 Describe the significant impacts governmental policies have on manufacturing
MB.01.03 Communicate ideas using appropriate industry terminology	1.3.1 Formulate written and verbal communications using industry standard terms 1.3.2 Prepare and deliver a visual presentation utilizing appropriate industry terminology

MB.02 Apply the appropriate mathematical principles and science methods to solve problems

Measures/Benchmarks	Learning Targets
MB.02.01 Demonstrate mathematics knowledge and skills required to pursue the full range of post-secondary education and career opportunities	2.1.1 Identify whole numbers, decimals, and fractions 2.1.2 Demonstrate knowledge of basic arithmetic operations such as addition, subtraction, multiplication, and division 2.1.3 Demonstrate use of relational expressions such as equal to, not equal, greater than, less than, etc. 2.1.4 Apply data and measurements to solve a problem 2.1.5 Analyze mathematical problem statements for missing and/or irrelevant data 2.1.6 Construct charts/tables/graphs from functions and data 2.1.7 Analyze data when interpreting operational documents
MB.02.02 Demonstrate science knowledge and skills required to pursue the full range of post-secondary and career education opportunities	2.2.1 Evaluate scientific constructs including conclusions, conflicting data, controls, data, inferences, limitations, questions, sources of errors, and variables 2.2.2 Apply scientific methods in qualitative and quantitative analysis, data gathering, direct and indirect observation, predictions, and problem identification.
MB.02.03 Utilize mathematical operations and measuring techniques	2.3.1 Identify industry standard units of measure 2.3.2 Convert between customary (i.e., SAE and Imperial) and metric units 2.3.3 Determine and apply the equivalence between fractions and decimals 2.3.4 Demonstrate proper use of precision measuring tools (i.e., micrometer, dial-indicator, and dial- caliper) 2.3.5 Utilize measurement systems to solve real manufacturing problems
MB.02.04 Demonstrate spatial reasoning and 3D modeling	2.3.1 Define spatial reasoning 2.3.2 Identify spatial reasoning techniques (e.g., mapping, rotating, matching, patterning, and counting) 2.3.3 Utilize spatial reasoning techniques to solve design problems 2.3.4 Prepare freehand sketches utilizing appropriate proportions 2.3.5 Utilize 3D modeling software to solve manufacturing design problems

MB.03 Apply fundamental printing reading, measuring, and sketching techniques

Measures/Benchmarks	Learning Targets
MB.03.01 Demonstrate print reading practices	3.1.1 Interpret basic elements of a technical drawing (e.g., title block information, dimensions, line types, and 1st and 3rd angle projection) 3.1.2 Identify industry standard symbols (i.e., hydraulic, pneumatic, electrical, welding, and mechanical) 3.1.3 Prepare a materials list from a technical drawing 3.1.4 Describe various types of drawings (i.e., part, assembly, pictorial, orthographic, isometric, and schematic) 3.1.5 Understand dimensioning, sectional drawings, fasteners, tables, charts, and assembly drawings
MB.03.02 Demonstrate measuring and scaling techniques	3.2.1 Identify industry standard units of measure 3.2.2 Convert between customary (i.e., SAE, Imperial) and metric systems 3.2.3 Determine appropriate engineering and metric scales 3.2.4 Measure and calculate speed, distance, object size, area, and volume 3.2.5 Determine and apply the equivalence between fractions and decimals 3.2.6 Demonstrate proper use of precision measuring tools (i.e., micrometer, dial-indicator, dial-caliper)
MB.03.03 Demonstrate freehand technical sketching techniques	3.3.1 Prepare freehand and field sketches 3.3.2 Identify appropriate proportions 3.3.3 Create schematic diagrams using proper symbols 3.3.4 Annotate sketches legibly

MB.04 Apply fundamental power system principles

Measures/Benchmarks	Learning Targets
MB.04.01 Identify power systems	4.1.1 Define terms used in power systems (e.g., power, work, horsepower, and watts) 4.1.2 Identify the basic power systems 4.1.3 List the basic elements of power systems 4.1.4 Summarize the advantages and disadvantages of various forms of power 4.1.5 Define potential and kinetic energy 4.1.6 Identify forms of potential and kinetic energy 4.1.7 Calculate the efficiency of power systems and conversion devices 4.1.8 Demonstrate the use of an energy conversion device
MB.04.02 Identify and utilize basic mechanical systems	4.2.1 Locate and explain examples of the six simple machines, their attributes and components 4.2.2 Measure forces and distances related to mechanisms 4.2.3 Calculate mechanical advantage 4.2.4 Design, construct, and test various basic mechanical systems
MB.04.03 Identify and utilize basic electrical systems	4.3.1 Define AC and DC electrical systems and terminology 4.3.2 Discuss the safety concerns of working with electricity 4.3.3 Describe the principles of generation, transmission, distribution, and storage of electricity 4.3.4 Compute values of current, resistance, and voltage using Ohm's law 4.3.5 Identify series, parallel and series-parallel (combination) circuits 4.3.6 Solve series and parallel circuits using basic laws of electricity including Kirchhoff's laws 4.3.7 Introduce single-phase and three-phase AC power 4.3.8 Construct and test simple electrical circuits from a schematic
MB.04.04 Identify and utilize basic fluid systems	4.4.1 Define fluid systems (e.g., hydraulic, pneumatic, and vacuum) 4.4.2 Identify and define the components of fluid systems 4.4.3 Compare and contrast hydraulic and pneumatic systems 4.4.4 Identify the advantages and disadvantages of using fluid power systems 4.4.5 Explain the difference between gauge pressure and absolute pressure 4.4.6 Discuss the safety concerns of working with liquids and gases under pressure 4.4.7 Calculate mechanical advantage using Pascal's law 4.4.8 Calculate values in a pneumatic system, using the ideal gas laws 4.4.9 Design, construct, and test various fluid systems

MB.05 Identify and apply manufacturing processes

Measures/Benchmarks	Learning Targets
MB.05.01 Identify basic manufacturing systems	5.1.1 Identify the basic processes, systems, design processes, and materials used in manufacturing 5.1.2 Identify and describe the major manufacturing processes 5.1.3 Conduct reverse engineering processes to describe the process and materials used to manufacture a given product 5.1.4 Describe how different manufacturing processes can be used to produce similar products
MB.05.02 Identify material properties and science	5.2.1 Identify the major material families used in manufacturing 5.2.2 Differentiate between the various types of materials and their usage in specific applications 5.2.3 Discuss the impact of material usage on the environment 5.2.4 Explain how production is affected by the availability, quality, and quantity of resources 5.2.5 Differentiate among a raw material standard stock and finished products 5.2.6 Analyze the effects of the environmental conditions and manufacturing processes on material properties
MB.05.03 Apply additive manufacturing processes	5.3.1 Identify and describe additive manufacturing processes (e.g., casting, molding, and 3D printing) 5.3.2 Develop a list of additive operations and identify the sequence needed to make a specific product 5.3.3 Construct a 3D model utilizing a design software 5.3.4 Print a 3D model utilizing the additive process 5.3.5 Research plating and finishing techniques and their uses as an additive process

Measures/Benchmarks	Learning Targets
MB.05.04 Demonstrate subtractive manufacturing processes	5.4.1 Identify and describe subtractive manufacturing processes 5.4.2 Explain the computer numerical control (CNC) processes and software requirements (e.g., Cartesian coordinates, numeric code, machine code, and import/export programs) 5.4.3 Perform safety inspections of subtractive equipment and accessories 5.4.4 Demonstrate the ability to use manual and computer numerical control subtractive equipment (e.g., oxy-fuel cutting, plasma cutting, mills, lathes, drill presses, saws, routers, and grinders) 5.4.5 Determine appropriate tooling, cutting speeds, and feed rates 5.4.6 Develop a list of manual material-cutting operations and identify the sequence needed to make a specific product 5.4.7 Utilize manual subtractive equipment to produce a specific product 5.4.8 Develop a list of CNC material-cutting operations and identify the sequence needed to make a specific product 5.4.9 Utilize a model or drawing to develop and adjust a CNC tool path 5.4.10 Utilize CNC subtractive equipment to produce a specific product
MB.05.05 Utilize joining and fastening manufacturing processes	5.5.1 Identify and describe joining processes (e.g., forming, forging, and welding) 5.5.2 Demonstrate the ability to utilize various mechanical and permanent joining processes 5.5.3 Perform safety inspections of welding equipment and accessories 5.5.4 Demonstrate the ability to set-up and operate welding equipment (i.e., SMAW and GMAW) 5.5.5 Demonstrate proper fit-up and completion of a welded joint 5.5.6 Identify various fastening methods (e.g., rivets, adhesive, screws, seams, and spot welds) 5.5.7 Categorize fastening methods by appropriate applications 5.5.8 Demonstrate fastening methods on various materials 5.5.9 Manufacture a product utilizing joining and fastening processes
MB.05.06 Research business operations and quality control	5.6.1 Describe the business cycle of manufacturing operations 5.6.2 Discuss the different types of production systems 5.6.3 Discuss the various manufacturing markets (e.g., local, domestic, and global) 5.6.4 Describe Lean manufacturing and explain its importance 5.6.5 Describe Just-in-Time systems 5.6.6 Identify and describe the importance of shift to shift communications 5.6.7 Investigate the importance of quality assurance systems 5.6.8 Research quality control testing methods (e.g., destructive and nondestructive)

MB 06 Apply fundamental drafting skills

Measures/Benchmarks	Learning Targets
MB.06.01 Create geometric constructions	6.1.1 Define geometric terms and recognize various geometric shapes by name 6.1.2 Use lines, circles, and arcs to construct regular and irregular geometric shapes 6.1.3 Construct angles, to include acute, obtuse, and right angles 6.1.4 Divide lines and bisect angles and arcs 6.1.5 Construct tangent, concentric, and perpendicular geometric relationships 6.1.6 Calculate area, perimeter, and volume of geometric shapes to include circle, square, rectangle, and triangle
MB.06.02 Demonstrate measuring and scaling techniques	6.2.1 Justify the scaling of objects 6.2.2 Determine appropriate engineering and metric scales 6.2.3 Measure and calculate object size, area, and volume 6.2.4 Construct drawings utilizing metric and customary (i.e., SAE, Imperial) measurement systems 6.2.5 Transcribe drawings accurately using ratios and proportions 6.2.6 Determine and apply the equivalence between fractions and decimals 6.2.7 Convert between customary (i.e., SAE, Imperial) and metric systems
MB.06.03 Demonstrate conventional drafting practices	6.3.1 Identify and select appropriate drafting media 6.3.2 Complete title blocks 6.3.3 Utilize appropriate drawing composition and layout 6.3.4 Identify and utilize industry standard object properties (i.e., line weight, line type) 6.3.5 Produce drawings from sketches 6.3.6 Apply symbols to industry standards (i.e., ASME, ANSI) 6.3.7 Apply appropriate annotations to drawings 6.3.8 Produce lettering to specific standards
MB.06.04 Create multi-view drawings using orthographic projection	6.4.1 Determine the principle view of an object 6.4.2 Project from an existing view to create additional views 6.4.3 Identify, create, and arrange the six standard views (using properties of similarities of right angles) 6.4.4 Identify, create, and arrange sectional views 6.4.5 Identify, create, and arrange primary auxiliary views 6.4.6 Apply appropriate measurement units

Measures/Benchmarks	Learning Targets
MB.06.05 Apply dimensions and annotations	6.5.1 Differentiate appropriate dimension standards (i.e., ANSI, ISO) 6.5.2 Arrange dimensions and annotations using appropriate standards (i.e., ANSI, ISO) 6.5.3 Use various dimensioning styles (i.e., aligned, unidirectional, polar, ordinate, datum) 6.5.4 Construct bill of materials or schedule 6.5.5 Identify and transcribe tolerancing dimensioning 6.5.6 Identify and transcribe thread designations
MB.06.06 Create pictorial drawings	6.6.1 Create oblique drawings 6.6.2 Create isometric drawings 6.6.3 Create perspective drawings
MB.06.07 Demonstrate sketching techniques	6.7.1 Develop design ideas using freehand sketching 6.7.2 Create pictorial and multi-view sketches 6.7.3 Create rough, refined, and presentation sketches 6.7.4 Prepare field sketches 6.7.5 Produce drawings from sketches 6.7.6 Utilize hand lettering techniques 6.7.7 Utilize the alphabet of lines (i.e., styles and weights)

MB 07 Apply fundamental CADD skills

Measures/Benchmarks	Learning Targets
MB.07.01 Utilize basic computer and IT skills	7.1.1 Use computer hardware and input/output devices to solve design drafting problems 7.1.2 Apply basic commands of an operating system and software 7.1.3 Apply file and disk management techniques 7.1.4 Import and export data files using various formats 7.1.5 Access and use a network to transfer files 7.1.6 Demonstrate the use of various storage media 7.1.7 Demonstrate basic troubleshooting skills related to fundamental hardware and software problems 7.1.8 Evaluate electronic media to acquire information to complete drafting problems (i.e., internet, books, PowerPoint) 7.1.9 Demonstrate personal safety (i.e., electrical and mechanical hazards) 7.1.10 Interpret and utilize acceptable use policies (i.e., network and lab agreements)

Measures/Benchmarks	Learning Targets
MB.07.02 Set up drawing environment	7.2.1 Select appropriate existing title blocks 7.2.2 Set drafting settings (i.e., grid, snap, and modes) 7.2.3 Determine and apply scaling factors 7.2.4 Assign line weights, line types, and colors 7.2.5 Utilize template files 7.2.6 Utilize sheets/layouts for plotting/printing 7.2.7 Scale sheets/layout views for plotting/printing
MB.07.03 Utilize the Cartesian coordinate system to create geometric shapes and objects	7.3.1 Describe and utilize the Cartesian Coordinate System to create geometric shapes and objects (x, y, z) 7.3.2 Calculate input coordinates 7.3.3 Manipulate coordinate systems (i.e., absolute, relative, and polar) 7.3.4 Utilize appropriate coordinate entry methods
MB.07.04 Create and modify objects utilizing CADD commands	7.4.1 Utilize multiple entry methods to invoke CADD commands (i.e., hot keys, icons, and menus) 7.4.2 Utilize geometric relationships to ensure accuracy (i.e., endpoint, midpoint, and center) 7.4.3 Create and modify objects using CADD commands 7.4.4 Assign property styles to objects 7.4.5 Access and integrate help resources to solve problems
MB.07.05 Create and modify annotations	7.5.1 Define, create, and modify industry standards text styles 7.5.2 Arrange text based on industry standards 7.5.3 Create and modify dimension styles 7.5.4 Arrange dimensions based on industry standards (may include dual dimensioning) 7.5.5 Use industry standard symbols to annotate drawings 7.5.6 Construct bill of materials or schedules
MB.07.06 Utilize basic output methods	7.6.1 Recognize plot/print areas for assigned plotter/printer 7.6.2 Utilize plot preview function 7.6.3 Plot drawings to proper scale 7.6.4 Plot drawings to various output media (i.e., paper or electronic) 7.6.5 Recognize the process to export files for different outputs/processes (i.e. 3D printing, laser engraving, CNC machining)

MB 08 Demonstrate advanced CADD skills and techniques

Measures/Benchmarks	Learning Targets
MB.08.01 Utilize templates, symbols, and libraries	8.1.1 Describe the use of symbols 8.1.2 Create and save symbols 8.1.3 Utilize symbols 8.1.4 Edit symbols 8.1.5 Assign symbol properties (i.e., attributes, parameters, constraints) 8.1.6 Edit symbol properties 8.1.7 Create and utilize symbol libraries 8.1.8 Create template files
MB.08.02 Develop and display three-dimensional models	8.2.1 Interpret and define the right-hand rule for the x, y, and z-axes 8.2.2 Develop three-dimensional models (i.e., wireframe, surface, solid, or parametric) 8.2.3 Manipulate the x-y plane in three-dimensional space 8.2.4 Display three-dimensional objects from various viewpoints 8.2.5 Edit the shape and configuration of solid models 8.2.6 Display objects as shaded or hidden lines removed 8.2.7 Create working drawings from three-dimensional models

MB 09 Apply mechanical drafting and design

Measures/Benchmarks	Learning Targets
MB.09.01 Apply drafting concepts related to basic manufacturing processes	9.1.1 Describe the basic design process (identify problem, brainstorm solutions, prototype, manufacture) 9.1.2 Describe standard machine processes 9.1.3 Identify standard welding symbols 9.1.4 Identify common stock forms (i.e., angle, channel, tube, pipe) 9.1.5 Create scaled working drawings with dimensions, tolerances, and other specifications for basic machine tool processes 9.1.6 Create working drawings that include dimensions, symbology, and other specifications for welding processes 9.1.7 Create thread and fastener representations 9.1.8 Create assembly drawings with a bill of materials table

Measures/Benchmarks	Learning Targets
MB.09.02 Apply geometric dimensional and tolerancing (GDandT) standards	9.2.1 Identify symbols used in GDandT (i.e., basic dimensions, datums, and feature control frames) 9.2.2 Edit feature control frames according to industry standards
MB.09.03 Apply drafting concepts related to basic pattern development	9.3.1 Define developments 9.3.2 List the major kinds of developments 9.3.3 Construct parallel line development 9.3.4 Determine proper placement of tabs

MB 10 Demonstrate career exploration and business skills

Measures/Benchmarks	Learning Targets
MB.10.01 Prepare and explore career opportunities	10.1.1 Discuss various career opportunities in the manufacturing industry 10.1.2 Differentiate between the relationships of all partners involved in the manufacturing process 10.1.3 Identify the primary duties and attributes of all partners involved in the manufacturing process 10.1.4 Describe the traditional career path needed for all partners involved in the manufacturing industry
MB.10.02 Apply workplace skills to production projects	10.2.1 Identify and locate all safety equipment in media labs and on location (first aid kit, fire extinguisher, etc.) 10.2.2 Practice time management in order to meet production deadlines 10.2.3 Conduct peer and self-evaluations using rubrics 10.2.4 Explain the elements of the critique process, including a respect for peer work and the ability to give and receive dispassionate criticism 10.2.5 Demonstrate effective application processes 10.2.6 Research and practice various interview methods
MB.10.03 Explain business concepts	10.3.1 Discuss the qualities of responsible business ownership 10.3.2 Research opportunities for remote workers, freelancers, etc. 10.3.3 Analyze the value of your services 10.3.4 Analyze and explain corporate structure 10.3.5 Analyze entrepreneurship concepts

[Return to the beginning of the document](#)

Career Pathway: Manufacturing Welding

Cluster: Manufacturing

Program: 171710

Manufacturing Welding Courses

Course Code	Recommended Course Title	Course Description
30	Basic Welding	Welding courses enable students to gain knowledge of the physical and chemical properties, uses, and applications of various metals. Students gain skills in various processes used to join and cut metals, such as oxyacetylene welding and cutting, plasma cutting, shielded metal arc welding (SMAW or stick), gas metal arc welding (GMAW or MIG), and tungsten inert gas welding (TIG). They gain experience in identifying, selecting, and using appropriate techniques. Other various tools and machines needed in the welding shop will be learned, demonstrated and used as well. Such skills could be mastered by allowing them to practice their welding skills on coupons and small projects. Students may begin to read and interpret blueprints in order to identify, select, and use appropriate techniques. These courses may prepare students to pass relevant industry certifications.
31	Intermediate Welding	Intermediate welding courses enable students to advance their knowledge of the physical and chemical properties, uses, and applications of various metals. Students gain more skills in various processes used to join and cut metals, such as oxyacetylene welding and cutting, plasma cutting, shielded metal arc welding (SMAW or stick), gas metal arc welding (GMAW or MIG), and tungsten inert gas welding (TIG). They gain more experience in identifying, selecting, and using appropriate techniques. Students read and interpret blueprints in order to identify, select, and use appropriate techniques. Such skills could be mastered by allowing them to follow a set of blueprints or plans and produce that project. These courses may prepare students to pass relevant industry certifications.

Course Code	Recommended Course Title	Course Description
32	Advanced Welding	Advanced welding courses enable students to master their techniques in welding. Students are able to hone in their skills in various processes used to join and cut metals, such as oxyacetylene welding and cutting, plasma cutting, shielded metal arc welding (SMAW or stick), gas metal arc welding (GMAW or MIG), and tungsten inert gas welding (TIG). They become more experienced in identifying, selecting, and using appropriate techniques. Students read and interpret blueprints in order to identify, select, and use appropriate techniques. Such skills could be mastered by allowing them to design and create a project of their choice. These courses may prepare students to pass relevant industry certifications.
33	Specialty Welding	In these courses students gain knowledge and skills in particular aspects of welding. Examples could include individual courses in each of the following types of welding: "Farm" welding with oxy-acetylene (including brazing), GMAW along with Flux Core Arc Welding and using an aluminum spool gun, SMAW along with pipe welding, and Stainless or aluminum TIG welding.

Manufacturing Welding Technical Skills

MW.01 Apply fundamental print reading, measurement, and layout/fit up techniques

Measures/Benchmarks	Learning Targets
MW.01.01 Demonstrate print reading and sketching techniques	1.1.1 Interpret basic elements of a technical drawing (i.e., title block information, dimensions, line types) 1.1.2 Identify and explain industry standard welding symbols 1.1.3 Prepare a materials list from a technical drawing (i.e., bill of material) 1.1.4 Describe various types of drawings (i.e., part, assembly, pictorial, orthographic, isometric, schematic) 1.1.5 Understand dimensioning, sectional drawings, fasteners, tables, charts, assembly drawings, and revisions 1.1.6 Sketch or draw a basic welding drawing

Measures/Benchmarks	Learning Targets
MW.01.02 Demonstrate measuring and scaling techniques	1.2.1 Identify industry standard units of measure 1.2.2 Convert between customary (i.e., SAE, Imperial) and metric systems 1.2.3 Determine appropriate engineering and metric scales 1.2.4 Measure and calculate size, area, and volume 1.2.5 Determine and apply the equivalence between fractions and decimals 1.2.6 Demonstrate proper use of appropriate measuring tools
MW.01.03 Utilize layout principles and practices	1.3.1 Interpret drawing, sketch, or specification information 1.3.2 Select appropriate materials to complete work assignment 1.3.3 Use layout and marking tools as required 1.3.4 Lay out parts using measurement practices
MW.01.04 Demonstrate preparation and fit-up practices	1.4.1 Identify and explain job specifications 1.4.2 Identify industry codes (i.e., American Welding Society, American Society of Mechanical Engineers, American Petroleum Institute) 1.4.3 Check joint misalignment and poor fit-up before and after welding

MW.02 Identify properties of metals

Measures/Benchmarks	Learning Targets
MW.02.01 Identify material properties	2.1.1 Identify base metals (e.g., aluminum, carbon steel, exotic steels, stainless) 2.1.2 Identify and explain forms and shapes of structural metals 2.1.3 Explain and demonstrate field identification methods for base metals (i.e., mill certificate, stamp) 2.1.4 Explain metallurgical considerations for welding metals (i.e., base metal prep, heat treatment)
MW.02.02 Identify filler metals	2.2.1 Explain filler metal classifications systems (i.e., American Welding Society, American Society of Mechanical Engineers) 2.2.2 Identify different types of filler metals 2.2.3 Explain the storage and control of filler metals

MW.03 Apply shielded metal arc welding (SMAW) techniques

Measures/Benchmarks	Learning Targets
MW.03.01 Apply safety procedures	3.1.1 Identify and explain different types of welding current and polarity 3.1.2 Perform safety inspections of SMAW equipment and accessories 3.1.3 Make minor external repairs to SMAW equipment and accessories
MW.03.02 Produce welds using SMAW on carbon steel	3.2.1 Set up for SMAW operations 3.2.2 Operate SMAW equipment 3.2.3 Perform welds in the 1F position 3.2.4 Perform welds in the 2F position 3.2.5 Perform welds in the 3F position 3.2.6 Perform welds in the 1G position 3.2.7 Perform welds in the 2G position 3.2.8 Perform welds in the 3G position

MW.04 Apply thermal cutting processes

Measures/Benchmarks	Learning Targets
MW.04.01 Demonstrate oxy-fuel gas cutting (OFC)	4.1.1 Perform safety inspections of OFC equipment and accessories 4.1.2 Make minor external maintenance to OFC equipment and accessories 4.1.3 Demonstrate safe startup, shutdown, disassembly, and connect and bleed regulator procedures of OFC equipment 4.1.4 Set up for OFC operations 4.1.5 Operate OFC equipment 4.1.6 Perform straight, square edge cutting operations in the flat position 4.1.7 Perform shape, square edge cutting operations in the flat position 4.1.8 Perform straight, bevel edge cutting operations in the flat position 4.1.9 Explain scarfing and gouging operations to remove base and weld metal, in flat and horizontal positions

Measures/Benchmarks	Learning Targets
MW.04.02 Demonstrate plasma arc cutting (PAC) on carbon steel and/or aluminum	4.2.1 Explain the PAC process 4.2.2 Determine the appropriate PAC settings for the various types of metals 4.2.3 Perform safety inspections of PAC equipment and accessories 4.2.4 Make minor external repairs to PAC equipment and accessories 4.2.5 Set up for PAC operations (handheld and/or Computer Numerical Controller [CNC]) 4.2.6 Operate PAC equipment (handheld and/or CNC) 4.2.7 Perform straight, square edge cutting operations in the flat position (handheld and/or CNC) 4.2.8 Perform shape, square edge cutting operations in the flat position (handheld and/or CNC)

MW.05 Apply fabrication fundamentals

Measures/Benchmarks	Learning Targets
MW.05.01 Utilize base metal preparation fundamentals	5.1.1 Clean base metal for welding or cutting 5.1.2 Identify and explain joint design and considerations 5.1.3 Identify and explain distortion and how it is controlled 5.1.4 Mechanically bevel the edge of a mild steel plate (i.e., hand beveller, grinder)
MW.05.02 Demonstrate part preparation with cutting and forming techniques	5.2.1 Perform bending or forming operations 5.2.2 Perform drilling or boring operations 5.2.3 Perform shearing operations
MW.05.03 Describe fabrication techniques	5.3.1 Demonstrate proper setup of fabrication area, equipment, and materials 5.3.2 Construct projects in the proper sequence 5.3.3 Produce tack welds to specifications 5.3.4 Properly lay out and fabricate projects from welding prints 5.3.5 Check work for accuracy

MW.06 Apply gas metal arc welding (GMAW-S, GMAW) techniques

Measures/Benchmarks	Learning Targets
MW.06.01 Utilize safety procedures	6.1.1 Identify and explain the use of GMAW equipment (i.e., spray transfer, globular, short circuit, pulse) 6.1.2 Perform safety inspections of GMAW equipment and accessories 6.1.3 Make minor external repairs to GMAW equipment and accessories 6.1.4 Demonstrate safe startup, shutdown, disassembly, and connect and bleed regulator procedures of GMAW equipment
MW.06.02 Produce welds using GMAW-S on carbon steel	6.2.1 Set up for GMAW-S operations 6.2.2 Operate GMAW-S equipment 6.2.3 Perform welds in the 1F position 6.2.4 Perform welds in the 2F position 6.2.5 Perform welds in the 1G position 6.2.6 Perform welds in the 2G position
MW.06.03 Produce welds using GMAW (spray transfer) on carbon steel	6.3.1 Set up for GMAW (spray) operations 6.3.2 Operate GMAW (spray) equipment 6.3.3 Perform welds in the 1F position 6.3.4 Perform welds in the 2F position 6.3.5 Perform welds in the 1G position

MW.07 Apply flux cored arc welding (FCAW-G, FCAW-S) techniques

Measures/Benchmarks	Learning Targets
MW.07.01 Utilize safety procedures	7.1.1 Identify and explain the use of FCAW equipment (i.e., spray transfer, globular, pulse) 7.1.2 Perform safety inspections of FCAW equipment and accessories 7.1.3 Make minor external repairs to FCAW equipment and accessories 7.1.4 Demonstrate safe startup, shutdown, disassembly, and connect and bleed regulator procedures of FCAW equipment

Measures/Benchmarks	Learning Targets
MW.07.02 Produce welds using FCAW-G on carbon steel	7.2.1 Set up for FCAW-G operations 7.2.2 Operate FCAW-G equipment 7.2.3 Perform welds in the 1F position 7.2.4 Perform welds in the 2F position 7.2.5 Perform welds in the 1G position 7.2.6 Perform welds in the 2G position
MW.07.03 Produce welds using FCAW-S on carbon steel	7.3.1 Set up for FCAW-S operations 7.3.2 Operate FCAW-S equipment 7.3.3 Perform welds in the 1F position 7.3.4 Perform welds in the 2F position 7.3.5 Perform welds in the 1G position 7.3.6 Perform welds in the 2G position

MW.08 Apply gas tungsten arc welding (GTAW) techniques

Measures/Benchmarks	Learning Targets
MW.08.01 Utilize safety procedures	8.1.1 Perform safety inspections of GTAW equipment and accessories 8.1.2 Make minor external repairs to GTAW equipment and accessories 8.1.3 Demonstrate safe startup, shutdown, disassembly, and connect and bleed regulator procedures of GTAW equipment
MW.08.02 Produce welds using GTAW on carbon steel	8.2.1 Set up for GTAW operations 8.2.2 Operate GTAW equipment 8.2.3 Perform welds in the 1F position 8.2.4 Perform welds in the 2F position 8.2.5 Perform welds in the 1G position
MW.08.03 Produce welds using GTAW on aluminum	8.3.1 Set up for GTAW operations 8.3.2 Operate GTAW equipment

Career Pathway: Manufacturing Machining

Cluster: Manufacturing

Program: 171710

Manufacturing Machining Courses

Course Code	Recommended Course Title	Course Description
40	Basic Machining	Machining courses enable students to design and manufacture metal parts using various machine tools and equipment. Course content may include interpreting specifications using blueprints; preparing and using manual and computer numerical controlled (CNC) lathes and milling machines, shapers, and grinders with skill, safety, and precision; maintenance; developing part specifications; selecting appropriate materials; and quality control. Courses may prepare students for industry certification.
41	Advanced Machining	Advanced machining courses enable students to design and manufacture metal parts using various machine tools and equipment. Advanced course topics may include quality control; statistical process control; and application of measurements, metalworking theory, and properties of materials. Courses may prepare students for industry certification.

Manufacturing Machining Technical Skills

MM.01 Apply fundamental print reading, measurement, and sketching techniques

Measures/Benchmarks	Learning Targets
MM.01.01 Demonstrate print reading and sketching techniques	1.1.1 Interpret basic elements of a technical drawing (i.e., title block information, dimensions, line types) 1.1.2 Identify industry standard welding symbols 1.1.3 Prepare a materials list from a technical drawing 1.1.4 Describe various types of drawings (i.e., part, assembly, pictorial, orthographic, isometric, schematic) 1.1.5 Understand dimensioning, sectional drawings, fasteners, tables, charts, and assembly drawings 1.1.6 Sketch or draw a basic welding drawing

Measures/Benchmarks	Learning Targets
	1.1.7 Fabricate parts from a drawing or sketch
MM.01.02 Demonstrate measuring and scaling techniques	1.2.1 Identify industry standard units of measure 1.2.2 Convert between customary (i.e., SAE, Imperial) and metric systems 1.2.3 Determine appropriate engineering and metric scales 1.2.4 Measure and calculate size, area, and volume 1.2.5 Determine and apply the equivalence between fractions and decimals 1.2.6 Demonstrate proper use of precision measuring tools (i.e., wire gauge, micrometer, dial-indicator, dial-caliper)
MM.01.03 Utilize layout principles and practices	1.3.1 Interpret drawing, sketch or specification information 1.3.2 Prepare work area for layout 1.3.3 Select appropriate materials to complete work assignment 1.3.4 Use layout and marking tools as required 1.3.5 Layout parts using measurement practices
MM.01.04 Demonstrate preparation and fit-up practices	1.4.1 Identify and explain job code specifications 1.4.2 Use fit-up gauges and measuring devices to check joint fit-up 1.4.3 Identify and explain distortion and how it is controlled 1.4.4 Fit-up joints using plate and pipe fit-up tools 1.4.5 Check for joint misalignment and poor fit-up before and after welding

MM.02 Apply machining techniques

Measures/Benchmarks	Learning Targets
MM.02.01 Demonstrate fundamentals of machining	2.1.1 Use charts and tables to determine cutting, drilling, and knurling speeds 2.1.2 Select the proper cutting tool based on job requirements 2.1.3 Safely sharpen cutting tools 2.1.4 Center a tailstock
MM.02.02 Utilize metalworking machines	2.2.1 Identify and explain the purpose and use of metalworking lathes and milling machines 2.2.2 Perform facing, straight turning, shoulder turning, center drilling, knurling, and parting operations on a lathe 2.2.3 Turn a taper using one of the three taper cutting techniques on a lathe (i.e., taper attachment, tailstock offset, and compound rest) 2.2.4 Perform thread cutting operations on a lathe

Measures/Benchmarks	Learning Targets
	2.2.5 Perform boring operations on a lathe
MM.02.03 Utilize drilling machine	2.3.1 Identify components of the drill press 2.3.2 Set up and securely clamp a work piece to the drill press table 2.3.3 Use charts and tables to determine cutting speeds and feeds for drilling a specific medium 2.3.4 Select appropriate drill size based on job requirements 2.3.5 Perform drilling operations

MM.03 Identify and apply manufacturing processes

Measures/Benchmarks	Learning Targets
MM.03.01 Identify basic manufacturing systems	3.1.1 Identify the basic processes, systems, design processes, and materials used in manufacturing 3.1.2 Identify and describe the major manufacturing processes 3.1.3 Conduct reverse engineering processes to describe the process and materials used to manufacture a given product 3.1.4 Describe how different manufacturing processes can be used to produce similar products
MM.03.02 Identify material properties and science	3.2.1 Identify the major material families used in manufacturing 3.2.2 Differentiate between the various types of materials and their usage in specific applications 3.2.3 Discuss the impact of material usage on the environment 3.2.4 Explain how production is affected by the availability, quality, and quantity of resources 3.2.5 Differentiate among a raw material standard stock and finished products 3.2.6 Analyze the effects of the environmental conditions and manufacturing processes on material properties

Measures/Benchmarks	Learning Targets
MM.03.03 Demonstrate subtractive manufacturing processes	3.3.1 Identify and describe subtractive manufacturing processes 3.3.2 Explain the computer numerical control (CNC) processes and software requirements (e.g., Cartesian coordinates, numeric code, machine code, and import/export programs) 3.3.3 Perform safety inspections of subtractive equipment and accessories 3.3.4 Demonstrate the ability to use manual and computer numerical control subtractive equipment (e.g., oxy-fuel cutting, plasma cutting, mills, lathes, drill presses, saws, routers, and grinders) 3.3.5 Determine appropriate tooling, cutting speeds, and feed rates 3.3.6 Develop a list of manual material-cutting operations and identify the sequence needed to make a specific product 3.3.7 Utilize manual subtractive equipment to produce a specific product 3.3.8 Develop a list of CNC material-cutting operations and identify the sequence needed to make a specific product 3.3.9 Utilize a model or drawing to develop and adjust a CNC tool path

[Return to the beginning of the document](#)

Career Pathway: Manufacturing Fabrication

Cluster: Manufacturing

Program: 171710

Manufacturing Fabrication Courses

Course Code	Recommended Course Title	Course Description
50	Metals Fabrication	Metalworking courses introduce students to the physical and chemical properties of various metals and the tools and equipment used to manipulate metal and form it into products. Students will develop planning, layout, and measurement skills; gain experience in cutting, bending, forging, casting, and/or welding metal; complete projects according to blueprints or other specifications; and may also learn how to polish and finish metals. Correct use of metalworking tools and equipment is stressed.
51	Metal and Wood Processing/Production	Metal and Wood Processing/Production courses allow students to study the physical and chemical properties of metals, woods, and composites and to use these materials to construct usable products according to industry standards. These courses enable students to experience the process of translating an idea into a finished product, with instruction in planning, designing, selecting materials, using tools and machines, and quality control.
52	Materials Processing	Material and Processes courses expose students to the tools, equipment, and processes that may be encountered in manufacturing-related occupations. In particular, these courses stress the analysis, testing, quality control, and processing of metals, plastics, woods, ceramics, and composite materials.
53	Basic Non-Metals Fabrication	Non-Metal Fabrication courses allow students to study the physical and chemical properties of woods, plastics, ceramics, and composites made from woods and to use these materials to construct usable products according to industry standards. These courses enable students to experience the process of translating an idea into a finished product, with instruction in planning, designing, selecting materials, using tools and machines, and quality control.
54	Advanced Non-Metals Fabrication	Advanced Non-Metal Fabrication courses allow students to mastery the physical and chemical properties of woods, plastics, ceramics, and composites made from woods and to use these materials to construct usable products according to industry standards. These courses enable students to experience the process of translating an idea into

Course Code	Recommended Course Title	Course Description
		a finished product, with instruction in planning, designing, selecting materials, using tools and machines, and quality control.

Manufacturing Fabrication Technical Skills

MF.01 Apply fundamental print reading, measurement, and layout/fit up techniques

Measures/Benchmarks	Learning Targets
MF.01.01 Demonstrate print reading and sketching techniques	1.1.1 Interpret basic elements of a technical drawing (i.e., title block information, dimensions, line types) 1.1.2 Identify industry standard welding symbols 1.1.3 Prepare a materials list from a technical drawing 1.1.4 Describe various types of drawings (i.e., part, assembly, pictorial, orthographic, isometric, schematic) 1.1.5 Understand dimensioning, sectional drawings, fasteners, tables, charts, and assembly drawings 1.1.6 Sketch or draw a basic welding drawing 1.1.7 Fabricate parts from a drawing or sketch
MF.01.02 Demonstrate measuring and scaling techniques	1.2.1 Identify industry standard units of measure 1.2.2 Convert between customary (i.e., SAE, Imperial) and metric systems 1.2.3 Determine appropriate engineering and metric scales 1.2.4 Measure and calculate size, area, and volume 1.2.5 Determine and apply the equivalence between fractions and decimals 1.2.6 Demonstrate proper use of precision measuring tools (i.e., wire gauge, micrometer, dial-indicator, dial-caliper)
MF.01.03 Utilize layout principles and practices	1.3.1 Interpret drawing, sketch or specification information 1.3.2 Prepare work area for layout 1.3.3 Select appropriate materials to complete work assignment 1.3.4 Use layout and marking tools as required 1.3.5 Layout parts using measurement practices

Measures/Benchmarks	Learning Targets
MF.01.04 Demonstrate preparation and fit-up practices	1.4.1 Identify and explain job code specifications 1.4.2 Use fit-up gauges and measuring devices to check joint fit-up 1.4.3 Identify and explain distortion and how it is controlled 1.4.4 Fit-up joints using plate and pipe fit-up tools 1.4.5 Check for joint misalignment and poor fit-up before and after welding

MF.02 Identify properties of metals

Measures/Benchmarks	Learning Targets
MF.02.01 Identify material properties and science	2.1.1 Identify and explain the composition and classification of base metals 2.1.2 Explain and demonstrate field identification methods for base metals (i.e., mill certificate) 2.1.3 Identify and explain the physical characteristics and mechanical properties of metals 2.1.4 Identify and explain forms and shapes of structural metals 2.1.5 Explain metallurgical considerations for metals (i.e., base metal prep, heat treatment, thermal conductivity)
MF.02.02 Identify filler metals	2.2.1 Explain filler metal classifications systems (i.e., American Welding Society, American Society of Mechanical Engineers) 2.2.2 Identify different types of filler metals 2.2.3 Explain the storage and control of filler metals 2.2.4 Explain filler metal traceability requirements and how to use applicable code requirements

MF.03 Apply welding techniques

Measures/Benchmarks	Learning Targets
MF.03.01 Apply safety procedures	3.1.1 Identify and explain the use of GMAW and FCAW equipment (i.e., spray transfer, globular, short circuit, pulse) 3.1.2 Perform safety inspections of OFW and SMAW equipment and accessories 3.1.3 Perform safety inspections of GMAW and FCAW equipment and accessories 3.1.4 Perform safety inspections of GTAW equipment and accessories 3.1.5 Make minor external repairs to OFW and SMAW equipment and accessories 3.1.6 Make minor external repairs to GMAW and FCAW equipment and accessories 3.1.7 Make minor external repairs to GTAW equipment and accessories 3.1.8 Demonstrate safe startup, shutdown, disassembly, and cylinder exchange procedures of OFW 3.1.9 Demonstrate safe startup, shutdown, disassembly, and cylinder exchange procedures of GMAW and FCAW equipment 3.1.10 Demonstrate safe startup, shutdown, disassembly, and cylinder exchange procedures of GTAW equipment

Measures/Benchmarks	Learning Targets
MF.03.02 Produce welds using oxy-fuel welding (OFW)	3.2.1 Set up for OFW operations 3.2.2 Operate OFW equipment 3.2.3 Perform welds in the 1F and 2F position
MF.03.03 Produce welds using shielded metal arc welding (SMAW) on carbon steel	3.3.1 Set up for SMAW operations 3.3.2 Operate SMAW equipment 3.3.3 Perform welds in the 1F position 3.3.4 Perform welds in the 2F position 3.3.5 Perform welds in the 1G position 3.3.6 Perform welds in the 2G position 3.3.7 Perform welds in the 3G position
MF.03.04 Produce welds using gas metal arc welding short circuiting transfer (GMAW-S) on carbon steel	3.4.1 Set up for GMAW-S operations 3.4.2 Operate GMAW-S equipment 3.4.3 Perform welds in the 1F position 3.4.4 Perform welds in the 2F position 3.4.5 Perform welds in the 3F position 3.4.6 Perform welds in the 1G position 3.4.7 Perform welds in the 2G position 3.4.8 Perform welds in the 3G position
MF.03.05 Produce welds using flux core arc welding short circuiting transfer (FCAW-g) on carbon steel	3.5.1 Set up for FCAW-G operations 3.5.2 Operate FCAW-G equipment 3.5.3 Perform welds in the 1F position 3.5.4 Perform welds in the 2F position 3.5.5 Perform welds in the 3F position 3.5.6 Perform welds in the 1G position 3.5.7 Perform welds in the 2G position 3.5.8 Perform welds in the 3G position

Measures/Benchmarks	Learning Targets
MF.03.06 Produce welds using gas tungsten arc welding (GTAW) on carbon steel	3.6.1 Set up for GTAW operations 3.6.2 Operate GTAW equipment 3.6.3 Perform welds in the 1F position 3.6.4 Perform welds in the 2F position 3.6.5 Perform welds in the 3F position 3.6.6 Perform welds in the 1G position 3.6.7 Perform welds in the 2G position 3.6.8 Perform welds in the 3G position
MF.03.07 Produce welds using gas tungsten arc welding (GTAW) on aluminum	3.7.1 Set up for GTAW operations 3.7.2 Operate GTAW equipment 3.7.3 Perform welds in the 1F position 3.7.4 Perform welds in the 2F position 3.7.5 Perform welds in the 1G position

MF.04 Apply thermal cutting processes

Measures/Benchmarks	Learning Targets
MF.04.01 Demonstrate oxy-fuel gas cutting (OFC)	4.1.1 Perform safety inspections of OFC equipment and accessories 4.1.2 Make minor external repairs to OFC equipment and accessories 4.1.3 Demonstrate safe startup, shutdown, disassembly, and cylinder exchange procedures of OFC equipment 4.1.4 Set up for OFC operations 4.1.5 Operate OFC equipment 4.1.6 Perform straight, square edge cutting operations in the flat position 4.1.7 Perform shape, square edge cutting operations in the flat position 4.1.8 Perform straight, bevel edge cutting operations in the flat position 4.1.9 Perform scarfing and gouging operations to remove base and weld metal, in flat and horizontal positions
MF.04.02 Demonstrate plasma arc cutting (PAC) on carbon steel and/or aluminum	4.2.1 Perform safety inspections of PAC equipment and accessories 4.2.2 Make minor external repairs to PAC equipment and accessories 4.2.3 Set up for PAC operations 4.2.4 Operate PAC equipment 4.2.5 Perform straight, square edge cutting operations in the flat position 4.2.6 Perform shape, square edge cutting operations in the flat position

MF.05 Identify welding codes, inspections, and testing principles

Measures/Benchmarks	Learning Targets
MF.05.01 Identify welding codes, qualifications, and certifications	5.1.1 Identify and explain codes governing welding 5.1.2 Identify and explain weld imperfections and their causes 5.1.3 Identify and explain nondestructive examination practices 5.1.4 Identify and explain welder qualification tests 5.1.5 Explain the importance of quality workmanship 5.1.6 Identify common destructive testing methods 5.1.7 Perform a visual inspection of fillet welds
MF.05.02 Demonstrate welding inspection and testing principles	5.2.1 Research the role of welding inspection/inspector and testing in industry 5.2.2 Examine cut surfaces and edges of prepared base metal parts 5.2.3 Examine tack, root passes, intermediate layers, and completed welds

MF.06 Apply fabrication fundamentals

Measures/Benchmarks	Learning Targets
MF.06.01 Utilize base metal/woods/plastics/ceramics/and composites preparation fundamentals	6.1.1 Clean base metal for welding or cutting 6.1.2 Identify and explain joint design 6.1.3 Explain joint design considerations 6.1.4 Mechanically bevel the edge of a mild steel plate 6.1.5 Thermally bevel the end of a mild steel plate 6.1.6 Select the proper joint design based on a welding procedure specification (WPS)
MF.06.02 Demonstrate part preparation with cutting and forming techniques	6.2.1 Perform bending or forming operations 6.2.2 Perform drilling or boring operations 6.2.3 Perform shearing operations
MF.06.03 Demonstrate fabrication techniques	6.3.1 Demonstrate proper setup of fabrication area, equipment, and materials 6.3.2 Construct projects in the proper sequence 6.3.3 Produce tack welds to specifications 6.3.4 Properly layout projects from prints 6.3.5 Check work for accuracy

Measures/Benchmarks	Learning Targets
MF.06.04 Identify threads and fasteners	6.4.1 Identify SAE and metric threads (i.e., screw, tapered, self-tapping) 6.4.2 Cut internal and external threads manually and mechanically (i.e., tap and die, lathe) 6.4.3 Identify various fastening methods (i.e., rivets, adhesive, screws, seams, etc.) 6.4.4 Categorize fastening methods by appropriate applications 6.4.5 Demonstrate fastening methods on various materials
MF.06.05 Utilize metal forming processes	6.5.1 Identify and explain various forming processes 6.5.2 Identify different types of forming equipment 6.5.3 Demonstrate metal drawing and tapering processes 6.5.4 Demonstrate heat treating processes 6.5.5 Demonstrate braking and bending applications, both manually and mechanically
MF.06.06 Utilize woods/plastics/ceramics forming or shaping processes	6.6.1 Identify and explain various forming processes 6.6.2 Demonstrate cutting methods of woods, plastics, and/or ceramics 6.6.3 Demonstrate drilling methods of woods, plastics, and/or ceramics 6.6.4 Demonstrate shaping methods of woods, plastics, and/or ceramics 6.6.5 Demonstrate finishing methods of woods, plastics, and/or ceramics

MF.07 Apply sheet metal techniques

Measures/Benchmarks	Learning Targets
MF.07.01 Utilize sheet metal layout principles and practices	7.1.1 Construct paper patterns for a simple sheet metal project 7.1.2 Layout directly on metal using dyes, scribes, dividers, trammel points, and edge gauges 7.1.3 Identify edges and seams used in typical sheet metal layout 7.1.4 Demonstrate the use of triangulation development 7.1.5 Demonstrate how to find true length lines
MF.07.02 Demonstrate fastening techniques	7.2.1 Identify and list the various sheet metal fastening techniques 7.2.2 Demonstrate the ability to join sheet metal together with rivets, resistance welding, and seaming techniques
MF.07.03 Utilize forming and cutting techniques	7.3.1 Perform basic preventative non-electrical maintenance on machines and tools to comply with safety requirements for optimal performance levels 7.3.2 Form sheet metal using a box and pan break, bar folder, slip roll, and a rotary machine 7.3.3 Cut sheet metal using foot shears/power shears, hand shears, Beverly shears, and Whitney punches

Measures/Benchmarks	Learning Targets
	7.3.4 Use appropriate cutting and folding techniques

Career Pathway: Manufacturing Technology

Cluster: Manufacturing

Program: 171710

Manufacturing Technology Courses

Course Code	Recommended Course Title	Course Description
60	Basic Electro --Mechanical Systems	Electro-Mechanical Systems courses provide students with instruction and experience in components and equipment used within a manufacturing environment powered by electricity and physical forces. Students gain an understanding of basic and industrial electricity, industrial electronics, and the automated systems used in the manufacturing process or within manufactured goods.
61	Advanced Electro --Mechanical Systems	Advanced Electro-Mechanical Systems courses extend students mastery of components and equipment used within a manufacturing environment powered by electricity and physical forces. Students gain an understanding of basic and industrial electricity, industrial electronics, and the automated systems used in the manufacturing process or within manufactured goods.
62	Basic Mechatronics	Basic Mechatronics courses provide students with an understanding of the fundamentals of mechatronics. Topics include an understanding of how a manufacturing process previously carried out manually is automated, learning about the parts (sensors, actuators) and processes (material flow, energy flow, signal flow) involved in automated processes.
63	Advanced Mechatronics	Advanced Mechatronics courses offer students hands-on training in next level elements of mechatronics. Topics include electrical engineering, electronics, pneumatics, robotics and programmable Logic Controllers (PLCs.) and maintenance of those elements and systems.

Course Code	Recommended Course Title	Course Description
64	Basic Robotics	Robotics courses help students develop and expand their skills and knowledge of robotics and related scientific and engineering topics. Course topics may include principles of mechanics, electronics, hydraulics, pneumatics, programmable logic controllers. These courses may emphasize the use of engineering principles to design and build robots, construct and connect sensors, and program robots in the programming language.
65	Advanced Robotics	Advanced Robotics courses help students master their skills and knowledge of robotics and related scientific and engineering topics. Course topics may include principles of mechanics, electronics, hydraulics, pneumatics, programmable logic controllers. These courses may emphasize the use of engineering principles to design and build robots, construct and connect sensors, and program robots in the programming language. They may also include maintenance of robots and robotic systems.
66	Engineering Applications	Engineering Applications courses provide students with an overview of the practical uses of a variety of engineering applications. Topics covered usually include hydraulics, pneumatics, computer interfacing, robotics, computer-aided design, computer numerical control, electronics, and mechatronics.
67	Power and Energy	Energy/Power courses focus on one or several aspects of energy and power in transportation and work. Course content may include various sources of energy and their use in society (for example, characteristics, availability, conversion, storage, environmental impact, and socioeconomic aspects of various energy sources); principles involved in various means of energy transfer, such as electricity/electronics, hydraulics, pneumatics, heat transfer, and wind/nuclear/solar energies; and the transmission and control of power through mechanical or electrical devices such as motors and engines.
68	Basic Super Mileage	Basic SuperMileage courses equip students with knowledge of the elements needed to design and build a fuel-efficient vehicle that will achieve the highest possible miles per gallon in competition while also achieving other tests: roll bar stress, braking, maneuverability, egress, and visibility. Topics would include aerodynamics, mechanical needs functions, and use of innovative materials, tools, and technology. Students must function as a team to conceptualize, design, build, test, promote, and race within the limits of race rules.

Course Code	Recommended Course Title	Course Description
69	Advanced Super Mileage	Advanced SuperMileage courses enable students to design and build a fuel-efficient vehicle that will achieve the highest possible miles per gallon in competition. Topics would include understanding of aerodynamics, mechanical needs functions, and use of innovative materials, tools, and technology. Students must function as a team to conceptualize, design, build, test, promote, and race within the limits of race rules. Students may also be tasked to generate financial support for their project and manage their educational priorities. Students prepare to compete against around teams in the state-wide competition.

Manufacturing Technology Technical Skills

MT.01 Apply fundamental electronic and instrumentation principles

Measures/Benchmarks	Learning Targets
MT.01.01 Demonstrate analog and digital electronic principles	1.1.1 Demonstrate safe use of electricity and lab equipment 1.1.2 Understand and demonstrate basic electronic theory 1.1.3 Identify electronic components and their applications (e.g., resistors, capacitors, inductors, transformers, etc.) 1.1.4 Utilize tools and test equipment appropriately 1.1.5 Measure electrical characteristics of voltage, current, and resistance in basic electronic circuits using multi-meters and oscilloscopes 1.1.6 Verify Ohm's Law and power equations 1.1.7 Construct, measure, and analyze simple series, parallel, and series-parallel (combination) circuits 1.1.8 Demonstrate appropriate solder and de-solder techniques for electronics and electrical circuits 1.1.9 Demonstrate appropriate use of various connectors (e.g., crimp connectors, wire nuts, RJ45, CAT5e, etc.) 1.1.10 Construct a simple AC circuit using passive components (i.e., resistors, inductors, capacitors) 1.1.11 Construct a simple AC circuit using active components (i.e., diodes, transistors, linear devices) 1.1.12 Demonstrate the appropriate use of relays and switches 1.1.13 Build electronic circuits utilizing basic TTL logic with AND, OR, NAND, NOR, buffer and inverter chips

Measures/Benchmarks	Learning Targets
MT.01.02 Demonstrate control technology and automation principles	1.2.1 Research the history and fundamentals of automation and control systems 1.2.2 Identify applications of control logic 1.2.3 Distinguish programmable controllers and PLC components and their functions 1.2.4 Interpret programming diagrams 1.2.5 Sketch programming diagrams for real world applications 1.2.6 Program ladder logic statements to perform a specific task 1.2.7 Develop ladder/relay logic application use for a PLC to control industry specific processes 1.2.8 Select most appropriate type of circuit logic for each application 1.2.9 Understand varying types of hardware used throughout the industry 1.2.10 Apply suitable commands for PLC circuits 1.2.11 Apply timer and counter principles to industry-related problems 1.2.12 Setup and test PLCs 1.2.13 Understand and select proper communication drivers to interface with a PLC system 1.2.14 Troubleshoot issues with PLCs 1.2.15 Perform basic maintenance with PLCs
MT.01.03 Demonstrate diagnostic and troubleshooting practices	1.3.1 Explain a diagnostic procedure 1.3.2 Identify the components of a safety procedure checklist 1.3.3 Utilize all safety procedures necessary before performing a repair (e.g., lock-out/tag-out, etc.) 1.3.4 Navigate through user software 1.3.5 Understand and use software instructions offered in user software 1.3.6 Develop a routine maintenance plan 1.3.7 Utilize various sources of repair, maintenance, and troubleshooting documentation (e.g., print media, electronic, tech support, local expert) 1.3.8 Use manufacturer's documentation for troubleshooting 1.3.9 Utilize diagnostic tools appropriately 1.3.10 Troubleshoot and repair common problems

MT.02 Understand and apply automation principles

Measures/Benchmarks	Learning Targets
MT.02.01 Investigate materials used in automation systems	2.1.1 Discuss the importance of material selection in an automated system 2.1.2 Identify the major material families (e.g., wood, glass, metal, plastic) 2.1.3 Differentiate between the various types of materials and their properties (e.g., mechanical, physical, chemical) 2.1.4 Discuss the impact of material usage on the environment
MT.02.02 Identify fundamental automation components and systems	2.2.1 Identify common automation systems 2.2.2 Identify common components in automation systems 2.2.3 Describe the function of components in automation systems 2.2.4 Examine the functions of an industrial network 2.2.5 Analyze the application of automation in various industries

MT.03 Apply fundamentals of electronics for automation

Measures/Benchmarks	Learning Targets
MT.03.01 Apply fundamentals of electricity	3.1.1 Define AC and DC electrical systems and terminology 3.1.2 Discuss the safety concerns of working with electricity (e.g., arc flash, electrical burns) 3.1.3 Describe the principles of generation, transmission, distribution, and storage of electricity 3.1.4 Compute values of current, resistance, and voltage using Ohm's law and power equations 3.1.5 Discuss the concept of impedance in relation to Ohm's Law 3.1.6 Identify series, parallel, and series-parallel (combination) circuits 3.1.7 Solve series and parallel circuits using basic laws of electricity including Kirchhoff's laws 3.1.8 Introduce single-phase and three-phase AC power 3.1.9 Construct and test simple electrical circuits from a schematic

Measures/Benchmarks	Learning Targets
MT.03.02 Apply fundamentals of electronics	3.2.1 Understand and demonstrate basic electrical theory 3.2.2 Identify electronic components and their applications (e.g., resistors, capacitors, inductors, and transformers) 3.2.3 Utilize tools and test equipment appropriately and safely (i.e., multi-meters) 3.2.4 Measure electrical characteristics of voltage, current, and resistance in basic electronic circuits 3.2.5 Demonstrate appropriate soldering and de-soldering techniques for electronic circuits 3.2.6 Demonstrate appropriate use of various connectors 3.2.7 Construct, measure, and analyze, simple series, parallel, and series-parallel (combination) circuits

MT.04 Characterize automation control devices

Measures/Benchmarks	Learning Targets
MT.04.01 Investigate motors in automated systems	4.1.1 Identify the function of an electric motor 4.1.2 Identify the various types of motors and their designated uses (e.g., 1 phase AC, 3 phase AC, DC, Servo) 4.1.3 Describe various motor applications in automation systems 4.1.4 Construct and test a simple motor application
MT.04.02 Investigate fluid power systems	4.2.1 Identify and apply safety protocols for fluid power systems 4.2.2 Identify components of fluid power systems 4.2.3 Describe the operation and use of fluid power in automation systems 4.2.4 Identify different control components used in pneumatic systems (e.g., DCVs, Flow control, Solenoids) 4.2.5 Construct and test a simple fluid power system
MT.04.03 Investigate sensors and actuators	4.3.1 Differentiate between sensors and actuators 4.3.2 Describe the functions of sensors and actuators used in automation systems 4.3.3 Construct and test a circuit utilizing sensors and actuators 4.3.4 Define analog and binary sensors 4.3.5 Differentiate between different Binary sensors and what they detect (e.g., inductive, capacitive, photoelectric)

Measures/Benchmarks	Learning Targets
MT.04.04 Investigate switches and relays	4.4.1 Differentiate between switches and relays 4.4.2 Explain the characteristics and operations of switches and relays 4.4.3 Explain the role of electromagnetic relays 4.4.4 Construct and test a simple circuit utilizing switches and relays
MT.04.05 Explore programmable logic controllers	4.5.1 Investigate the basic components of a programmable logic controller (PLC) 4.5.2 Identify the major advantages in the use of PLCs in automation 4.5.3 Identify the various programming devices used to program a PLC 4.5.4 Explain the various modes of operations of a PLC
MT.04.06 Research conveyance systems	4.6.1 Investigate different conveyance systems 4.6.2 Describe control systems utilized in conveyance systems 4.6.3 Examine applications of conveyance systems in automation systems
MT.04.07 Explore variable frequency drives	4.7.1 Define the functions of variable frequency drives 4.7.2 Explore the application of variable frequency drives in automation systems 4.7.3 Construct and test a simple automated process utilizing variable frequency drives
MT.04.08 Investigate identification and vision systems	4.8.1 Identify different identification and vision systems used in automation systems 4.8.2 Investigate the applications of different identification and vision systems (i.e., barcode, RFID, QR codes, machine vision systems, applications of ID systems)

MT.05 Apply model control systems

Measures/Benchmarks	Learning Targets
MT.05.01 Demonstrate control technology and automation principles	5.1.1 Distinguish between standard and safety programmable controllers, their components, and their functions 5.1.2 Interpret programming diagrams (e.g., flow charts) 5.1.3 Sketch programming diagrams for real world applications 5.1.4 Compare and contrast open and closed loop control systems 5.1.5 Initialize a PLC 5.1.6 Understand and select proper communication drivers to interface with a PLC system 5.1.7 Apply suitable commands for PLC circuits 5.1.8 Apply timer and counter principles to industry-related problems 5.1.9 Program ladder logic statements to perform a specific task

Measures/Benchmarks	Learning Targets
	5.1.10 Design, construct, and test an automated system
MT.05.02 Demonstrate diagnostic and troubleshooting practices	5.2.1 Explore diagnostic procedures 5.2.2 Identify components of a safety procedure checklist 5.2.3 Utilize all safety procedures necessary before performing a repair (e.g., lock-out/tag-out) 5.2.4 Navigate through user software 5.2.5 Understand and use software instructions offered in user software 5.2.6 Use manufacturer's documentation for troubleshooting 5.2.7 Create a detailed troubleshooting checklist 5.2.7 Utilize diagnostic tools appropriately 5.2.8 Troubleshoot and repair common problems in control systems 5.2.9 Complete a troubleshooting work order
MT.05.03 Demonstrate maintenance fundamentals	5.3.1 Explore mechanical fundamentals (e.g., alignment, wear, lubrication) 5.3.2 Distinguish between preventative and predictive maintenance 5.3.3 Develop a routine maintenance plan 5.3.4 Utilize various repair, maintenance, and troubleshooting resources (e.g., print media, electronic, tech support, and local experts)

MT.06 Explore robotic systems

Measures/Benchmarks	Learning Targets
MT.06.01 Explore robotic systems in automation	6.1.1 Research the history of robotics (i.e., industrial and non-industrial) 6.1.2 Identify Isaac Asimov's three laws of robotics 6.1.3 Investigate the societal impact of robotics 6.1.4 Apply robotic vocabulary (e.g., degrees of freedom, axis, work envelope, tool point, tool tip)
MT.06.02 Determine components in robotic systems for automation	6.2.1 Identify main components of a robot 6.2.2 Investigate robotic specifications (e.g., payload, repeatability, environmental requirements, power sources) 6.2.3 Identify robot control systems 6.2.4 Describe end effectors utilized by robots 6.2.5 Identify teaching and programming interfaces for robots 6.2.6 Construct a simple automated system utilizing HMI interfaces

Measures/Benchmarks	Learning Targets
MT.06.03 Construct a robotic system for automation	6.3.1 Identify programming languages for robotics applications 6.3.2 Identify path control techniques used by robots 6.3.3 Create a robotic control program 6.3.4 Construct a robotic control system combining several automation components (e.g., electrical, pneumatic, conveyance, VFDs, PLCs, and HMIs)

MT.07 Apply fundamental energy principles

Measures/Benchmarks	Learning Targets
MT.07.01 Identify energy forms	7.1.1 Define energy 7.1.2 Categorize types of energy into major forms: thermal, radiant, nuclear, chemical, electrical, mechanical, and fluid 7.1.3 Identify units used to measure energy 7.1.4 Analyze and apply data and measurements to solve problems and interpret documents 7.1.5 Calculate unit conversions between common energy measurements 7.1.6 Classify energy resources as non-renewable or renewable energy 7.1.7 Classify energy resources as potential or kinetic energy
MT.07.02 Compare non-renewable and renewable energy sources	7.2.1 Define non-renewable and renewable energy 7.2.2 Identify forms of non-renewable and renewable energy 7.2.3 Research non-renewable and renewable energy sources 7.2.4 Calculate non-renewable and renewable energy including unit conversions 7.2.5 Analyze the environmental impact of non-renewable and renewable energy 7.2.6 Assess energy efficiency and conservation
MT.07.03 Distinguish potential and kinetic energy	7.3.1 Define potential and kinetic energy 7.3.2 Identify forms of potential and kinetic energy 7.3.3 Research energy conversions (i.e., potential to kinetic) 7.3.4 Calculate potential and kinetic energy, including unit conversions
MT.07.04 Identify thermodynamics	7.4.1 Define thermodynamics 7.4.2 Utilize industry standard terminology 7.4.3 Identify the common units of measurement 7.4.4 Apply the Laws of Thermodynamics 7.4.5 Demonstrate the concepts of heat transfer (i.e., conduction, convection, radiation)

MT.08 Apply fundamental power system principles

Measures/Benchmarks	Learning Targets
MT.08.01 Identify power systems	8.1.1 Define terms used in power systems (e.g., power, work, horsepower, watts) 8.1.2 Identify the basic power systems 8.1.3 List the basic elements of power systems 8.1.4 Summarize the advantages and disadvantages of various forms of power 8.1.5 Calculate the efficiency of power systems and conversion devices 8.1.6 Demonstrate the use of an energy conversion device
MT.08.02 Identify and utilize basic mechanical systems	8.2.1 Locate and explain examples of the six simple machines, their attributes and components 8.2.2 Measure forces and distances related to mechanisms 8.2.3 Determine efficiency in a mechanical system 8.2.4 Calculate mechanical advantage 8.2.5 Measure torque and use it to calculate power 8.2.6 Design, construct, and test various basic mechanical systems
MT.08.03 Identify and utilize advanced mechanical systems	8.3.1 Identify and explain the differences between gasoline engines and diesel engines 8.3.2 Identify and explain electrical motor systems and motor controls by application 8.3.3 Identify and utilize all safety procedures for advanced mechanical systems 8.3.4 Identify, inspect, and repair engine assembly for fuel, oil, coolant, and other leaks 8.3.5 Identify, inspect, and repair drivetrain assemblies for leakage at external seals, gaskets, and bushings 8.3.6 Identify, inspect, and repair suspension and steering systems for leaks 8.3.7 Identify, inspect, and repair braking systems 8.3.8 Identify, inspect, and repair mechanical power transmissions 8.3.9 Examine the relationship between bearings, couplings, and gear drives 8.3.10 Explain belt drive concepts, v-belt operation, belt tensioning, and belt tension measurement 8.3.11 Explain chain drive concepts, chain tensioning, and chain tension measurement 8.3.12 Demonstrate chain and belt tensioning procedures

Measures/Benchmarks	Learning Targets
MT.08.04 Identify and utilize basic fluid systems	8.4.1 Define fluid systems (e.g., hydraulic, pneumatic, vacuum) 8.4.2 Identify and define the components of fluid systems 8.4.3 Compare and contrast hydraulic and pneumatic systems 8.4.4 Identify the advantages and disadvantages of using fluid power systems 8.4.5 Explain the difference between gauge pressure and absolute pressure 8.4.6 Discuss the safety concerns of working with liquids and gases under pressure 8.4.7 Calculate mechanical advantage using Pascal's law 8.4.8 Calculate values in a pneumatic system, using the ideal gas laws 8.4.9 Design, construct, and test various fluid systems
MT.08.05 Identify and utilize basic electrical systems	8.5.1 Define AC and DC electrical systems and terminology 8.5.2 Discuss the safety concerns of working with electricity 8.5.3 Describe the principles of generation, transmission, distribution, and storage of electricity 8.5.4 Identify the advantages and disadvantages of using electrical systems 8.5.5 Compute values of current, resistance, and voltage using Ohm's Law 8.5.6 Identify series, parallel and series-parallel (combination) circuits 8.5.7 Solve series and parallel circuits using basic laws of electricity including Kirchhoff's laws 8.5.8 Introduce single-phase and three-phase AC power 8.5.9 Analyze the laws, principles, and types of electricity to utilize, repair, and maintain equipment used in an industrial environment 8.5.10 Construct and test simple electrical circuits from a schematic

MT.09 Identify and apply manufacturing processes

Measures/Benchmarks	Learning Targets
MT.09.01 Identify material properties and science	9.1.1 Identify the major material families used in manufacturing 9.1.2 Differentiate between the various types of material properties and their applications 9.1.3 Discuss the impact of material usage on the environment 9.1.4 Explain how production is affected by the availability, quality and quantity of resources 9.1.5 Differentiate among a raw material standard stock and finished products

Measures/Benchmarks	Learning Targets
MT.09.02 Identify manufacturing processes	9.2.1 Identify and describe the five major manufacturing processes (i.e., forming, separating, fabricating, conditioning, and finishing) 9.2.2 Discuss the impact of manufacturing processes on the environment 9.2.3 Describe Lean manufacturing and explain its importance
MT.09.03 Apply manufacturing processes	9.3.1 Demonstrate cutting methods of metals and plastics 9.3.2 Demonstrate drilling methods of metals and plastics 9.3.3 Demonstrate grinding methods of metals 9.3.4 Demonstrate finishing methods of metals and plastics
MT.09.04 Identify fasteners	9.4.1 Identify various fastening methods (e.g., rivets, welds, adhesive, screws, seams, etc.) 9.4.2 Categorize fastening methods by appropriate applications 9.4.3 Demonstrate fastening methods on various materials
MT.09.05 Demonstrate safe and proper welding techniques	9.5.1 Apply safe procedures 9.5.2 Produce welds using oxy-fuel welding (OFW) 9.5.3 Produce welds using shielded metal arc welding (SMAW) on carbon steel 9.5.4 Produce welds using gas metal arc welding short circuiting transfer (GMAW-S) on carbon steel 9.5.5 Produce welds using flux core arc welding short circuiting transfer (FCAW-G) on carbon steel 9.5.6 Produce welds using gas tungsten arc welding (GTAW) on carbon steel 9.5.7 Produce welds using gas tungsten arc welding (GTAW) on aluminum

[Return to the beginning of the document](#)

Career Pathway: Air Conditioning, Heating, and Refrigeration Services

Cluster: Manufacturing

Program: 171710

Air Conditioning, Heating, and Refrigeration Services Courses

Course Code	Recommended Course Title	Course Description
70	Heating, Vent and Air Conditioning	These courses synthesize basic and advanced principles in heating, ventilation, and air conditioning and include topics such as air filtration methods, humidity control, and the maintenance and operation of heat pumps, furnaces, and air conditioners. Students also learn about repairing, maintenance, and operation of climate control systems; electrical wiring; systems design; ductwork; maintaining climate control systems; and safety.
71	Refrigeration	Refrigeration courses provide students with exposure to and training in the theories, equipment, and skills needed to design, install, and repair commercial and residential refrigeration systems. Course topics typically include the theory of thermodynamics, measurement of pressures and temperatures, components and common accessories of refrigeration systems, and repair and safety procedures.

Air Conditioning, Heating, and Refrigeration Services Technical Skills

HVAC 01 Display knowledge of science and engineering associated with heating, ventilation, and air conditioning systems

Measures/Benchmarks	Learning Targets
HVAC.01.01 Demonstrate an understanding of the methods and devices used to improve air quality and comfort	1.1.1 Explain the historical development and principals of air-conditioning and refrigeration. 1.1.2 Describe the differences between air-conditioning and refrigeration. 1.1.3 Explain the impact of heating, air-conditioning, and refrigeration on society. 1.1.4 Explain the differences in comfort applications (cooling/heating air) and process applications (improving air quality). 1.1.5 Describe the benefits of conditioned air and environments. 1.1.6 Explain the methods and devices used to improve air quality. 1.1.7 List several situations in which the improvement of air quality is essential. 1.1.8 Debate current issues and concerns, such as indoor air quality, the ozone layer, and computer technology, in the heating, air-conditioning, and refrigeration industry and in the environment and explain their future ramifications. 1.1.9 Describe the purpose and importance of local, state, and federal heating, air-conditioning, and refrigeration codes and standards. 1.1.10 Identify various HVAC professional organizations, associations, and societies, and explain their purposes.
HVAC.01.02 Describe the basic components and concepts of heating, air-conditioning, and refrigeration	1.2.1 Demonstrate a working knowledge of the four major components of a refrigeration system. 1.2.2 Identify and explain the characteristics of vapor compression refrigeration. 1.2.3 Explain the advantages and disadvantages of the different refrigerants used in a vapor compression system. 1.2.4 Distinguish between split systems and package systems.
HVAC.01.03 Demonstrate an understanding of the scientific theories and physical properties of heat and matter	1.3.1 Describe and explain freezing point, critical temperature, and absolute zero. 1.3.2 Describe matter and heat and their relation to heat transfer. 1.3.3 Compare and contrast the characteristics of heat, humidity, and temperature. 1.3.4 Distinguish between, and explain the characteristics of, the three different states of matter. 1.3.5 Define the differences between latent heat and sensible heat.

Measures/Benchmarks	Learning Targets
HVAC.01.04 Analyze the effects and reactions of fluids, pressures, and temperatures on refrigerants	1.4.1 Summarize the refrigeration cycle. 1.4.2 Define and explain “fluid,” “pressure,” and “temperature.” 1.4.3 Utilize pressure and temperature charts. 1.4.4 Demonstrate ways to measure and calculate absolute and gauge pressures according to industry standards. 1.4.5 Identify and explain the classifications, uses, and properties of different refrigerants. 1.4.6 Explain how fluids react and flow in a closed system versus an open system. 1.4.7 Identify and classify the color-coding of refrigerant cylinders. 1.4.8 Practice proper methods of storing, transferring, and recovering refrigerants. 1.4.9 Summarize the effects of contaminants or using an improper refrigerant in a system.

HVAC 02 Apply systems, processes, applications, and standards supporting the design and application of heating, ventilation, and air conditioning systems

Measures/Benchmarks	Learning Targets
HVAC.02.01 Demonstrate skills necessary to fabricate and service the tubing, piping, and fittings utilized in accordance with accepted industry standards	2.1.1 Understand the basic codes in the Uniform Plumbing Codes (UPC). 2.1.2 Select materials and fittings for use in piping a system. 2.1.3 Demonstrate techniques for cutting, deburring, and bending tubing. 2.1.4 Connect tubing utilizing proper fittings and connection methods. 2.1.5 Demonstrate the ability to identify and select the appropriate materials for the soldering and brazing of tubing. 2.1.6 Explain the purposes and procedures for protecting piping materials and fittings from effects of heat. 2.1.7 Demonstrate the ability to braze and/or solder tubing, including aluminum. 2.1.8 Silver-braze bras, steels, and copper. 2.1.9 Fabricate and leak test the piping, tubing, and connections of a heating, air-conditioning, and/or refrigeration unit.

Measures/Benchmarks	Learning Targets
HVAC.02.02 Demonstrate the skills necessary to service, maintain, and repair heating, air-conditioning, and refrigeration system components and accessories	2.2.1 Explain the types, operation, use, and maintenance requirements of different compressors (e.g., reciprocating, rotary, screw, and scroll). 2.2.2 Analyze the operating condition of a compressor. 2.2.3 Explain the types, operation, use, and maintenance requirements of condensers and evaporators. 2.2.4 Explain the types, operation, use, and maintenance requirements of different metering devices. 2.2.5 Evaluate the performance of a metering device. 2.2.6 Explain the methods of compression, lubrication, and compressor loading and unloading. 2.2.7 Analyze and evaluate the proper operating condition of a compressor. 2.2.8 Locate and explain the uses of refrigerant flow accessories. 2.2.9 Locate and explain the uses of system accessories (e.g., receivers, solenoids, valves, heat exchangers, filters, and separators). 2.2.10 Analyze, troubleshoot, and correct mechanical problems in a heating, air-conditioning, and refrigeration system. 2.2.11 Evaluate system performance.
HVAC.02.03 Demonstrate a practical knowledge of basic electricity and skills necessary to service and maintain the electrical components of heating, air-conditioning, and refrigeration equipment	2.3.1 Explain the principles and properties of electricity. 2.3.2 Compare and contrast single-phase versus three-phase electrical distribution. 2.3.3 Define and distinguish amps, ohms, volts, and watts. 2.3.4 Demonstrate the ways to measure watts, voltage, amperage, and resistance using appropriate instruments while adhering to industry standards. 2.3.5 Illustrate and summarize a wiring schematic diagram for a heating or cooling system. 2.3.6 Analyze and troubleshoot the protection devices, such as fuses and breakers, in an electrical system. 2.3.7 Interpret charts and tables from the National Electrical Codes (NEC).
HVAC.02.04 Troubleshoot electrical control systems, motors, and their components	2.8.1 Identify and explain the operations of electrical control systems and their components. 2.8.2 Install and troubleshoot electrical control systems. 2.8.3 Describe the operation and function of different types of electromechanical thermostats. 2.8.4 Analyze operational problems with different types of electromechanical thermostats. 2.8.5 Describe the electrical and mechanical operations of a basic heat pump.

[Return to the beginning of the document](#)

Career Pathway: Manufacturing Capstone

Cluster: Manufacturing

Program: 171710

Capstone Course

Course Code	Recommended Course Title	Course Description
91	Simulated School Business	A manufacturing operation within the school setting coupled with a hands-on course/laboratory. Operation does not exceed 40 hours of work for students. Operations may include: repair and maintenance, vehicle modification, etc. Course portion may include the following topics: operations, product services management, pricing, distribution management, and promotion/marketing. Goals are typically set cooperatively by the student, teacher, and employer (although students are not paid). These courses may include classroom activities as well, involving further study of the field or discussion regarding experiences that students encounter in the workplace.

Capstone Technical Skills

CP.01 Apply the appropriate financial analysis

Measures/Benchmarks	Learning Targets
CP.01.01 Identify the role of finance in a Simulated Student Business (SSB)	1.1.1 Explain the significance of finance and how it can determine the ultimate success of the SSB 1.1.2 Apply appropriate fiscal management for a successful business operation
CP.01.02 Demonstrate the need for financial information	1.2.1 Apply the financial information needed for proper operations, economic outlook, and cash flow of the SSB. 1.2.2 Read, understand, and analyze financial information to effectively run the SSB.
CP.01.03 Understand and apply proper budget management	1.3.1 Identify the importance of budgets for the SSB 1.3.1 Describe the budgeting process and decision-making with the SSB budget
CP.01.04 Make responsible financial decisions	1.4.1 Provide details of how responsible financial decisions impact the operations of the SSB. 1.4.2 Make financial decisions which will impacted the operations of the SSB

Measures/Benchmarks	Learning Targets
CP.01.05 Maintain the business' financial records	1.5.1 Identify the importance of financial record keeping 1.5.2 Keep and used financial record for the SSB
CP.01.06 Describe the use of technology in the financial-information management function	1.6.1 Identify how information technology systems is used by the SBE to automate or customize financial reporting 1.6.2 Use various types of technology for financial-information management in the SBE

CP.02 Perform appropriate production and/or service operations for business

Measures/Benchmarks	Learning Targets
CP.02.01 Follow instructions for proper use of equipment, tools and machinery	2.1.1 Identify the types of equipment, tools and machinery used in the SSB, including the location, use and responsibilities regarding equipment and machines 2.1.2 Plan for who is responsible for the training and what steps are taken to ensure safety 2.1.3 Provide checks and balances in regard to equipment training used in the SSB 2.1.4 Provide proper training to use equipment and tools necessary for the SSB
CP.02.02 Apply health and safety regulations in business	2.2.1 Identify the health and safety regulations set forth by the school, district, county and/or state in regard to operation of your SSB 2.2.2 Outline the equipment, fire, and emergency safety, and other precautions/trainings and regulations that must be addressed and practiced
CP.02.03 Explain routine security precautions	2.3.1 Identify the routine measures that ensure overall security in the SSB, including advisor and student responsibilities 2.3.2 Describe activities and tasks that are required by the SSB, school and district that have a positive or negative impact on the SSB

CP.03 Conduct marketing and information management operations

Measures/Benchmarks	Learning Targets
CP.03.01 Understand and apply proper marketing data	3.1.1 Identify the advantages and challenges of data-driven marketing that can impact the SSB 3.1.2 Provide examples of the marketing data collected and of how the information is used for the SSB

Measures/Benchmarks	Learning Targets
CP.03.02 Identify date monitored for marketing decision-making	3.2.1 Identify product decisions, price decisions, place (distribution) decisions and promotion decisions made based on marketing data 3.2.2 Identify decision-making responsibilities and how these decisions have impacted the SSB
CP.03.03 Track trends (e.g. social, buying, social media, advertising agency, etc.)	3.3.1 Provide examples of types of industry trend analysis, the importance of tracking trends in business, and how the SSB monitors trends 3.3.2 Identify the challenges and opportunities of tracking trends in the SSB
CP.03.04 Analyze customer behavior (e.g. media-consumption buying, etc.)	3.4.1 Explain the importance of customer behavior (customer acquisition, customer retention and customer growth) to drive business decisions 3.4.2 Provide examples of student decision-making in analyzing customer behavior and the impact of their decisions on the SSB

CP.04 Develop market plan

Measures/Benchmarks	Learning Targets
CP.04.01 Generate profile of target customer	4.1.1 Create a customer profile that includes demographic and psychographic information describing the SSB's average customer in detail 4.1.2 Identify the average amount of dollars spent by customers and what affects changes in customer decisions 4.1.3 Identify how customer profiles are used to enhance business decisions
CP.04.02 Determine market needs	4.2.1 Conduct market research to determine product purchases and customer service offerings 4.2.2 Provide real examples of how market research impacts decision making for product development and customer approval 4.2.3 Identify responsibilities for tracking sales and customer demand and the impact demand has on business operations 4.2.4 Provide examples where product demand influenced other SSB decisions in product, purchasing or other operational strategies
CP.04.03 Determine customer demand for merchandise	4.3.1 Discuss student responsibilities in tracking sales and customer demand and the impact demand has on business operations 4.3.2 Provide examples where product demand influenced other SSB decisions in product, purchasing or other operational strategies

CP.05 Manage product/service development

Measures/Benchmarks	Learning Targets
CP.05.01 Identify components of a retail image	5.1.1 Develop a detailed description of the SSB retail image from all levels (students, faculty, administration, district, community) 5.1.2 Provide examples how the SSB is viewed as a community-oriented, service-oriented and/or price-oriented business by customers 5.1.3 Identify relevant changes or upgrades in the SSB's image
CP.05.02 Choose vendors	5.2.1 Identify considerations for new vendors, adding new product selections, and requirements and feasibility of keeping current vendors 5.2.2 Identify vendor selection process for selecting new merchandising, changing merchandise offers, etc. and how decisions have impacted the operation of the SSB 5.2.3 Provide specific examples of the vendor selection processes as well as any challenges that have occurred.
CP.05.03 Plan merchandise assortment (e.g., styling, sizes, quantities, colors)	5.3.1 Identify the width, length, depth and consistency of the SSB product line and the brand mix 5.3.2 Explain the process for planning merchandise assortment and how this impacts the SSB operation
CP.05.04 Determine stock turnover	5.4.1 Identify and provide examples of stock turnover for the SSB 5.4.2 Identify decisions that ensure appropriate stock turnover by product lines; include steps determined to avoid over-stocking and/or inadequate inventory levels
CP.05.05 Plan reductions (e.g., anticipated markdowns, employee/other discounts, stock shortages)	5.5.1 Identify responsibilities for merchandise planning include information on potential reductions such as sale items, discounts, and/or markdowns 5.5.2 Create a process for handling challenges with pricing and turnover

CP.06 Determine product/service pricing

Measures/Benchmarks	Learning Targets
CP.06.01 Determine cost of product (breakeven, ROI, markup)	6.1.1 Determined product's prices and explain how prices impact the SSB 6.1.2 Provide pricing decisions for a variety of products and the various cost determinations (breakeven point, ROI and markup)
CP.06.02 Describe pricing strategies	6.2.1 Determine pricing strategies and how they will be implemented in the business 6.2.2 Identify the impact pricing strategies will have on sales including information, as applicable, on seasonal pricing, competition pricing, bundle pricing, psychological pricing, product line pricing, cost plus/cost based/value cost pricing, etc.
CP.06.03 Evaluate pricing decisions	6.3.1 Evaluate pricing decisions for effectiveness 6.3.2 Identify learning outcomes derived from success and/or failure of the pricing plan

CP.07 Manage product/service distribution

Measures/Benchmarks	Learning Targets
CP.07.01 Explain the relationship between customer service and distribution	7.1.1 Identify roles in establishing positive customer relationships. Share specific duties and responsibilities that reach beyond good customer service (greeting and thanking customers). 7.1.2 Explain how the timing of orders, stock rotation and product availability can affected SSB's ability to provide customers with goods and services
CP.07.02 Explain the receiving process	7.2.1 Create a merchandise receiving process 7.2.2 Identify the importance of the process for the SSB
CP.07.03 Complete inventory counts	7.3.1 Develop process for inventory control in SSB, including physical, perpetual or a combination of both 7.3.2 Identify learning outcomes that are met through proper control of receipt and distribution of inventory
CP.07.04 Determine inventory shrinkage	7.4.1 Identify the types of shrinkage the SSB can encountered and steps taken to ensure limited shrinkage 7.4.2 Identify employees' role play in inventory shrinkage control 7.4.3 Identify how inventory shrinkage affects the SSB financial picture.

CP.08 Develop and execute promotional plan

Measures/Benchmarks	Learning Targets
CP.08.01 Plan promotional strategy	8.1.1 Identify the SSB promotional objectives for the school year including information on learning activities and tasks that need to be implemented 8.1.2 Create a promotional budget and how it will be incorporated into the promotional mix
CP.08.02 Explain the use of visual merchandising in retailing	8.2.1 Identify the importance of appropriate visual merchandising 8.2.2 Identify roles in the visual merchandising component of the SSB 8.2.3 Implement a visual merchandising plan
CP.08.03 Use cross-merchandising techniques	8.3.1 Identify the importance of cross-merchandising 8.3.2 Implement cross-merchandising strategies
CP.08.04 Plan special events	8.4.1 Identify the impact of special events on the success of a SSB 8.4.2 Determine any special events that can benefit the SSB
CP.08.05 Measure success of promotional efforts	8.5.1 Evaluate the effectiveness of the SSB's promotional strategy 8.5.2 Identify the learning impact promotional strategy has on the SSB

CP.09 Understand and perform selling tasks

Measures/Benchmarks	Learning Targets
CP.09.01 Determine customer/client needs	9.1.1 Determine and address customer/client needs 9.1.2 Determine how employees engage with customers, particularly indecisive and/or unhappy customers, so that their needs are met
CP.09.02 Establish relationship with customer/client	9.2.1 Determine how employees build customer/client relationships beyond initial greeting and thanking customers 9.2.2 Provide information and examples of establishing an online relationship with customers/clients for virtual SSB
CP.09.03 Demonstrate suggestion selling	9.3.1 Identify how routine suggestive selling techniques can be provided 9.3.2 Identify how negative customers might impact sales and create policies for addressing customer complaints

Measures/Benchmarks	Learning Targets
CP.09.04 Process sales documentation	9.4.1 Identify how tracking of sales impacts SSB 9.4.2 Provide process for the documenting and tracking of sales
CP.09.05 Process returns/exchanges	9.5.1 Identify how a return policy impacts business 9.5.2 Develop SSB return policy

CP.10 Manage human resources

Measures/Benchmarks	Learning Targets
CP.10.01 Explain human resource management function	10.1.1 Develop process for the acquisition and selection of employees 10.1.2 Determine process for training and developing employees 10.1.3 Provide employee motivation to do their job well including self-motivation, SSB competition, sales quotas, appreciation activities, etc. 10.1.4 Determine how the SSB maintains employees 10.1.5 Provide a safe and healthy environment for employees
CP.10.02 Foster positive working environment for employees	10.2.1 Describe the processes in place to ensure a positive working environment for employees 10.2.2 Describe special considerations provided for employees, including special events or incentives to boost morale
CP.10.03 Facilitate employees learning	10.3.1 Develop process to conduct formal and informal employee training including instructor-led training, on the-job training, any job rotation programs or mentoring/coaching by more experienced employees 10.3.2 Identify how the SSB functions as a learning laboratory for students
CP.10.04 Assess employee performance	10.4.1 Explain the various methods used to measure and evaluate employee performance used in the SSB 10.4.2 Describe responsibilities in evaluating employee performance (peer evaluation, self-evaluation) and include learning activities that strengthened overall performance

[Return to the beginning of the document](#)

Appendix – Sources and Resources

Sources Material

Performance Indicators/Standards and Measures/Benchmarks were developed from the following sources:

- American Welding Society (Level 1)
- Advance CTE States' Career Clusters Initiative
- Employment and Training Administration - United States Department of Labor
- International Society for Technology in Education (ISTE)
- Manufacturing Skill Standards Council (MSSC)(Production, Logistics)
- Minnesota Common Core Competencies
- Minnesota Technical Skills Attainment
- National Center for Construction Education and Research (NCCER) (Welding)
- National Institute Metalworking Skills (NIMS) (Machine Level 1)

Online Resources

General Resources

- [Advance CTE](https://careertech.org/) – (https://careertech.org/)
- [Association for Career and Technical Education](http://www.acteonline.org) – (http://www.acteonline.org)
- [Career Fields, Clusters and Pathways](http://www.minnstate.edu/system/cte/consortium_resources/documents/POS_Framework-2017-Final-8x11.pdf) – (http://www.minnstate.edu/system/cte/consortium_resources/documents/POS_Framework-2017-Final-8x11.pdf)
- [American Institutes for Research \(AIR\) College and Career Readiness](https://www.air.org/our-work/education/college-and-career-readiness) – (https://www.air.org/our-work/education/college-and-career-readiness)
- [NOCTI Blueprints](https://www.nocti.org/credentials/blueprints/) – (https://www.nocti.org/credentials/blueprints/)
- [Precision Exams Career Skills Exams](http://www.precisionexams.com/minnesota/exams.html) – (http://www.precisionexams.com/minnesota/exams.html)
- [United States Department of Labor, Bureau of Labor Statistics](http://www.bls.gov/) – (http://www.bls.gov/)
- [United States Small Business Administration \(SBA\)](http://www.sba.gov/) – (http://www.sba.gov/)

Minnesota Career Outreach Organizations

- [Explore the Trades](https://explorethetrades.org/) – (https://explorethetrades.org/)
- [Trades Hub](https://trades-hub.com/) – (https://trades-hub.com/)
- [218 Trades](https://www.218trades.com/) – (https://www.218trades.com/)

Minnesota Department of Education (MDE) Resources

- [Minnesota Department of Education \(MDE\)](https://education.mn.gov/mde/index.html) – (https://education.mn.gov/mde/index.html)
- [Program Approvals - Minnesota Department of Education](https://education.mn.gov/MDE/dse/cte/progApp/) – (https://education.mn.gov/MDE/dse/cte/progApp/)
- [Trade and Industry Resources - Minnesota Department of Education \(MDE\)](https://education.mn.gov/MDE/dse/cte/prog/ind/) – (https://education.mn.gov/MDE/dse/cte/prog/ind/)

Minnesota State Colleges and Universities Resources

- [Articulation/Concurrent Credit Agreements](https://askus.minnstate.edu/app/answers/detail/a_id/855/~articulation-agreements) – (https://askus.minnstate.edu/app/answers/detail/a_id/855/~articulation-agreements)
- [Centers of Excellence](https://www.minnstate.edu/coe/index.html) – (https://www.minnstate.edu/coe/index.html)
- [Advanced Manufacturing](https://mnmfg.org/) – (https://mnmfg.org/)
- [Engineering](https://engineering.mnsu.edu/) – (https://engineering.mnsu.edu/)
- [National Center for Autonomous Technologies \(NCAT\)](https://ncatech.org/) – (https://ncatech.org/)
- [Programs of Study Guide](http://www.minnstate.edu/system/cte/programs/index.html) – (http://www.minnstate.edu/system/cte/programs/index.html)

Minnesota Trade Associations and Organizations

- [Local/Regional Chambers of Commerce](https://www.uschamber.com/co/chambers/minnesota) – (https://www.uschamber.com/co/chambers/minnesota)
- [Midwest Manufacturers Association \(MMA\)](https://www.midwestmanufacturers.com/k-12-info/) – (https://www.midwestmanufacturers.com/k-12-info/)
- [Minnesota Tech Association \(MnTECH\)](https://mntech.org/) – (https://mntech.org/)

National Trade Associations or Accrediting Organizations

- [American Welding Society \(AWS\)](https://www.aws.org/home) – (https://www.aws.org/home)
- [Manufacturing Skill Standards Council \(MSSC\)](https://www.msscusa.org/) – (https://www.msscusa.org/)
- [National Institute Metalworking Skills \(NIMS\)](https://www.nims-skills.org/) – (https://www.nims-skills.org/)
- [Smart Automation Certification Alliance \(SACA\)](https://www.saca.org/) – (https://www.saca.org/)

Other State Agency Resources

- [Data Center for labor market statistics - Minnesota Department of Employment and Economic Development \(DEED\)](https://mn.gov/deed/data/) – (https://mn.gov/deed/data/)
- [Education Information - Minnesota Department of Transportation \(MnDOT\)](https://www.dot.state.mn.us/aero/aviationeducation/index.html) – (https://www.dot.state.mn.us/aero/aviationeducation/index.html)
- [Minnesota Service Cooperatives](https://www.mnservcoop.org/) – (https://www.mnservcoop.org/)
- [Workforce Strategy Consultants - Minnesota Department of Employment and Economic Development \(DEED\)](https://mn.gov/deed/business/help/workforce-assistance/wf-strategy.jsp) – (https://mn.gov/deed/business/help/workforce-assistance/wf-strategy.jsp)

Minnesota and National Teacher Associations

- [International Technology and Engineering Education Association \(ITEEA\)](https://www.iteea.org/) – (https://www.iteea.org/)
- [Minnesota Technology and Engineering Education Association \(MTEEA\)](https://www.mteea.net/index.php/resources) – (https://www.mteea.net/index.php/resources)

Advisory Committee/Industry Engagement Resources

- [Career Program Advisory Committee Handbook](https://www.minnstate.edu/system/cte/consortium_resources/documents/Minnesota-State-Career-Advisory-Handbook-June-2020-web.pdf) – (https://www.minnstate.edu/system/cte/consortium_resources/documents/Minnesota-State-Career-Advisory-Handbook-June-2020-web.pdf)
- [ACTE Employer Engagement Strategies](https://www.acteonline.org/professional-development/high-quality-cte-tools/business-and-community-partnerships/) – (https://www.acteonline.org/professional-development/high-quality-cte-tools/business-and-community-partnerships/)
- [Employer Engagement Toolkit](https://www.jff.org/resources/employer-engagement-toolkit-placement-partners/) – (https://www.jff.org/resources/employer-engagement-toolkit-placement-partners/)
- [Tools for Building Employer-Educator Partnerships](https://lincs.ed.gov/employers/) – (https://lincs.ed.gov/employers/)
- [National Career Pathways Advisory Committee Toolkit](https://www.ncpn.info/wp-content/uploads/2021/11/cp_adv_cmte_toolkit.pdf) – (https://www.ncpn.info/wp-content/uploads/2021/11/cp_adv_cmte_toolkit.pdf)
- [10 Tips for Building Great Partnerships](https://www.communityworkshopllc.com/goodstuff/10-tips-partnerships) – (https://www.communityworkshopllc.com/goodstuff/10-tips-partnerships)

Student Leadership Organizations and Opportunities

- [SkillsUSA MN](http://www.mnskillsusa.org/) – (http://www.mnskillsusa.org/)
- [FIRST Upper Midwest](https://firstuppermidwest.org/) – (https://firstuppermidwest.org/)
- [High Tech Kids](https://hightechkids.org/) – (https://hightechkids.org/)
- [VEX Minnesota](https://vexmn.com/) – (https://vexmn.com/)
- [Real World Challenge](http://www.realworlddesignchallenge.org/) – (http://www.realworlddesignchallenge.org/)
- [SuperMileage Challenge](https://www.mteea.net/index.php/competitions/supermileage) – (https://www.mteea.net/index.php/competitions/supermileage)
- [Solar Boat Regatta](https://www.mnrenewables.org/solar-boat-regatta/) – (https://www.mnrenewables.org/solar-boat-regatta/)

Work Based Learning Resources

- [CTE Work Based Learning – Minnesota Department of Education](https://education.mn.gov/MDE/dse/cte/prog/wbl/) – (https://education.mn.gov/MDE/dse/cte/prog/wbl/)

Curriculum options available for Work-Based Learning career seminar courses:

- [College preparation](https://www.ohe.state.mn.us/) – (https://www.ohe.state.mn.us/)
- [College and career readiness curriculum](https://www.rampuptoreadiness.org/curriculum/) – (https://www.rampuptoreadiness.org/curriculum/)
- [College Preparation](http://knowhow2go.acenet.edu/) – (http://knowhow2go.acenet.edu/)
- [Ready, Set, Go](http://readyssetgo.state.mn.us/RSG/index.html) – (http://readyssetgo.state.mn.us/RSG/index.html)
- [YouthRules!](https://www.youthrules.gov) – (information on workplace rules and safety in work experiences for teens) (https://www.youthrules.gov)
- [Employer Engagement Toolkit](http://www.advancingcredentials.org/toolkit/) – (http://www.advancingcredentials.org/toolkit/)

[Return to the beginning of the document](#)