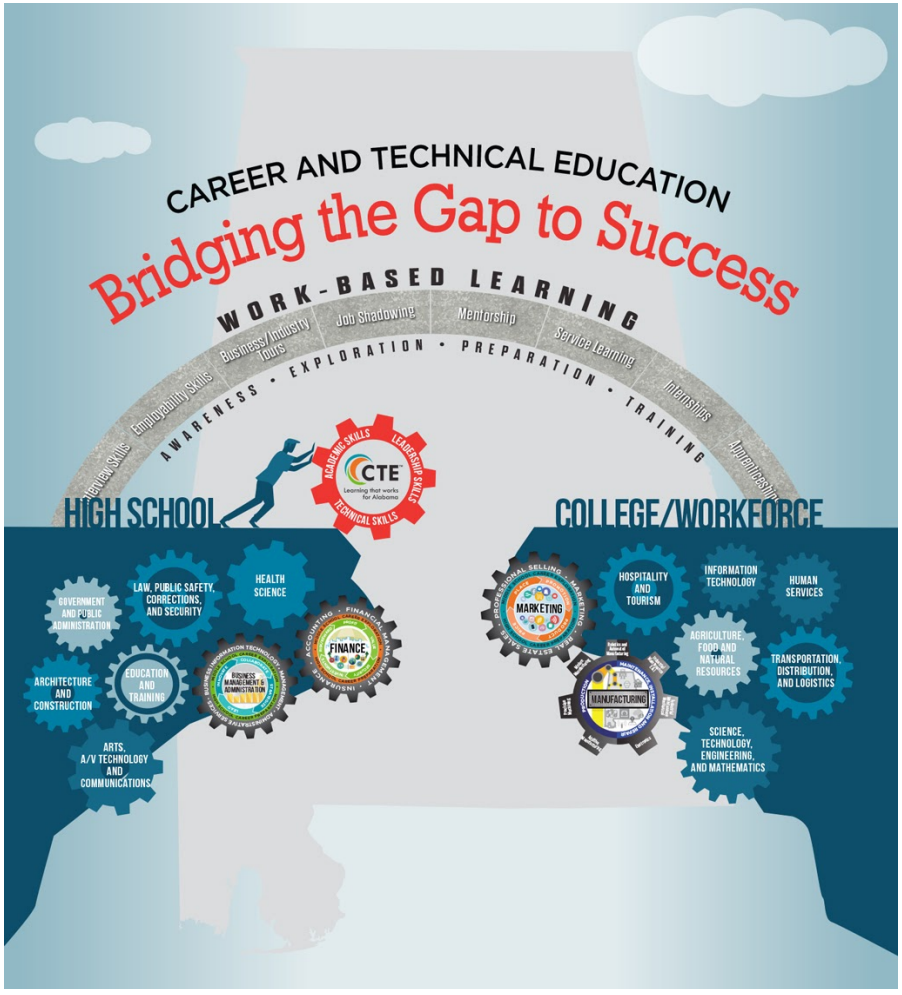
Alabama Course of Study
Career and Technical Education



2021
Eric G. Mackey, State Superintendent of Education
Alabama State Department of Education

For information regarding the
Alabama Course of Study: Career and Technical Education
and other materials, contact:

Alabama State Department of Education
Instructional Services Section
3345 Gordon Persons Building
Montgomery, Alabama

P.O. Box 302101
Montgomery, AL 36130-2101

(334) 694-4768

©2021
Alabama State Department of Education
Eric G. Mackey, State Superintendent of Education

The Alabama State Board of Education and the Alabama State Department of Education do not discriminate on the basis of race, color, disability, sex, religion, national origin, or age in their programs, activities, or employment and provide equal access to the Boy Scouts and other designated youth groups. The following person is responsible for handling inquiries regarding the non-discrimination policies: Title IX Coordinator, Alabama State Department of Education, P.O. Box 302101, Montgomery, AL 36130-2101, telephone (334) 694-4717.

Alabama Course of Study
Manufacturing

Eric G. Mackey
State Superintendent of Education

STATE SUPERINTENDENT OF EDUCATION'S MESSAGE

Dear Alabama Educator:

The Manufacturing cluster of Career and Technical Education contains two diverse career pathways: *Production* and *Maintenance, Installation and Repair*. Within the Production pathway are programs in Additive Manufacturing, Modern Manufacturing, and Precision Machining. Programs in the Maintenance, Installation, and Repair pathway are Industrial Maintenance Electrical & Instrumentation, Industrial Maintenance Mechanical, and Electronics. Robotics and Automated Manufacturing cross over into both pathways.

The 2021 *Alabama Course of Study: Career and Technical Education, Manufacturing* presents standards designed to prepare students for the career and technical demands of the future, both in the workplace and in postsecondary educational settings. This document contains a set of challenging standards designed to promote students' engagement and interest in manufacturing fields. I encourage each system to use the document in developing local curriculum guides that determine how its students will achieve and exceed these standards.

The 2021 *Alabama Course of Study: Career and Technical Education, Manufacturing* was developed by educators and business and community leaders to provide a foundation for building quality manufacturing programs across the state. Implementing its content through appropriate instruction will promote students' exploration and engagement in manufacturing content and enhance preparation for manufacturing career fields.

Eric G. Mackey
State Superintendent of Education

MEMBERS of the ALABAMA STATE BOARD OF EDUCATION

Governor Kay Ivey
President of the State Board of Education

District

I. **Jackie Zeigler**
Vice President

II. **Tracie West**

III. **Stephanie Bell**

IV. **Yvette Richardson, EdD**
President Pro Tem

V. **Tonya S. Chestnut, EdD**

VI. **Cynthia McCarty, PhD**

VII. **Belinda McRae**

VIII. **Wayne Reynolds, EdD**

State Superintendent
Eric G. Mackey
Secretary and Executive Officer

Alabama Course of Study
Manufacturing
Table of Contents

Alabama Course of Study: Manufacturing

PREFACE

The 2021 *Alabama Course of Study: Career and Technical Education, Manufacturing* provides the framework for Grades 8-12 programs within the Manufacturing cluster in Alabama's public schools. Content standards in this document are minimum and required (Code of Alabama, 1975, §16-35-4). They are fundamental and specific, but not exhaustive. When developing local curriculum, school systems may include additional content standards to reflect local needs and philosophies and may add implementation guidelines, resources, and activities.

In developing the minimum required content for Manufacturing instruction, the 2020-2021 Career and Technical Education Course of Study Committee and Task Force made extensive use of previous Alabama Career and Technical Courses of Study, as well as national standards documents and certification standards.

In addition, Committee and Task Force members reviewed information found in professional journals, on Internet sites, and in similar documents from other states. The Committee and Task Force attended state and national conferences, considered suggestions from independent reviewers and the general public, and sought input from advisory councils. A consensus was reached, leading to the development of what members believe to be the best Manufacturing Course of Study for students in Alabama's public schools.

Alabama Course of Study: Manufacturing
ACKNOWLEDGMENTS

This document was developed by the Manufacturing Committee and Task Force of the 2020-2021 Alabama Career and Technical Education Course of Study Committee and Task Force, composed of high school, and college educators appointed by the Alabama State Board of Education and business and professional persons appointed by the Governor (*Code of Alabama*, 1975, §16-35-1). The Committee and Task Force began work in February of 2020 and submitted the document to the Alabama State Board of Education for adoption at the March 2021 meeting.

Manufacturing Course of Study Committee and Task Force

Chair: Ann West, MS, Superintendent, Marion County Schools

Elisa G. Harris, EdS, Advanced Manufacturing Instructor, Hartselle High School, Hartselle City Schools

James A. Hill, MEd, Robotics and Automated Manufacturing Instructor, Career and Technical Education Center, Shelby County Schools

Jason Blackwell, MS, Industrial Maintenance and E&I Instructor, Escambia Career Readiness Center, Escambia County Schools

Lensey C. King, Jr., MEd, Industrial Maintenance E&I Instructor, Pinson Valley High School, Jefferson County Schools

Don Wilcher, MS, Director of Manufacturing and Technology, Jefferson State Community College

State Department of Education personnel who managed the development process were:

Eric G. Mackey, EdD, State Superintendent of Education
Daniel Boyd, PhD, Deputy State Superintendent
Elisabeth Davis, EdD, Assistant State Superintendent, Office of Student Learning
Jimmy Hull, EdD, Assistant State Superintendent, Career and Technical Education
Sean J. Stevens, MEd, Program Coordinator, Instructional Services

Cathy Jones, MS, Executive Secretary, State Courses of Study Committees, Instructional Services
Craig Collins, Education Administrator, Career and Technical Education
Dawn Morrison, Education Administrator, Career and Technical Education
Jennifer Burt, Education Administrator, Career and Technical Education
Andy Chamness, Education Administrator, Career and Technical Education
Demekia Maddox, Administrative Assistant, Instructional Services
Catherine Wilbourne, MEd, Editor, Courses of Study.
Carol Sprayberry, MEd, NBCT, Consultant, Courses of Study

The State Department of Education specialists who assisted the Task Force in developing the document were:

Lisa Bruce, MEd, Education Specialist, Career and Technical Education, Manufacturing and Cosmetology
Hailey Ridgeway, MA, Education Specialist, Educational Technology
Susan Goldthwaite, MS, Education Administrator, Special Education Services
Pamela Ivey, MS, Education Specialist, Special Education Services
Charles V. Creel, Graphic Arts Specialist, Communications

Alabama Course of Study: Manufacturing
GENERAL INTRODUCTION

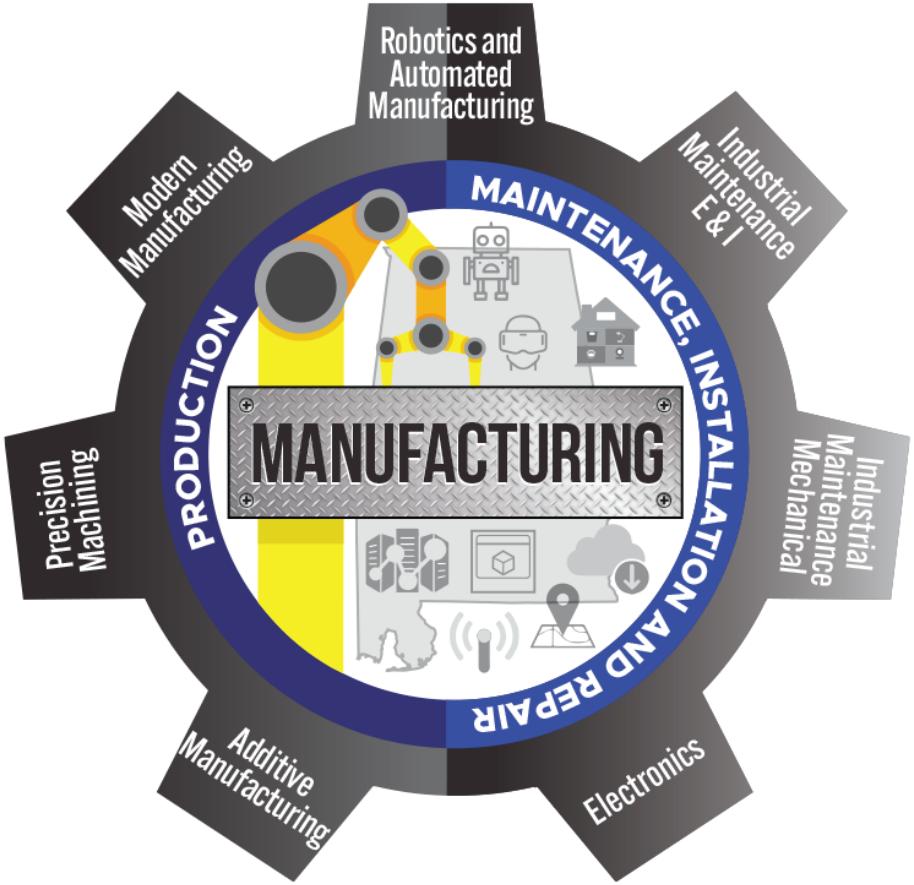
Alabama's Career and Technical Education programs empower students with the workplace-readiness skills necessary for success in the twenty-first century. As a result, students are productive citizens who are prepared with the necessary knowledge and skills for postsecondary education and employment. Career and Technical Education provides opportunities for students to combine core academic content with rigorous and relevant technical knowledge and skills.

The *Alabama Course of Study: Career and Technical Education* is intended for all students in Grades 6-12. Alabama's Career and Technical Education programs promote students' career awareness through engaging career exploration and development activities. Career and Technical Education programs focus on providing students with the knowledge and skills that reinforce attainment of academic core content through hands-on experiential learning. These programs are organized into the sixteen national career clusters identified by the United States Department of Education, which arrange instruction into groups of similar occupations. Within the national career clusters, separate course content standards have been developed for more than fifty career pathways.

Alabama's Career and Technical Education programs are designed to keep abreast of the rapid changes in business and industry and be responsive to current and future workforce demands. Rigor in each course of study is derived from core academic content and industry-specific knowledge and skills required for students to achieve, maintain, and advance in employment in a particular career pathway. The level of academic and workplace rigor determines the degree to which each Alabama Career and Technical Education program prepares students for high-skill, high-wage, and in-demand careers. For each Career and Technical Education program, industry-recognized credentials of value and certifications have been established that validate the rigor of the curriculum to students, parents, and members of business and industry. In addition, articulation agreements are developed in partnership with the Alabama Community College System to allow for a seamless transition for students to further their education.

Alabama's growing economy has created the demand for more highly-skilled workers. Alabama's Career and Technical Education programs, through the implementation of each career cluster's course of study, equip students with the employability skills and technical knowledge necessary to meet current and future workforce demands by preparing them for lifelong learning.

Alabama Course of Study: Manufacturing
CONCEPTUAL FRAMEWORK



Alabama Course of Study: Manufacturing

CONCEPTUAL FRAMEWORK

The conceptual framework pictured on the previous page is a graphic representation of the essential and highly technical field of manufacturing.

Listed in a blue band encircling the center of the gear are the two pathways of this cluster: *Production* and *Maintenance, Installation, and Repair.* Within the Production pathway are programs in Additive Manufacturing, Modern Manufacturing, and Precision Machining. Programs in the Maintenance, Installation, and Repair pathway are Industrial Maintenance Electrical & Instrumentation, Industrial Maintenance Mechanical, and Electronics. The Robotics and Automated Manufacturing program crosses over into both pathways, symbolized by its location where the pathways intersect in the blue band. Each program is aligned with one of the teeth of the gear, which allows it to interlock with other gears in the Career and Technical Education system and symbolizes the close relationship between Manufacturing and other technical fields.

The pictures in the center represent Industry 4.0, which encompasses data-enabling technologies like robotics, virtual reality, cloud computing, data analytics, 3D modeling, and wireless communications. Industry 4.0 is the growing trend toward automation and data exchange in technology and processes within the manufacturing industry, including the Internet of things, cyber-physical systems, smart factories, cloud computing, and artificial intelligence. The diversity of these technological resources is an important source of the state's economic development and industrial growth in manufacturing.

Modern manufacturing is the lifeblood of Alabama's industrial base. The Manufacturing Course of Study provides Alabama's students with the skills and knowledge they need to produce the goods and services that are essential for the economic growth of our state and nation.

POSITION STATEMENTS

MANUFACTURING

The Manufacturing cluster of Career and Technical Education focuses on preparing students for the highly technical world of modern manufacturing. Certain fundamental understandings which undergird the Manufacturing cluster must be embraced by schools and school districts in order to provide students with the best possible experiences in the classroom and in the field. These position statements summarize the requirements for an effective Manufacturing cluster.

Classroom and Laboratory Environment

The effective Manufacturing classroom and laboratory should be safe environments, fully equipped with current and emerging technologies, supplies, and materials needed for instruction, where students can increase their skills. As in other clusters in Career and Technical Education, Manufacturing instruction cannot be confined within the four walls of a traditional classroom. Students and teachers should have access to laboratory environments on campus and in the community where students can experience practical, real-world circumstances.

Technology, Equipment, and Facilities

Classroom technology must be readily available, efficiently maintained, and routinely upgraded according to a regular schedule. Students and teachers utilize equipment to conduct a variety of classroom instruction and learning activities. Using up-to-date technology enhances the learning environment and prepares students for future career opportunities. In addition, students should have ready access to other classroom supplies and materials (such as textbooks, reference materials, and software) in classroom libraries, research areas, and materials centers to support instruction and credentialing. Sufficient funds must be allocated to provide and maintain the technology and materials necessary for a superior Career and Technical Education program.

Safety

The safety of students and instructors is a prime consideration in every learning environment, and it is absolutely essential in manufacturing work-places. Creating and implementing a written safety plan is a critical part of designing, carrying out, and evaluating each Career and Technical

Education program. An effective plan may include federal, state, local, school, and program guidelines. Care must be taken to ensure that students are in safe environments both on and off campus. Students are required to pass safety tests with one hundred percent accuracy. Safety includes not only physical and emotional well-being but also digital and online security.

Professional Development

Because both technology and instructional methods continue to evolve, it is essential for teachers to participate in professional development and technical training opportunities to stay abreast of innovations in their content area and the workplaces in which their students will be employed. Teachers who continually expand their pedagogical knowledge and skills are able to adjust the learning environment to reflect current and emerging trends in teaching methods and to address their students' varied learning styles. Regular program assessment by students, administrators, business and industry personnel, and the educators themselves guides professional development, which in turn enhances the instructional program.

Administrative Support

Full support from district and local administrators is essential in providing the necessary components of programs within the Manufacturing cluster. Administrators should recruit highly qualified teachers who possess appropriate credentials and secure funding for professional development activities and industry certification for those teachers. Administrators must also provide time for professional development and for planning for the integration of academic content areas into the Manufacturing cluster. Administrators should actively promote programs in the Manufacturing cluster within the school and in the community.

Instructional Model

The Manufacturing Course of Study is designed to address the challenges of a changing, technological, diverse, and global society in which students must apply knowledge, skills, and ideas to solve problems and make decisions. The curriculum for programs within the Manufacturing cluster designed by each local education agency should be project-based, process-oriented, and work-based so that students can develop their abilities to collaborate, analyze, communicate, manage, and lead.

The content standards contained in this document require students to use innovative, critical-thinking skills. Teachers should utilize the Manufacturing Course of Study to identify the issue or concern addressed in a specific content standard and then use the local curriculum guide to plan appropriate learning experiences. Teachers must understand that there are differences among standards, curriculum, and resources. The Manufacturing Content Standards delineate what students are expected to know or be able to do at the end of each course. A curriculum is a

sequence of tasks, activities, and assessments that teachers enact to support students in learning the standards while drawing on a textbook or other resources when appropriate.

Academic content should be integrated into the Manufacturing cluster. To achieve the solution to a given problem, students must possess an adequate foundation in reading, writing, speaking, listening, viewing, and presenting; knowledge and skills in mathematics, science, and social studies; and knowledge of current and emerging technologies.

The Manufacturing cluster should also integrate workplace demands and employability skills, incorporating various instructional strategies to accommodate students' learning styles and interests. A variety of assessments should be used to evaluate individual students' interests, aptitudes, and abilities.

When individual needs have been determined for students in special populations, a support service program should be planned cooperatively by Manufacturing instructors and other appropriate personnel, because Individual Education Programs are most effective when developed in conjunction with students' career and technical education instructors. Courses and equipment may be tailored to ensure equal access to the full range of learning experiences and skill development in the Manufacturing cluster.

Career and Technical Student Organizations (CTSOs)

Nationally affiliated Career and Technical Student Organizations such as SkillsUSA are an integral part of classroom instruction in each Career and Technical Education program. CTSOs make a positive difference in the lives of students by developing their potential for leadership, personal growth, and career success. The focus of these organizations is to help students develop an understanding of all aspects of industry and technology while learning teamwork and leadership skills. The importance of CTSOs is indicated by their inclusion in the foundational standards to be taught in every course in the Manufacturing cluster.

Business-Industry-School Relationships

Successful programs within the Manufacturing cluster require a close relationship between the school and the industries in its community. Some aspects of this relationship are specified by state and federal laws and regulations, while others are determined by the desires, interests, and willingness of school personnel and business leaders in the local community. The relationship between schools and businesses can be very beneficial to all parties involved.

Certification

Maintaining relationships with local businesses and industries is vital to the certification process as well as to federal funding through the Carl D. Perkins legislation. Certain elements of program certification require local industries to participate in the Career and Technical Education program's adoption of industry standards. Representatives from local businesses and industries interact with school programs to address the ever-changing needs of the competitive global economy. Through this interaction, the program is reviewed to ensure that needs are being met through lesson plans, instructional techniques, facilities, professional development, technical updates, equipment, and implementation of CTSOs.

Student Work Experience

As students begin to plan careers, they must have opportunities to visit, tour, and work at local industries and businesses. Real-world experiences such as cooperative education, internships, apprenticeships, and job shadowing contribute to the work-based, service-based, and project-based learning that enhances classroom instruction. An additional benefit comes from continuous feedback from students and supervisors, who evaluate the program to facilitate changes that satisfy industry needs.

Advisory Councils and Partnerships

In accordance with Alabama State Department of Education guidelines, each Career and Technical Education program has an advisory council made up of business and industry personnel who provide professional, real-world input regarding equipment needs, curriculum emphases, technical updates, and problem-solving. This link to business and industry may also provide external support by supplying equipment, resource materials, or qualified speakers. Community partners may provide program sponsors, judges for student career development events, financial support, scholarships, field trip sites, and other program needs.

Community Involvement and Service

There are many ways for students and teachers in programs within the Manufacturing cluster to become involved with community service projects, providing benefits for students and their communities. Local organizations such as civic clubs, professional educational groups, youth organizations, and community adult education programs are valuable resources for programs within the Manufacturing cluster. Open houses, tours, and presentations allow families and other interested citizens to become more informed about Manufacturing programs and more involved in the education environment.

Postsecondary and Higher Education Credit

Postsecondary and higher education articulation is a significant element in a student's career cluster. Secondary and postsecondary instructors must communicate on a regular basis to ensure a smooth transition for students and to ensure students are aware of articulation opportunities. Articulation may occur through program alignment with postsecondary programs, early college enrollment, or dual enrollment programs.

Students benefit in a variety of ways when cooperation exists between secondary and postsecondary institutions. One of the benefits is the earning of postsecondary credit in conjunction with work completed while the student is still in secondary school. Postsecondary teachers offer additional benefits by serving as guest speakers, donating equipment, sharing expertise through professional development activities, and addressing other needs appropriate for the school community.

Dual Enrollment for Dual Credit is an enrichment opportunity allowing eligible high school students to earn high school and college credits for courses taken through an Alabama Community College System (ACCS) institution or an Alabama college or university while still enrolled in high school. Articulated credit is awarded when a student enrolls and satisfactorily completes work in a postsecondary institution that has an articulation agreement with that student's participating school.

Directions for Interpreting Standards

The 2021 *Alabama Course of Study: Manufacturing* is organized around the following elements: foundational standards, topics, and content standards.

Foundational standards are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership and take advantage of the opportunities afforded by Career and Technical Student Organizations, and learn and practice essential digital skills.

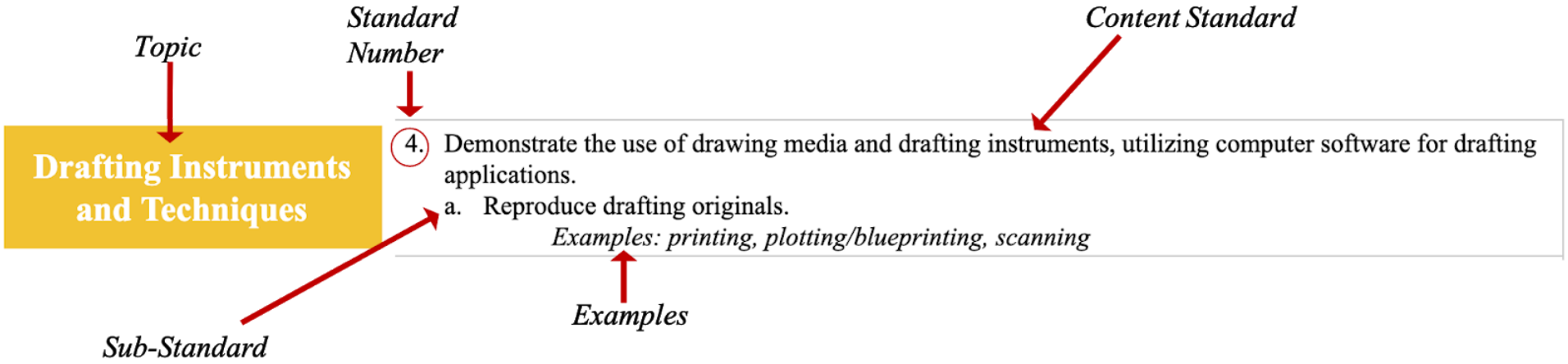
Related content standards are grouped under **Topics**. In the example below, the topic is "Drafting Instruments and Techniques." Standards from different topics may be closely related.

Content Standards contain the minimum required content and define what students should know or be able to do at the conclusion of a course. Some have **sub-standards**, indicated with a, b, c..., which are extensions of the content standards and are also required. Some standards are followed

by italicized **examples**, which represent options that might prove useful in instruction of the standard. Examples are not intended to be exhaustive lists and are not required to be taught. When "including" appears in standards, it should be construed as "including but not limited to." The items listed must be taught; others may also be included in instruction.

Local education agencies (LEAs) may add standards to meet local needs and incorporate local resources. Each content standard completes the stem *"Students will..."*

The course of study does not dictate curriculum, teaching methods, or sequence; the order in which standards are listed within a course is not intended to convey the order for instruction. Even though one topic may be listed before another, the first topic does not have to be taught before the second. A teacher may choose to teach the second topic before the first, to teach both at the same time to highlight connection, or to select a different topic that leads to students reaching the standards for both topics. Each local education agency should create its own curriculum and pacing guide based on the Course of Study.



CLUSTER OVERVIEW

MANUFACTURING

In the Manufacturing cluster, students select one of the seven programs – Additive Manufacturing, Modern Manufacturing, Electronics, Industrial Maintenance Electrical and Instrumentation, Industrial Maintenance Mechanical, Precision Machining, or Robotics and Automated Manufacturing. Students choose courses leading through specific programs. Four courses are included in every program: Safety and Health Regulations and Introduction to Manufacturing, which are entry-level courses; and CTE Lab in Manufacturing and Career Pathway Project in Manufacturing, which are higher-level courses available to students who have completed two full-credit courses.

Sequential courses require students to complete prerequisites in a particular order. Prerequisites are noted in the title chart at the beginning of a course. Most numbered courses, such as Industrial Maintenance Mechanical I, II, and III, are sequential. However, the Manufacturing I, II, III, and IV courses in Modern Manufacturing are an exception -- they are not sequential and can be taken in any order.

Hands-on training is especially important for programs within the Manufacturing cluster. Students gain knowledge and skills through an active, structured, and stimulating classroom environment which is augmented by actual and simulated workplace learning experiences, including on-site visits and job shadowing. Classrooms and laboratories of programs within the Manufacturing cluster provide safe and appropriate settings where students can learn and practice their skills. Also, students can be assessed in meaningful ways in these simulated workplace settings.

Students in programs within the Manufacturing cluster affiliate with SkillsUSA, a career and technical student organization (CTSO). This organization enhances classroom instruction while helping students develop leadership abilities, expand workplace-readiness skills, and take advantage of opportunities for personal and professional growth.

Students in Grade 8-12 possess varying learning styles and levels of maturity. Their backgrounds include diverse family structures and varying social and emotional environments. Throughout these grades, students are adjusting to personal, physical, and emotional changes as well as to social changes taking place in the world around them while they tackle challenging academic requirements and opportunities. Courses in programs within the Manufacturing cluster provide options for them to consider as they determine their academic and professional pathways; the courses also teach skills and competencies which will serve students well as they progress from educational settings to careers.

Course of Study standards represent the minimum required content and are not intended to be the course curriculum. Local education agencies and local schools should use these standards to create a curriculum that utilizes available resources to meet the specific needs and interests of the local community. Teachers are encouraged to adapt and utilize appropriate SkillsUSA resources that provide leadership development in all courses. All Career and Technical Education courses emphasize application of knowledge and skills to solve practical problems.

Safety and Health Regulations

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Safety and Health Regulations is designed to provide students with information on the importance of government and industry regulations as well as individual responsibilities for performing activities safely. Students identify common safety hazards found in the workplace and examine their own roles in minimizing and avoiding unsafe practices. Specific topics include flammable and combustible liquids, emergency egress and fire protection, electrical safety, environmental control, machine guarding, tool safety, first aid, hazard communication, personal protective equipment, walking and working surfaces, and material handling and storage. This entry-level course may be taken in any program within the Manufacturing cluster.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

SAFETY AND HEALTH REGULATIONS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Explain the importance of both Occupational Safety and Health Administration (OSHA) industry regulations and individual responsibility for workplace safety and health practices. 2. Examine job-related, high-hazard-area risk assessment techniques. a. Gather and present information on the impact of accidents on industry. b. Utilize job safety analysis worksheets. 3. Summarize federal and state child labor laws regarding hours and locations where youth may work, including required permits.
OSHA	4. Explain worker rights according to OSHA safety and health standards.
Flammable and Combustible Liquids	5. Describe characteristics of flammable and combustible liquids, including flash point, flammable limits, boiling point, vapor density, vapor pressure, ignition temperature, and specific gravity. 6. Demonstrate proper procedures for storing and handling flammable and combustible liquids.
Workplace Fire Safety	7. Differentiate among types of fires and indicate which class of extinguisher should be used for each type. 8. Describe proper use of fire extinguishers.
Fire Protection	9. Develop an emergency plan, including the recognition of fire emergencies, means of egress, exit routes and exits, and special instructions for confined spaces.
Electrical	10. Demonstrate procedures of assured equipment grounding programs. *Examples: continuity test, terminal connection test*

General Environmental Control	11. Interpret safety color codes for marking physical hazards and explain general environmental controls and specifications for accident prevention signs and tags.
Machine Guarding	12. Explain general machine guarding requirements for industrial and construction equipment and operations.
Hand and Power Tools	13. Explain and perform safety procedures for handling, operating, and maintaining tools and machinery, including utilizing materials and protective equipment, maintaining a safe work area, and handling hazardous materials.
Introduction to Industrial Hygiene and First Aid	14. Summarize industrial and construction health and first aid procedures, including personal protection from body fluids; skin, rash, or dermatitis incidents; and oil, gas, and chemical spills. a. Describe the purpose and function of a poison control center, and explain how and when one should be contacted.
Hazard Communication	15. Explain the importance of hazard communication methods used on a job site, including signs, signals, barricades, markers, lockouts, and tags. 16. Interpret information on Material Safety Data Sheets. a. Correlate MSDS information to procedures for handling materials and to personal protective equipment needed when handling hazardous materials.
Personal Protective Equipment	17. Gather and present information on the use of personal protective equipment, including respirators and eye, face, and foot protection, and the circumstances in which equipment should be employed.
Walking and Working Surfaces	18. Explain site-specific protection procedures and safety requirements regarding housekeeping, use of ladders and scaffolding, rigging procedures, and hazardous wall or floor openings.
Material Handling and Storage	19. Demonstrate safe practices for manual lifting, load lifting, and rigging procedures.

Introduction to Manufacturing

Course Credit	1.0
Grade Levels	9-12 **Note:** This course may be offered to 8th grade students as an exploratory, non-credit-bearing option. Standards under the topics Foundational Standards, Safety, Drafting Design, Blueprint Reading, and General Standards are required to be taught in an 8th grade course.
Prerequisites	

Introduction to Manufacturing focuses on the fundamental knowledge and skills needed in the manufacturing industry. Emphasis is placed on job safety, use of manufacturing materials, primary manufacturing processes, secondary manufacturing processes, and manufacturing systems. Upon successful completion of this course, students perform basic tasks related to the manufacturing industry. This entry-level course may be taken in any program within the Manufacturing cluster.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway.

	5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTRODUCTION TO MANUFACTURING CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Apply safety rules, regulations, and procedures related to manufacturing. *Example: plant floor, interpretation of Safety Data Sheets (SDS), Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) rules and regulations*
Manufacturing Materials	2. Identify types of manufacturing materials, including metallic, polymeric, ceramic, and composites. 3. Assess properties of manufacturing materials, including physical, mechanical, chemical, thermal, academic, electrical and magnetic, acoustical, and optical.
Primary Manufacturing Processes	4. Differentiate among thermal, mechanical, and chemical changes in manufacturing materials.
Secondary Manufacturing Processes	5. Demonstrate casting and molding processes, including mold preparation and pouring or forcing liquids. 6. Demonstrate die forming and roll forming of materials. 7. Explain separating processes for cutting and shearing material. 8. Explain processes for thermal conditioning, mechanical force, and chemical action. 9. Demonstrate temporary, permanent, two-part, and multiple-part assembling processes. 10. Demonstrate finishing processes, including processes for product protection and appearance.

Manufacturing Systems	11. Compare custom, intermittent, and continuous manufacturing systems. 12. Describe ways to make improvements in manufacturing processes, including value adding, non-value adding, control systems, and factors to control.
Drafting Design	13. Explain the importance of drafting design in today's technological workforce. 14. Demonstrate the safe use of drafting design tools following established procedures and regulations. 15. Demonstrate mathematics skills related to drafting design, including basic fractions, scale reading, and conversion between customary and metric measurements.
Blueprint Reading	16. Relate information on blueprints to actual locations on the print, including terms, components, and symbols. 17. Construct basic multiview, two-dimensional drawings, including visualizing principal views, creating third-angle projections, selecting proper drawing scale, and organizing layout of primary views.
General	18. Interpret technical information related to the manufacturing process. 19. Demonstrate financial management, budgeting, and investing as they relate to career goals and objectives in manufacturing industries. 20. Describe the use of slings, common rigging hardware, basic hitch configuration, proper connections, and basic load-handling safety practices. 21. Demonstrate correct use of hand tools and power tools utilized in the manufacturing industries.

CTE Lab in Manufacturing

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Successful completion of two or more full-credit courses in the Manufacturing career cluster

CTE Lab in Manufacturing is designed to enhance the student's general understanding and mastery of the cluster. This course is designed as a learning laboratory to support students' individual interests and goals. This laboratory may take place in a traditional classroom, in an industry setting, or in a virtual learning environment. This course may be taken in any program within the Manufacturing cluster.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**…"*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

CTE LAB IN MANUFACTURING
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Occupational Expertise	1. Demonstrate expertise in a specific occupation within the Manufacturing cluster. a. Meet benchmarks selected by the instructor from the appropriate curriculum frameworks, based upon the individual student's assessed needs.
Research and Investigation	2. Conduct investigative research on a selected topic related to manufacturing using approved research methodology; interpret findings; and prepare a presentation to defend results. a. Select an investigative study referencing prior research and knowledge. b. Collect, organize, and analyze data accurately and precisely. c. Design procedures to test the research. d. Report, display, and defend the results of investigations to audiences that may include professionals and technical experts. 3. Demonstrate higher order critical thinking and reasoning skills appropriate for a career in manufacturing. a. Use mathematical and/or scientific skills to solve problems encountered in the chosen occupation. b. Locate, evaluate, and interpret information related to the chosen occupation, in both oral and written formats. c. Analyze and apply data and/or measurements to solve problems and interpret documents.
Professional Skills	4. Apply enhanced leadership and professional skills needed in a career in manufacturing. a. Develop and present a professional presentation offering potential solutions to a current issue. b. Practice leadership and career skills in job placement, job shadowing, entrepreneurship, or internship, or by obtaining an industry-recognized credential of value. c. Participate in leadership development opportunities available through SkillsUSA and/or professional organizations in the manufacturing field. d. Demonstrate written and oral communication skills through presentations, public speaking, live or virtual interviews, and/or an employment portfolio.

Career Pathway Project in Manufacturing

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Successful completion of two or more full-credit courses in the Manufacturing career cluster

Career Pathway Project (CPP) in Manufacturing is a capstone course designed for career and technical education students who have completed two or more courses in the Manufacturing career cluster. This course allows students to utilize their secondary coursework through an experience that showcases their learning. It provides an opportunity for a student to choose an area of interest and engage in an in-depth exploration of the area while demonstrating problem-solving, decision-making, and independent-learning skills. The CPP contributes to an educational plan of challenging courses and practical experiences that prepares students for the workplace or for pursuing further education. This course may be taken in any program within the Manufacturing cluster.

During the CPP, the student works with his or her coordinating teacher, academic teachers, and a product or process mentor who has expertise in the student's field of study. At the conclusion of the CPP, the student presents or demonstrates knowledge gained to an audience consisting of the coordinating teacher, academic teachers, the mentor, peers, and community and business representatives.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork.

	3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

CAREER PATHWAY PROJECT IN MANUFACTURING CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Project Proposal	1. Create a formal, narrative proposal that communicates a specific concept, creates a process, or develops a product related to manufacturing.
Research	2. Conduct independent research related to the selected manufacturing project. *Example: Internet research, related readings, original research*
Project Report	3. Write a detailed report on the chosen career pathway project, following established conventions for format, grammar, and usage.
Presentation	4. Produce an original multimedia presentation that communicates project results to an audience. *Examples: Produce a digital presentation and oral explanation, create a documentary, present a project model and explanation.*
Portfolio	5. Design and create a project portfolio that documents all components of the career pathway project and demonstrates the validity of the process.

Program: Additive Manufacturing

Introduction to Drafting Design	
Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Introduction to Drafting Design provides an introduction to the drafting design technology field. It provides essential information that builds a strong foundation for the entire program. Emphasis is placed on student orientation, safety, tools and procedures, geometric construction, sketching, dimensioning practices, visualization, and orthographic projection concepts. Computer-Aided Drafting (CAD) functions and techniques using CAD software applications are introduced. Upon successful completion of this course, students are able to utilize tools and interpret basic drafting standards to complete a multiview drawing.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing.

	4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTRODUCTION TO DRAFTING DESIGN CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Orientation	1. Explain the importance of drafting design technology in today's technological workplace.
Safety	2. Demonstrate the safe handling of drafting design tools according to classroom and environmental best practices, procedures, and regulations.
Applied Mathematics for Drafting	3. Demonstrate mathematical skills related to drafting design, including fractions, scale reading, and conversions of customary to metric and metric to customary measurements. a. Utilize mathematics to solve drafting problems. *Example: calculating thread depth and pitch*
Drafting Instruments and Techniques	4. Demonstrate the use of drawing media and drafting instruments, utilizing computer software for drafting applications. a. Reproduce drafting originals. *Examples: printing, plotting/blueprinting, scanning*
Lettering and Drawing Techniques	5. Demonstrate drafting techniques for freehand sketching, lettering, geometric figures, and the alphabet of lines.

Multiview Drawing	6. Construct basic multiview, two-dimensional drawings, including visualizing principal views, creating third-angle projections, selecting proper drawing scale, and organizing layout of primary views.
Basic Dimensioning	7. Apply dimensions and notes to multiview drawings, utilizing the American National Standards Institute (ANSI) dimensioning standards and decimal, metric, or dual dimensioning.
Fundamentals of Computer-Aided Drafting	8. Utilize CAD software to generate multiview drawings using appropriate file management techniques, basic drawing commands, and basic dimensioning techniques. *Examples: create, set up, and save files; line, ellipse, circle, and scale; linear and angular*

Intermediate Drafting Design

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Introduction to Drafting Design

Intermediate Drafting Design is designed to further the development of students' knowledge of drafting design practices and procedures. Students expand their ability to illustrate more complex objects using the computer-aided drafting (CAD) system. Topics include sectioning, auxiliary views, threads and fasteners, pictorials, and the continuation of conventional dimensioning practices. Upon successful completion of the course, students are able to develop section views, primary auxiliary views, thread representations and pictorial views, and apply dimensions properly on a drawing.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTERMEDIATE DRAFTING DESIGN
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Section Views	1. Demonstrate the proper use of sectional view concepts to create a full section, half section, broken-out section, offset section, revolved section, and a removed section, utilizing cutting planes and applying section lining.
Auxiliary Views	2. Create drawings of inclined surfaces, constructing primary auxiliary views.
Threads and Fasteners	3. Create drawings illustrating detailed, schematic, and simplified thread representation, identifying common thread terms.
Pictorial Views	4. Utilize pictorial concepts to produce an isometric drawing, identifying obliques, trimetric, and diametric views.
Dimensioning	5. Apply dimensions, notes, and other relevant information to an isometric drafting design project, utilizing American National Standards Institute (ANSI) dimensioning standards. a. Identify and explain dimensioning symbols and tolerances.

Advanced Drafting Design

Course Credit	1.0
Grade Levels	11-12
Prerequisites	Intermediate Drafting Design

Advanced Drafting Design is designed for students who are interested in engineering and related mechanical drafting areas that require more in-depth study of mechanical design. Emphasis is placed on detailed parts drawings, bills of materials, and assembly drawings. Students are introduced to basic geometric dimensioning and tolerancing (GD&T) applications. Through intersections and development, students acquire basic sheet metal forming knowledge. Using this knowledge, students lay out and form models of geometric figures. Career readiness projects allow students opportunities to research industry standards and practices.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ADVANCED DRAFTING DESIGN
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Auxiliary Views	1. Create drawings of inclined surfaces that incorporate auxiliary sections and secondary auxiliary views.
Working Drawings	2. Create a complete working drawing, including all dimensions, notes, and specifications. a. Create assembly drawings. b. Prepare a bill of materials for a completed assembly drawing.
Geometric Tolerancing	3. Apply basic geometric dimensioning and tolerancing concepts, with references to American National Standards Institute (ANSI) dimensioning standards, in an advanced drafting design project.
Surface Developments and Intersections	4. Create three-dimensional geometric figures utilizing two-dimensional flat pattern surface development concepts. a. Develop layouts of geometric figures. b. Cut geometric patterns using printed layouts. c. Form and fold geometric patterns.
Introduction to Three-Dimensional Solid Modeling Design	5. Create a basic three-dimensional model of a mechanical part, utilizing three-dimensional application software.

Three-Dimensional Solid Modeling Design I

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Three-Dimensional Solid Model Design I introduces students to three-dimensional modeling utilizing the three-dimensional capabilities of computer-aided design (CAD) software. Emphasis is placed on working planes, profile creation, protrusions, extrusions, and rendering techniques. Students create two-dimensional part drawings relative to three-dimensional models.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

THREE-DIMENSIONAL SOLID MODEL DESIGN I
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Solid Modeling Commands	1. Identify three-dimensional modeling commands necessary to complete a three-dimensional solid model design and explain the outcome of each command. *Examples: produce command, revolved protrusion command*
Three-Dimensional Planes	2. Develop three-dimensional working planes for part sketching and profile creation. a. Demonstrate how to attach additional working planes to a three-dimensional working plane. *Examples: parallel, inclined, perpendicular*
Part Creation	3. Construct a three-dimensional model by selecting working planes, creating profiles for protrusion, and utilizing rendering commands.
Part Features	4. Utilize commands to add features to three-dimensional models. *Examples: constructing holes, adding fillets and rounds, applying cutouts, chamfering edges*
File Transitions	5. Demonstrate operations needed for converting a three-dimensional model to a two-dimensional parts drawing, including all dimension notes and other relevant information. a. Create two-dimensional parts drawings that incorporate primary views, section views, and auxiliary views.
Two-Dimensional Part Drawing	6. Arrange primary views, including all dimensions, notes, and other related information needed to complete a two-dimensional drawing for production. *Examples: specifying sheet size, detailing drawing information, revising drawings*

Three-Dimensional Solid Modeling Design II

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Three-Dimensional Solid Modeling Design I

Three-Dimensional Solid Model Design II is designed for students who wish to extend their expertise in three-dimensional modeling. Emphasis is placed on assembly, animation, and sheet metal concepts. Students organize and develop a career-related project based on current research and design practices.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

THREE-DIMENSIONAL SOLID MODEL DESIGN II
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Multi-Part Assembly	1. Create a three-dimensional assembly with clearances to ensure complete functionality. a. Describe the application part of constraints to a three-dimensional assembly.
Inspection and Evaluation	2. Analyze models to determine whether necessary engineering design features are included.
Prototyping	3. Create prototype models of flat pattern drawings, including the specification of relief settings and creation of a flat pattern.
Data Analysis	4. Perform data analysis on a three-dimensional, multipart assembly to ensure functionality.
Presentation	5. Create a three-dimensional presentation with computer-generated models, prototypes, and drawings.

Introduction to Engineering Design

Course Credit	1.0
Grade Levels	9-12 **Note:** This course may be offered to 8th grade students as an exploratory, non-credit-bearing option. Foundational Standards, Orientation, Engineering Design Process standards 5 and 6, and Presentation and Safety standards are required to be taught in an 8th grade course.
Prerequisites	

Introduction to Engineering Design is designed to offer students an overview of the engineering profession and the fundamental skills utilized in general engineering. Students investigate various engineering disciplines and related career paths. They develop communication and teamwork skills and increase their understanding of basic scientific and mathematical principles used in problem-solving through the engineering design process.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTRODUCTION TO ENGINEERING DESIGN
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Orientation	1. Gather and share information about emerging job opportunities in engineering fields, including earning potential for various careers. 2. Explain positive and negative impacts of engineering on society, including ethical, professional, and legal considerations. a. Differentiate among engineering, technology, and science. b. Outline significant contributions of past and present leaders in engineering. 3. Correctly utilize terminology associated with the engineering discipline. 4. Describe characteristics of sound financial management for engineers and engineering companies. *Example: preparing a budget*
Engineering Design Process	5. Apply the systems model of input, process, output, feedback, and impact. a. Analyze an engineering design brief to determine a course of action. b. Apply problem-solving skills to individual and collective responsibilities of the members of an engineering team. c. Develop projects, reports, and oral presentations related to engineering designs. d. Utilize mathematical concepts in engineering designs. 6. Demonstrate the use of analog and digital precision measuring instruments utilized in engineering. a. Explain the purpose and history of measurement systems. b. Describe customary and metric measurement systems. c. Utilize conversion factors of customary and metric measurements to convert between the two systems. d. Utilize significant digits in precision measurement.

	7. Produce basic engineering drawings and their components, including sketches and mechanical and computer-aided (CAD) drafting techniques. a. Generate thumbnail sketches, two-dimensional and three-dimensional sketches, and CAD drawings. b. Create multiview sketches and drawings. c. Produce orthographic and isometric sketches and drawings. 8. Identify patterns, relations, and functions of an engineering organization or workplace.
3D Prototyping	9. Demonstrate computer modeling and prototyping for an engineering design.
Presentation	10. Utilize information technology as it relates to engineering, including spreadsheets, databases, word processing, audiovisual presentations, and Internet research.
Safety	11. Identify and correct functional safety concerns in engineering designs.
3D Printing	12. Describe the operation and programming of three-dimensioning equipment and software.

Engineering Design Applications

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Introduction to Engineering Design

Engineering Design Applications enables students to make an informed career choice through the study and application of mechanical, electrical, and other engineering systems. Students conduct research and design engineering projects to enhance abilities and expand interest in the field of engineering. Projects reinforce the application of communication, mathematics, and science. Computer technology applications are utilized extensively in this course to enable students to visualize, model, prototype, solve, and report comprehensive design problems.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces.
	2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork.
	3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing.
	4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway.
	5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ENGINEERING DESIGN APPLICATIONS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Materials and Processes	1. Analyze a specific engineering design that involves live and dead loads for tension, compression, shear, and torsion. 2. Explain manufacturing processes of casting and molding, forming, separating, conditioning, assembling, and finishing of various engineering products. 3. Demonstrate the process of multiple axis movement. 4. Explain the operation and programming of 3D software and equipment.
Design Project Proposal	5. Create a formal, narrative proposal for an engineering design project.
Research	6. Perform independent research related to a chosen engineering design.
Reverse Engineering	7. Select and use tools to capture the data of an existing part in order to create sketches to proper scale with precise dimensions, so that a three-dimensional model can be produced.
Design Project	8. Perform the engineering design process, including defining the problem, developing and choosing a solution, constructing a prototype, testing and evaluating, and redesign as needed.
Design Project Presentation	9. Create a written technical report and a multimedia presentation to demonstrate an engineering design project, using industry recognized guidelines.

Program: Electronics

Direct Current	
Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Direct Current is designed to provide students with basic knowledge and skills in the electrical industry. Emphasis is placed on basic circuitry, measuring and calculating electrical quantities, characteristics of resistors, circuit construction, and troubleshooting

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

DIRECT CURRENT CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Sources	1. Describe the structure and characteristics of the atom. 2. Explain the relationship of the atom to an electrical charge, including electrostatic field and law of charges. 3. Research and share information on sources of electricity, including chemical, mechanical, and solar. *Examples: chemical - battery; mechanical - generator*
Terminology and Symbols	4. Explain electrical terms, including *direct current (DC), voltage, resistance, power, conductors,* and *insulators*. 5. Interpret electrical symbols used in schematic drawings of DC applications.
Components of a Basic Circuit	6. Explain components of a basic circuit, including source, load, and conductor.
Electrical Quantities and Measurements	7. Explain electrical quantities and units of measure, including voltage, current, resistance, and power. 8. Measure volts, ohms, and amperes with appropriate test equipment.
Characteristics of Resistors	9. Explain different types of resistors, including fixed and variable resistors. 10. Determine resistance values using the standard resistor color code. 11. Describe the electrical and physical characteristics of resistors. *Examples: resistance, power rating, wattage*
Ohm's Law	12. Solve problems in electrical series, parallel, and combination circuits using Ohm's law to determine voltage, current, resistance, and power.

Circuit Construction	13. Fabricate specified DC circuits, using soldering, breadboard, and wiring techniques.
Troubleshooting	14. Demonstrate troubleshooting techniques for problems with circuits, including opens, shorts, and grounds.

Alternating Current

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Alternating Current addresses principles and concepts of magnetism, measuring electrical quantities, calculating electrical quantities using Ohm's law in alternating current circuits, and reactive circuits.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ALTERNATING CURRENT
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Terminology and Symbols	1. Explain electrical terms, including *alternating current, frequency, period, sine wave, capacitance,* and *inductance*. 2. Interpret electrical symbols used in schematic drawings of AC applications. *Examples: unit symbols, schematic symbols*
Magnetism	3. Explain terms and principles of electromagnetism, including permeability, retentivity, and inductance.
Electrical Quantities	4. Explain electrical quantities, including frequency, impedance, power, capacitance, inductance, voltage, current, watts, and periods. 5. Measure electrical units, including volts, amperes, ohms, and hertz. 6. Determine electrical quantities utilizing test equipment, including volts, frequency and period, amperes, and power.
Ohm's Law in AC Circuits	7. Solve problems in AC electrical circuits using Ohm's law, including voltage, current, impedance, and power.
Reactive Circuits	8. Solve resistive-capacitive circuits. 9. Solve resistive-inductive circuits. 10. Solve resistive-capacitive-inductive circuits. 11. Analyze filter circuits to determine electrical values, including hi-pass, low-pass, band pass, and band stop. 12. Demonstrate troubleshooting techniques for evaluating reactive circuits.

Semiconductors

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Semiconductors emphasizes the characteristics and uses of semiconductors, semiconductor circuits, and analog circuits. Instruction on job safety is stressed.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

SEMICONDUCTORS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Analog Signals	1. Obtain and share information about signal levels, impedances, and wiring formats. 2. Explain dynamic range, noise, signal to noise ratio, and distortion. 3. Calculate decibels for standard reference levels. a. Outline the typical level, dynamic range, spectrum, impedance, and format for various audio, baseband video, modulated video, and radio frequency (RF) signals.
Active Devices	4. Obtain and share information on active devices, transistor biasing, and amplifier circuits. a. Describe the three configurations of transistor amplifier circuits. b. Compare base junction transistors (BJTs) and field-effect transistors (FETs). c. Calculate values of transistor amplifier circuits.
Integrated Circuits	5. Gather, evaluate, and share information on op-amps and other integrated circuits. a. Describe an operational amplifier, including its input and output functions. b. Calculate gain for op-amp circuits. 6. Discuss *discrete* and *integrated* as they apply to semiconductors.
Oscillators	7. Describe the characteristics and uses of oscillators and multivibrators. a. Explain the uses and basic operating principles of tuned and non-tuned oscillators. b. Compare and contrast various types of LC oscillators, including Hartley, Colpitts, Clapp, Armstrong, Meissner, and non-tapped tanks. c. Discuss various types of RC oscillators and their uses.
Wave Shaping	8. Obtain and share information on waveshaping circuits a. Explain *differentiation* and *integration* as they apply to waveshaping circuits. b. Describe various waveform clipping, clamping, and rectification circuits.

Filters	9. Describe multiple filters circuits.
Power Supplies	10. Describe the uses of AC-operated power supplies.
Optoelectronics	11. Investigate and describe the functions and applications of optoelectronic devices.
Semiconductor Circuits	12. Construct semiconductor circuits, including diodes and transistors. 13. Troubleshoot semiconductor circuits.

Digital Electronics

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Digital Electronics introduces students to digital fundamentals and number systems. Emphasis is placed on characteristics of digital circuit signals, logic gates, logic devices, and digital circuits.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

DIGITAL ELECTRONICS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Orientation	1. Describe career opportunities and earnings potential in the field of digital electronics.
Characteristics of Digital Circuit Signals	2. Explain the characteristics of digital circuit signals, including electrical signal types. 3. Utilize digital number systems, including binary, octal, decimal, hexadecimal, and Boolean operations. 4. Determine the truth table for each logic gate used in digital electronics.
Logic Gates	5. Interpret logic gate symbols, including standard form and alternate form. 6. Compare and contrast types of logic devices and their uses. *Examples: multivibrators, encoders, converters, memory storage devices* 7. Interpret logic device symbols.
Digital Circuits	8. Utilize breadboarding techniques to construct digital circuits, including simple logic and combinational logic. 9. Troubleshoot digital circuit problems.
Microprocessors	10. Utilize terminology related to microprocessor system components. 11. Explain principles and operation of a microprocessor system.

Introduction to Robotics

Course Credit	1.0
Grade Level	9-12
Prerequisites	

Introduction to Robotics is designed to introduce students to the fundamentals of robotics. The course emphasizes fundamentals of electrical current, digital circuits, electronic control systems, and the design and operation of robotic systems. This course may be taken in the Robotics and Automated Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTRODUCTION TO ROBOTICS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Orientation	1. Gather and share information on how robotics has influenced the manufacturing process, citing real-world examples. a. List personal characteristics necessary to succeed in robotics. 2. Demonstrate how to program a robot, using safety devices and hand tools correctly.
Fundamentals of Electrical Current	3. Gather and share information on chemical, mechanical, and solar sources of electricity. 4. Explain the relationship of the atom to an electrical charge. 5. Gather and share information on electrical terms and units of measures, including direct and alternating current measured in amperes, the voltage measured in volts, the resistance measured in ohms, power measured in watts, and conductors and insulators. 6. Diagram components of a basic circuit. a. Design series, parallel, and combination circuits. b. Compute current, voltage, and resistance using available devices. 7. Construct electrical circuits utilizing soldering and breadboarding techniques. a. Measure current, voltage, and resistance in electrical circuits.
Digital Circuits	8. Gather and share information about basic digital principles, including signal levels and signal types. a. Explain various digital number systems. b. Interpret logic gate symbols used in digital circuits. c. Develop the truth table for each logic gate as specified in robotic applications.

Electronic Control Systems	9. Compare and contrast open-loop and closed-loop control systems. a. Document the differences between manual and automatic control systems. 10. Interpret symbols used in control circuit diagrams. a. Correlate construction, electrical, and mechanical schematic symbols to real-world devices. 11. Compare programming methods and the input and output devices used in motion control systems. a. Identify ways programmable logic controllers can be used. b. Develop a ladder logic diagram to perform a specific function. c. Model ladder logic programs for multiple programmable logic controllers.
Design	12. Explain and utilize robotics design terms, including *controller, teach pendant, manipulator, end-effector and end-of-arm tooling, degrees of freedom, work envelope,* and *power supplies*. 13. Compare and contrast types of robot configurations, including revolute, selective compliant assembly robot arm (SCARA), Cartesian, cylindrical, spherical, and jointed-arm. a. Describe the use of specialty robots in automated systems.
Operation	14. Demonstrate the proper use of input and output devices for performing robotic tasks. 15. Explain the operation of fluid power systems used in robotic systems. 16. Debug a robotic work cell. a. Identify robotic abnormalities. b. Change errors in robotics programs.

Robotics Applications

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Introduction to Robotics

Robotics Applications standards mandate the design and construction of a robotic system with peripheral devices, including the design and creation of mechatronic systems and use of automated tooling. This course may be taken in the Robotics and Automated Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ROBOTICS APPLICATIONS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Orientation	1. Implement safety procedures and rules in robotic applications. a. Maintain a safe work area around the robot and equipment. b. Demonstrate the correct use of hand tools used in robotics and surrounding systems.
Systems	2. Investigate and report on applications of a robotic system. a. Describe how robotic systems are incorporated into the manufacturing industry. 3. Compare uses of multiple robotic systems. 4. Formulate a plan to perform multiple robotic tasks, including a flow chart. a. Configure a robotic system plan to perform multiple tasks.
Peripheral Systems	5. Create plans and use them to program robots and peripheral devices to perform a variety of operations. 6. Plan a coordinated robotic system with peripheral devices. a. Outline a basic computer program to control robots and peripherals. b. List and explain applications of peripheral devices. 7. Verify the function of a coordinated robotic system.
Projects	8. Construct a robotic system with various peripheral devices. a. Program a coordinated robotic system. b. Test a coordinated robotic system. c. Test system performance of different robotic designs. 9. Predict system performance in a robotic device. 10. Verify system performance of different robotic designs.

Telecommunications Cabling

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Telecommunications Cabling is based on industry credentials as outlined by ETA-I (Electronics Technician Association) and BISCI, the internationally known and recognized cabling and installation industry standard for communications employees. This is a program designed to train students in the proper standards of installation and maintenance of data cabling, fiber optics, proper termination, equipment, and industry standards, certification and credentialing. This outline is based on standards approved and utilized by NIDA training equipment and other industry standards.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

TELECOMMUNICATIONS CABLING
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Cables and Cabling	1. Describe unshielded twisted pair (utp) cables. a. List common usage locations of unshielded twisted pair (utp) cables. b. List common usage capabilities of unshielded twisted pair (utp) cables. 2. Install and troubleshoot rj45/48 telephone connectors and fittings. 3. Compare Cat 5 cables to single twisted pair and unshielded twisted pair wiring, indicating where Cat 5 is most often used. 4. Explain where 10Base t cable is commonly used. a. Describe the frequency capabilities of 10Base t cable. 5. Summarize t568a/t568b standards. 6. Explain how cable TV wiring is used for data and voice services. 7. Explain the differences between coax types rg58, rg59, and rg6. 8. Describe proper methods of grounding for electronics equipment. 9. Describe the differences between single- and multi-mode fiber optics.
Equipment	10. Describe the principal parts of a telephone and explain the functions of each. 11. Describe the differences among rs232, rs530, v35, and USB interfaces. 12. Assess a telephone set, testing the line for continuity and identifying faults that could degrade the signal. *Examples: partial shorts, cross connections*

Telecom Mathematics	13. Utilize the mathematics required in telecommunications service and installation. a. Compute power, voltage, and current gain in electrical networks. b. Find the total impedance of an AC network and reduce it to an equivalent series circuit. c. Find the total current and impedance of an RLC parallel circuit. d. Apply Ohm's law to AC circuits. 14. Explain Kirchhoff's law for current and voltage.
Telecom Safety	15. Demonstrate and practice general safety procedures in the workplace while accessing telecom ports and all electronic devices. 16. Demonstrate and practice safety procedures in homes and businesses to safeguard customers. *Examples: proper identification upon arrival* 17. Explain proper electrostatic discharge (ESD) safety procedures. 18. Demonstrate special safety procedures required for outside equipment.

Embedded Arduino Controls

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Embedded Arduino Controls focuses on embedded controllers and systems used in the evolving health care, industrial, consumer, automotive and defense/aerospace industries, and electronics and robotics technologies fields. The course is designed to meet the needs of the twenty-first century's workforce in these complex industries through training in electronics embedded systems and sensor technologies.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

EMBEDDED ARDUINO CONTROLS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Basic Components	1. Apply Arduino microcontroller control concepts to robotics applications using electronic sensors, transistor relays, and small DC motor control circuits. a. Construct a basic Arduino LED control circuit. b. Construct a basic Arduino sensor circuit. c. Construct a basic Arduino transistor relay control circuit. d. Construct a basic small DC motor control circuit using an Arduino. 2. Identify basic electronic components of a typical embedded microcontroller platform.
Circuit Design	3. Draw basic embedded Arduino microcontroller circuits by hand, including LED, sensor, and transistor relay circuits. 4. Draw a basic embedded Arduino microcontroller control circuit block diagram by hand.
Programming	5. Construct a basic logic control software application using C programming language. 6. Construct a basic flowchart for a robotics application using C programming language.
Research	7. Gather and share information on a basic embedded Arduino microcontroller control circuit block diagram for a robotics application. a. Create and plan a basic embedded Arduino microcontroller control circuit block diagram.

Electronics and Control Systems

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Electronics and Control Systems provides instruction and experiences in electronic circuitry, emphasizing relays, sensors, variable frequency drives, and programmable logic controllers. This course may be taken in the Robotics and Automated Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ELECTRONICS AND CONTROL SYSTEMS CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Safety	1. Adhere to safety rules for electronic power and control systems. a. Outline elements of a lockout/tagout (LOTO) program, describe the LOTO process, and test to ensure a zero energy state. b. Describe safety procedures for disconnecting or connecting electronic components. c. Summarize the NFPA 70E arc flash guidelines and explain their importance.
DC Power	2. Connect and test a DC power supply. a. Explain the operation of PN junction diodes, LEDs, Zener diodes, and voltage regulators. b. Describe the operation of half wave and full wave rectifiers. c. Measure output from a DC power supply to determine noise or quality of filtering.
Relays	3. Install and test a solid-state relay.
Sensors	4. Install and test analog electronic sensors. a. Document the operation of thermistors, RTD temperature sensors, and thermocouples. b. Document the operation of resistive, capacitive, and piezoelectric pressure sensors.
Variable Frequency Drives	5. Test capabilities of an AC variable frequency drive. a. Connect and operate an AC variable frequency drive (VFD) with an AC motor and relay control circuit.
Programmable Logic Controllers	6. Connect and transfer programs between a personal computer and a programmable controller via a serial, USB, or Ethernet connection. a. Demonstrate how programmable logic controllers are wired to power, input/output, and network devices.

	7. Create a basic programmable logic controller ladder-style program. a. Interpret programmable logic controller programs with internal and external contacts, timers, counters, non-retentive output coils, internal coils, subroutines, conditional commands, and math commands. b. Interpret programmable logic controller programs that control and sequence electric motors and fluid power systems. c. Explain the operation of basic programmable logic controller commands, including internal and external contacts, timers, counters, nonretentive output coils, and internal coils. 8. Install and test a human-machine interface and programmable logic controller system.
Troubleshooting	9. Demonstrate basic electromechanical installation and troubleshooting. a. Make mechanical, electrical, and software adjustments to tune the performance of a machine run by a programmable logic controller. b. Plan and collaborate as a team to install, troubleshoot, and optimize systems.

Program: Industrial Maintenance Electrical & Instrumentation

Industrial Maintenance Electrical & Instrumentation I	
Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Industrial Maintenance: Electrical & Instrumentation I provides an overview of the basic skills and concepts needed by an E&I technician. Topics include orientation, work environment, industrial safety, gaskets and packing, construction drawings, test instruments, and craft-related mathematics. Educators may choose to incorporate additional standards to build upon those which are required.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INDUSTRIAL MAINTENANCE ELECTRICAL & INSTRUMENTATION I
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Orientation to the Trade	1. Obtain and share information about Occupational Safety and Health Administration (OSHA) standards, material safety data sheets (MSDS) requirements, and Environmental Protection Agency (EPA) regulations related to working with electricity.
Work Environment	2. Describe the scope of work and work environments encountered by industrial maintenance craftspeople. a. Gather and share information on apprenticeship and training programs available for the industrial Electrical & Instrumentation technician.
Industrial Safety for E&I Technicians	3. Follow safety rules and regulations for electrical workers. a. Explain and implement the OSHA-mandated lockout/tagout procedures.
Gaskets and Packing	4. Describe various types and uses of gaskets, packing, and O-rings. a. Lay out and fabricate gaskets using units and measurements with accuracy and precision, while using hand tools safely.
Construction Drawings	5. Explain the basic components of construction drawings including engineer scales, symbols, and circuit diagrams. a. Explain electric current flow, using the terms *voltage, resistance,* and *current*.
Introduction to Test Instruments	6. Identify different kinds of test instruments and demonstrate how to test various types of electrical systems with meters.
Craft-Related Mathematics	7. Apply mathematical formulas, determine ratios and proportions, calculate areas and volumes, and use scales and tables of comparative values to read and interpret plans used for instrumentation.

Industrial Maintenance Electrical & Instrumentation II

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Industrial Maintenance Electrical & Instrumentation I

Industrial Maintenance Electrical & Instrumentation II elaborates on the overview of skills presented in Industrial Maintenance Electrical and Instrumentation I. Topics include basics of electricity, alternating current, magnetism, fasteners and anchors, grounding, and sensors and sensing. Educators may choose to incorporate additional standards to build upon those which are required.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**…"*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INDUSTRIAL MAINTENANCE ELECTRICAL & INSTRUMENTATION II
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Basics of Electricity	1. Identify properties of electricity and electronics. a. Explain the functions of components of electrical and electronic systems. b. Explain Coulomb's laws of electrical charges. c. Identify insulators, conductors, and semiconductors and describe their functions. d. Follow electrical safety rules.
Alternating Current	2. Gather and share information about the applications of alternating current in homes, commercial buildings, and industrial facilities. a. Explain the differences between alternating current and direct current. b. Use a multimeter to measure AC voltage used in residential and industrial settings. c. Use an ammeter to measure AC current found in residential and industrial settings.
Magnetism	3. Obtain, evaluate, and share information about properties of magnetism and magnetic materials. a. Explain the operation of various magnetic devices an electrical technician would encounter. b. Demonstrate magnetism as it relates to electrical theory.
Fasteners and Anchors	4. Demonstrate how to install fasteners and anchors safely in residential, commercial, and industrial settings. a. Describe various types of fasteners and anchors and their applications.
Grounding	5. Demonstrate safe installation of grounding connections. a. Explain the importance of electrical grounding connections. b. Explain the importance of mechanical grounding connections.
Sensors and Sensing	6. Wire, terminate, set up, and troubleshoot contact sensors, non-contact sensors, presence sensors, and limit sensors. a. Describe the uses of various types of sensors in the manufacturing process.

Industrial Maintenance Electrical & Instrumentation III

Course Credit	1.0
Grade Levels	11-12
Prerequisites	Industrial Maintenance Electrical & Instrumentation II

Industrial Maintenance Electrical & Instrumentation III provides experiences that are designed to give students advanced knowledge of electrical applications. Topics include safety, conduit, National Electrical Code, circuits, conductors, and metering devices. Educators may choose to incorporate additional standards to build upon those which are required.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INDUSTRIAL MAINTENANCE ELECTRICAL & INSTRUMENTATION III
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Identify electrical safety hazards and demonstrate safe practices around circuits and equipment.
Conduit	2. Install conduit from ½ inch to 2 inches according to the National Electrical Code. a. Identify types of conduit and sizes. b. Select the proper conduit for specific jobs. c. Bend conduit to prescribed radiuses.
National Electrical Code	3. Describe the purpose of the National Electrical Code (NEC), reference NEC code, and explain current applications of the NEC code in residential and industrial settings.
Circuits	4. Troubleshoot a circuit, applying principles of Ohm's law and Kirchoff's law. a. Identify and perform electrical measurement. *Examples: resistance, ohms, volts, amps, nano farads* b. Identify types of circuits found in residential and industrial settings.
Conductors	5. Identify and make connections using various types of conductors and fastening devices, following NEC requirements for terminations and splices.
Metering Devices	6. Test circuits and mechanisms using available devices. a. Identify and explain the uses of various testing equipment used in the trade. b. Differentiate between analog and digital meter readouts.

Program: Industrial Maintenance Mechanical

Industrial Maintenance Mechanical I	
Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Industrial Maintenance Mechanical I provides an overview of the basics of an industrial technician's responsibilities and skills. Topics include safety, measurement, basic employability skills, material handling, rigging, construction mathematics, and construction drawings. Educators may choose to incorporate additional standards to build upon those which are required.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INDUSTRIAL MAINTENANCE MECHANICAL I
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Measurements	1. Identify and perform exact measurements using various measuring tapes, calipers, and instruments commonly used in industrial settings.
Material Handling	2. Identify and perform proper lifting and material-handling procedures needed in the maintenance field.
Safety	3. Identify and perform safety evaluations of site-specific hazards. a. Describe types of personal protective equipment found in industry and their uses.
Construction Math	4. Apply the four basic math operations with whole numbers, fractions, and percentages in construction and maintenance contexts.
Rigging	5. Identify and explain safe rigging equipment and practices, load distribution, and hand signals.
Employability	6. Explain the job search process with an emphasis on career opportunities, skills needed in various settings, and levels of remuneration for various types of industrial maintenance work.
Construction Drawings	7. Identify basic elements of construction drawings including units of measurements, symbols, and mechanical diagrams. a. Convert units of measurement from scales on construction drawings.

Industrial Maintenance Mechanical II

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Industrial Maintenance Mechanical I

Industrial Maintenance Mechanical II builds on Industrial Maintenance I to provide a detailed look into the skills and knowledge required to be an industrial technician. Topics include tools of the trade, fasteners and connections, oxy-fuel cutting, gaskets and packing, pumps, valves, and lubricants. Educators may choose to incorporate additional standards to build upon those which are required.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards

1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces.
2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork.
3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing.
4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway.
5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INDUSTRIAL MAINTENANCE MECHANICAL II
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Fasteners and Connections	1. Make connections using various types of conductors and fastening devices for hydraulic and pneumatic controls, following National Electrical Code (NEC) requirements for terminations and splices. a. Describe appropriate uses for various types of conductors and fastening devices.
Gaskets	2. Install gaskets and packing. a. Identify different types of gasket and packing materials, and list their applications.
Pumps	3. Identify types of pumps and prime movers. a. Measure and explain the pressure differential between inlet and outlet of pumps.
Valves	4. Demonstrate installation of valves. a. Select the proper type of valve for various uses. b. Explain methods and importance of proper storage of valves.
Tools	5. Demonstrate the use of specialized tools found in industrial maintenance.
Lubricants	6. Categorize lubricants and additives according to their composition and uses. a. Summarize environmental regulations regarding disposal of oils and greases.
Oxy-Fuel Cutting	7. Describe the basic equipment, setup, and safety rules for proper use of equipment for oxy-fuel cutting. a. Prepare base metal for oxy-fuel cutting and heating.

Industrial Maintenance Mechanical III

Course Credit	1.0
Grade Levels	11-12
Prerequisites	Industrial Maintenance Mechanical II

Industrial Maintenance Mechanical III provides advanced knowledge of industrial applications. Topics include machine drawings, pumps, drive systems, material handling and hand rigging, and disassembly and reassembly of pumps and compressors.. Educators may choose to incorporate additional standards to build upon those which are required.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards

1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces.
2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork.
3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing.
4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway.
5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INDUSTRIAL MAINTENANCE MECHANICAL III
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Machine Drawings	1. Identify and explain elements of machine drawings, including geometric dimensioning and tolerance (GD&T) symbols and their meanings.
Rigging	2. Select proper equipment for safe rigging and lifting and demonstrate its use.
Pumps	3. Demonstrate troubleshooting, repairing, and installing pumps, following safety guidelines.
Drive Systems	4. Identify and explain the components and uses of chain and belt drive systems. a. Troubleshoot and repair gearboxes. 5. Install belt drives as recommended by the manufacturer, following prescribed procedures and safety protocols. 6. Install chain drives as recommended by the manufacturer, following prescribed procedures and mechanical safety guidelines.
Disassembly	7. Disassemble and reassemble pumps and compressors as recommended by the manufacturer, following prescribed procedures and mechanical safety guidelines. a. Identify and explain the function of various components in pumps and compressors.

Program: Modern Manufacturing

Manufacturing I: Safety	
Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Manufacturing I: Safety provides students with knowledge of industrial safety, leadership, and communication. Topics included personal protective equipment, fire and electrical safety, work area safety, hazardous material and material handling safety, and tool and machine safety.

Manufacturing I, II, III, and IV are not sequential -- they may be taken in any order.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

MANUFACTURING I: SAFETY
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Equipment Safety	1. Assess equipment and operator performance for compliance with safety rules. 2. Adhere to safety and health requirements during maintenance, installation, and repair of machinery and equipment. 3. Demonstrate equipment safety procedures.
General Safety	4. Identify unsafe conditions and take corrective action. 5. Develop and use safety checklists. 6. Research and present information on safety procedures of industry 4.0, including 5g technologies.
Workplace Safety	7. Demonstrate safe and productive manufacturing workplace behaviors. 8. Explain the role of production workers in helping to ensure competitive levels of cost, quality, and delivery in a safe work environment. 9. Explain workplace codes of conduct and responsibilities for ethical and responsible behavior in all work activities. 10. Perform emergency drills and fulfil responsibilities on emergency teams. 11. Facilitate employee safety in all topics and procedures. 12. Propose new processes and procedures that support safety in the work environment.

Manufacturing II: Quality

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Manufacturing II: Quality provides students with knowledge of quality practices and measurement. Topics include blueprint reading, basic measurement, precision measurement, quality systems, and statistical process control concepts.

Manufacturing I, II, III, and IV are not sequential -- they may be taken in any order.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

MANUFACTURING II: QUALITY
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Precision Measurement	1. Perform and document calibration of gauges and other data collection equipment to verify accuracy. 2. Summarize calibration standards and requirements for equipment inspection.
Quality Control Practices	3. Compare and contrast quality control methods, including statistical process control (SPC), total quality management (TQM), lean management, "plan-do-check-act," and International Organization of Standardization (ISO) standards. 4. Describe the documentation process and requirements used to produce verifiable evidence of product quality. 5. Complete statistically-based internal quality audit procedures. 6. Explain concepts and uses of lean manufacturing, citing real-world examples. 7. Explain the principles and application of total quality management (TQM).
Quality Practices and Measurement	8. Assess and document conformance to quality standards. 9. Make and defend data-based suggestions for continuous improvement. 10. Assess materials, products, and processes at all stages to be sure they meet specifications. 11. Use correct inspection tools and procedures. 12. Identify products, processes, and materials that do not meet specifications. 13. Check data forms to ensure that they are complete and accurate.

14. Evaluate and interpret the results of quality information tests.

15. Select and use correct analytical tools, including statistical process controls (SPC).

16. Report quality problems to appropriate parties.
    a. Explain follow-up and reporting documentation procedures to ensure proper communication.

17. Identify appropriate corrective actions for quality problems and obtain approvals when needed.

18. Make and defend clear, concise, data-supported recommendations for action.

19. Complete corrective actions and quality improvements in a standardized manner.

20. Explain the use of statistical quality tools to reach accurate decisions about quality data.
    Examples: Root Cause Failure Analyses, Pareto charts

21. Chart outcomes of quality processes according to industry-accepted methods and standards.

22. Read and interpret blueprints.
    a. Identify product features, dimensions, and tolerances of an object from a multiview drawing.
    b. Identify geometric dimensioning and assembly tolerances on a drawing.
    c. Interpret dimensions of an object in a technical drawing.
    d. Interpret assembly drawings.

23. Use common measurement systems and precision measurement tools.
    a. Use and convert between U.S. measurements and standard international metric systems.
    b. Measure parts using a machinist's rule, tape measure, dial and digital calipers, digital and Vernier micrometer, and dial indicator.
    c. Interpret data from a digital gauge using a computer.

Manufacturing III: Production

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Manufacturing III: Production is designed to provide students with knowledge of manufacturing processes, production, and equipment. Topics include mechanical principles and linkages, material quality control, machining processes and machine tooling, equipment procedures, production planning and workflow, and production control.

Manufacturing I, II, III, and IV are not sequential -- they may be taken in any order.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

MANUFACTURING III: PRODUCTION
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Manufacturing Processes and Controls	1. Describe basic casting, molding, and stamping processes. 2. Explain how lasers are used in production equipment. 3. Perform, monitor, and document the manufacturing process to make the product. 4. Document product and process compliance with customer requirements. 5. Prepare a final product for shipping or distribution.
Manufacturing Equipment	6. Explain procedures for machinery setup, operation, and testing. 7. Describe emergency shutdown procedures for production machines. 8. Identify common types of mechanisms used in machines. 9. Describe ways in which force and torque are used in machine operations. 10. Explain impacts of friction on machine operation and methods. 11. Explain the functions of cams. 12. Describe ways in which machines use pulleys and gear drives. 13. Explain basic machine tooling. 14. Describe computer numerically-controlled (CNC) equipment and its use. 15. Describe programmable logic controllers (PLCs) and their uses. 16. Explain human-machine interface (HMI). 17. Set up and verify equipment for the production process.

Manufacturing Materials	18. Check raw materials, tools, and equipment against work orders.
Lean Manufacturing Processes	19. Determine resources available for the production process. a. Describe equipment capabilities for maximizing productivity. b. Ensure that necessary resources are available at workstations. c. Schedule workers with appropriate skills according to production needs. 20. Work as a team to set production goals. a. Describe principles of lean manufacturing and high-performance work organizations. b. Set team goals that are specific, measurable, achievable, relevant, time-bound, and aligned with the needs of the customer and the business. c. Document team goals and communicate them to all parties. 21. Make job assignments to maximize production. a. Match workers' skills with production work to be done. b. Notify workers of job assignments effectively. 22. Communicate production and material requirements and product specifications to the appropriate people. a. Coordinate workflow with team members and other workgroups.

Manufacturing IV: Maintenance

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Manufacturing IV: Maintenance is designed to show students the importance of maintenance awareness in the manufacturing setting and provide the knowledge they need to carry out basic maintenance procedures. The importance of cleaning, inspections, and preventive maintenance is stressed. Areas of focus include basic electric circuits, power, pneumatic, and hydraulic power systems; lubrication concepts, bearings and couplings, belt and chain drives, and machine automation and control concepts.

Manufacturing I, II, III, and IV are not sequential -- they may be taken in any order.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**…"*

Foundational Standards

1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces.
2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork.
3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing.
4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway.
5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

MANUFACTURING IV: MAINTENANCE
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Maintenance Awareness Monitoring	1. Monitor indicators and adjust equipment to ensure correct operations. a. Accurately read a pressure gauge. b. Calculate the shaft speed and torque of a belt drive system. c. Perform belt tension for an application. d. Use a belt tension tester to measure belt tension. e. Calculate shaft speed and torque of a chain drive system. f. Determine allowable chain sag for a given application.
Maintenance Awareness Procedures	2. Create a schedule of facility cleaning, organizing, and repairs to maintain a production schedule. 3. Plan for and conduct regular inspections of machinery and equipment. a. Identify potential and impending failures in manufacturing equipment.
Preventive Maintenance Awareness	4. Perform preventive maintenance and routine repair on manufacturing equipment. a. Adjust belt tension using an adjustable mounting base. b. Explain how to install, align, and remove a roller chain drive system with adjustable centers. c. Use a ruler and a straightedge to measure chain sag. d. Explain how to inspect a hydraulic system during operation. 5. Identify potential maintenance issues with basic pneumatics, fluid power, mechanic transmissions, belt drives, electromechanical relays, and chain drive systems and indicate when maintenance personnel should be informed about problems. a. Compare pneumatics and fluid power and give an example of when and how they are used. b. Describe the function of a mechanical power transmission system. c. Describe the functions of the three basic components of a belt drive. d. Describe the function of an electromechanical relay and give an example of its use. e. Describe the functions of the three basic components of a chain drive.

6. Explain the cost of downtime to a manufacturing facility in terms of time and financial loss.
   a. Gather and share information regarding the cost of downtime to the manufacturing industry as a whole.

7. Develop a preventive maintenance plan with a reasonable financial allocation to keep manufacturing equipment in good operating condition.

Program: Precision Machining

Introduction to Precision Machining	
Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Introduction to Precision Machining provides an introduction to high-skills manufacturing processes and job opportunities for students who are considering careers in manufacturing. Topics include print reading, drill press, power saws, and benchwork. Safety is also strongly emphasized. This entry-level course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTRODUCTION TO PRECISION MACHINING
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Apply safety rules, regulations, and procedures for precision machining equipment. *Examples*: *laboratory, fire, electrical, and equipment safety*
Print Reading	2. Interpret blueprint symbols and lines related to precision machining. *Examples: dual dimensions, limit dimensioning, scales and rulers, single view and multiview drawings*
Drill Press	3. Demonstrate maintenance procedures for a drill press. *Examples: cleaning, lubricating, setting up* 4. Demonstrate drill press operations, including hand sharpening a drill bit, center drilling, drilling a workpiece, countersinking a hole, counterboring a hole, calculating speed and feed per material, and tooling.
Power Saws	5. Demonstrate maintenance procedures for vertical and horizontal power saws. *Examples: cleaning, lubricating, setting up* 6. Demonstrate saw operations. a. Install a saw blade. b. Straight cut a workpiece. c. Saw an angle. d. Saw a slot using a vertical saw.
Benchwork	7. Demonstrate benchwork skills related to precision machining. a. Ring test a grinding wheel. b. Mount a grinding wheel on a bench grinder and adjust safety guards. c. Hand grind various cutting tools.

8. Demonstrate layout with combination square and scribe and with a Vernier height gauge.
   a. Lay out a circle using chord length.
   b. Hand tap internal threads.
   c. Produce external threads with a threading die.

9. Demonstrate accurate and precise measurements, geometric dimensioning, and use of trigonometric functions related to precision machining.

Computer Numerical Control (CNC) I

Course Credit	1.0
Grade Level	9-12
Prerequisites	

Computer Numerical Control (CNC) I provides an introduction to the operation of Computer Numerical Control machinery used in manufacturing. Topics include CNC programming and CNC operations. Standards are based on the National Institute for Metalworking Skills (NIMS) Level I CNC Mill and NIMS Level I CNC Lathe. This entry-level course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**…"*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COMPUTER NUMERICAL CONTROL (CNC) I
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Safety	1. Apply safety rules, regulations, and procedures when using computer numerical control equipment. 2. Demonstrate care and maintenance for computer numerical control machines. *Examples: cleaning, lubricating, setting up*
Operations	3. Demonstrate introductory skills for writing a computer numerical control program. a. Identify and demonstrate the use of basic G and M codes. b. Identify and demonstrate the use of basic speed and feed codes. c. Identify and demonstrate the use of basic cutter positioning codes. 4. Write a basic computer numerical control mill program for straight and circular moves. 5. Write basic computer numerical control lathe programs for turning, facing, and corner radii.
Projects	6. Create a finished project using a computer numerical control mill. *Example: Utilize NIMS Level I CNC Mill specifications to create a product.* a. Demonstrate correct machine setup of a CNC mill. b. Set tool length offsets for a CNC mill. c. Set tool diameters for a CNC mill. d. Install workholding for a CNC mill project. e. Load a part program into a CNC mill. 7. Create a finished project using computer numerical control lathe. *Examples: Utilize NIMS Level I CNC Lathe specifications to create a product.*
Operations	8. Edit, graph, and simulate mill and lathe programs.

Computer Numerical Control (CNC) II

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Computer Numerical Control (CNC) I

Computer Numerical Control (CNC) II is designed to further develop students' skills using Computer Numerical Control machinery, with application of critical-thinking skills coupled with principles of science, mathematics, and safety. Topics include advanced CNC programming, setup, and proper operations. Skills from the National Tooling and Machining Association (NTMA) and National Institute for Metalworking Skills (NIMS) are incorporated into the standards. This course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COMPUTER NUMERICAL CONTROL (CNC) II
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Demonstrate and apply safety rules, regulations, routine care, and preventive maintenance of computer numerical control machines.
Project	2. Demonstrate complex computer numerical control programming skills using G and M codes and correct speed and feed codes to write computer numerical control milling programs for straight, angle, radii, and circular cuts. 3. Set up and machine a part according to specifications of a blueprint. 4. Interpret and demonstrate complex G code programs for CNC milling, including using a fourth axis for machining of shaft grooves or locking slots or rings.
Operations	5. Demonstrate proper setup of computer numerical control machines, including home setup and tool setup. *Examples: axis of motion; select from various operation modes; determine appropriate sequence of operation* 6. Describe and illustrate common problems and solutions with tooling and fixtures in CNC programming and machining. 7. Identify differences in setup, operation, and uses of two-, three-, four-, and five-axis CNC lathes.

Computer-Aided Design and Computer-Aided Manufacturing I

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Computer-Aided Design and Computer-Aided Manufacturing (CAD-CAM) I includes CAD-CAM safety, mathematics concepts, computer proficiency, programming CAM software, manufacturing of parts, and creating two-dimensional design topics. This entry-level course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**…"*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COMPUTER-AIDED DESIGN AND COMPUTER-AIDED MANUFACTURING I CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Safety	1. Apply safety rules, regulations, and procedures for maintaining and using CAD-CAM equipment.
Technology	2. Program software to perform CAD-CAM applications. 3. Demonstrate file management techniques with the CAM program, including creating a folder, saving a file to an existing folder, and retrieving and editing a file.
Advanced Mathematics	4. Use trigonometric ratios sine, cosine, tangent, and their inverses to solve various angles, lengths, and distance values for right triangles. a. Use and apply appropriate decimal rounding of trigonometric ratios to solve problems in design or drafting. 5. Create a two-dimensional design and a two-dimensional numeric control operation tool path for a mill or a lathe, including features that involve interfacing with the display screen, utilizing frequently used menus and hot keys, utilizing various tools displayed on the status menu, and generating and editing a G and M code with a post processor. 6. Construct a part to a specified tolerance range with CAD-CAM applications, utilizing workholding devices to locate part features and applying established manual machining techniques.

Computer-Aided Design and Computer-Aided Manufacturing II

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Computer-Aided Design and Computer-Aided Manufacturing I

Computer-Aided Design and Computer-Aided Manufacturing (CAD-CAM) II is designed to further the development of students' skills and knowledge of CAD-CAM safety procedures, advanced mathematics concepts, CAD-CAM project development, computer numerical control (CNC) mill and lathe procedures, three-dimensional tool path operations, and verification topics. This course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COMPUTER-AIDED DESIGN AND COMPUTER-AIDED MANUFACTURING II CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Safety	1. Apply safety rules, regulations, and procedures related to precision machining.
Advanced Technology	2. Apply trigonometry and geometry to solve various computer-aided design and drafting related problems in both two-dimensional and three-dimensional space settings. 3. Demonstrate critical thinking, problem-solving, and programming skills to create toolpaths for CNC machines. 4. Demonstrate file management skills within a CAD-CAM program for documentation of design. 5. Demonstrate CNC mill procedures utilizing CAD-CAM software to design and manufacture prototypes and finished products. 6. Demonstrate ability to select tooling, set up a CNC lathe, load and verify a program, and run a part. 7. Demonstrate the creation and management of a three-dimensional numeric control operation tool path for a lathe to create a part that meets customer specifications. 8. Use simulation to verify tool paths created in the CNC software to reduce machining errors.

Coordinate Measuring Machine

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Coordinate Measuring Machine is an entry-level course that includes care and safety, setup, analysis of data, and demonstration of proper procedures to inspect parts of coordinate measuring machines. This course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COORDINATE MEASURING MACHINE
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Follow safety rules, regulations, and procedures when operating a coordinate measuring machine (CMM). 2. Perform cleaning and preventive maintenance on a coordinate measuring machine.
Technology	3. Demonstrate file management techniques within a coordinate measuring machine, including creating a folder, saving a file to an existing folder, retrieving a file from an existing folder or storage system, editing a file, and printing an inspection report. 4. Locate software applications within the CMM.
Operations	5. Identify parts of the coordinate measuring machine and describe the features and functions of each. 6. Compare the machine coordinate system and the part coordinate system. 7. Complete alignments on a specified part to be measured by a coordinate measuring machine. 8. Demonstrate datum features on a specified part to be measured by a coordinate measuring machine. 9. Show translations on a specified part to be measured by a coordinate measuring machine. 10. Demonstrate rotations on a specified part to be measured by a coordinate measuring machine. 11. Demonstrate probe tip compensation for a specified part when using a coordinate measuring machine. 12. Use construction features for a specified part when using a coordinate measuring machine. 13. Interpret projections for a specified part when using a coordinate measuring machine. 14. Collect inspection data, including measuring a point, line, circle, and plane on a specified part.

15. Interpret coordinate measuring machine inspection reports.
    a. Analyze data contained in coordinate measuring machine inspection reports.
    b. Summarize an inspection report to include the process, measurements, and features of the final product.

Introduction to Lathe

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Introduction to Precision Machining

Introduction to Lathe emphasizes skills and techniques for using a lathe to perform cutting, center drilling, threading, knurling, and turning operations. Safety is a prime consideration in this course. This course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTRODUCTION TO LATHE
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Demonstrate care and safety for an engine lathe. *Examples: operating, cleaning, lubricating, setting up*
Lathe Operations	2. Demonstrate engine lathe operations, including mounting the chuck on the lathe, indicating the round stock in an independent jaw chuck, indicating the square stock in an independent jaw chuck, sharpening the lathe tool bit, centering or positioning cutting tools, face cutting a work piece, turning multiple diameters, center drilling a workpiece, demonstrating angle cuts, knurling a work piece, threading a workpiece, calculating speed and feed per material, and tooling. *Examples: threading a workpiece—chasing right and left hand external threads, manually tapping a hole, countersinking a hole, drilling a hole, picking up lead on existing threads* 3. Turn stock to specifications on a lathe, using a variety of methods and materials. 4. Identify the major parts of a lathe and explain their functions. 5. Demonstrate installation of a cutting tool. 6. Contrast turning, tapping, and threading.
Projects	7. Produce a completed lathe project according to specifications. 8. Demonstrate use of measuring tools, including calipers, dial indicators, and micrometers, to produce precision lathe projects.

Milling and Surface Grinder I

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Milling and Surface Grinder I provides an introduction to the skills needed to operate milling machines and surface grinders. Topics include milling and grinding safety, operation, and techniques. Student instruction in manufacturing reflects the national skills standards of the National Tooling and Machining Association (NTMA) and the National Institute for Metalworking Skills (NIMS). This entry-level course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

MILLING AND SURFACE GRINDER I
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Mill Safety	1. Apply safety rules, regulations, and procedures related to milling applications. 2. Demonstrate care and safety for operating milling machines. *Examples: operating, cleaning, lubricating, setting up*
Mill Operations	3. Use various types of milling cutters and applications, including center drill, drill, reamer, taps, end mills, fly cutter, and carbide insert cutters. 4. Complete milling machine operations, including verifying that a machining vise is true to machine axis, verifying that the machine head is perpendicular to the machine table, using workpiece clamping techniques, milling a flat surface, milling steps in a workpiece, performing slot milling, milling a square block, calculating speed and feed per material and tooling, and milling a pocket in a workpiece.
Surface Grinder	5. Demonstrate care and safety for a surface grinder. *Examples: operating, cleaning, lubricating, setting up* 6. Demonstrate grinding techniques, including mounting a grinding wheel, dressing a grinding wheel, grinding a flat surface, and grinding a workpiece square and parallel.

Drill Press

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Drill Press provides an introduction to drill press skills and techniques, including setting up and operating the machine, interpreting drawings, sharpening a twist drill, and conducting hardness tests. This entry-level course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces.
	2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork.
	3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing.
	4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway.
	5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

DRILL PRESS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Demonstrate care and safety for a drill press. *Examples: operating, cleaning, lubricating, setting up*
Drill Press Techniques	2. Demonstrate drill press techniques, following National Institute for Metalworking Skills (NIMS) Level I drill press standards.
Quality	3. Conduct hardness tests on a workpiece, including a file test and a Rockwell hardness test.
Controls	4. Identify and set the machine controls.
Operations	5. Set up and operate a drill press for hole work, center drill, drill, ream, spot facing, tapping, countersink, and counterbore. 6. Set drill presses for proper feed and speed for specific operations.
Drill Press Preparation	7. Describe the anatomy of a twist drill bit. 8. Sharpen a twist drill using the drill grinding machine and the offhand method, applying concepts of drill geometry.
Performance	9. Demonstrate the ability to use a tape measure for accurate cutting of metal parts. 10. Identify and use basic hand tools needed to adjust and maintain machine tools to manufacturers' specifications.

Print Reading

11. Read and interpret a mechanical drawing.

12. Demonstrate the fundamentals of blueprint reading.
    a. Identify product features, dimensions, and tolerances of an object from a multiview drawing.
    b. Identify geometric dimensioning and assembly tolerances on a drawing.
    c. Interpret dimensions of an object in a technical drawing.
    d. Interpret assembly drawings.

Intermediate Lathe and Bench Work

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Introduction to Lathe

Intermediate Lathe and Benchwork is designed to further the development of critical thinking and skills for lathe and bench work. Topics include lathe maintenance, lathe operations, and benchwork operations. Student instruction in manufacturing reflects national skill standards of the National Tooling and Machining Association (NTMA) and the National Institute for Metalworking Skills (NIMS). This course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTERMEDIATE LATHE AND BENCH WORK
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Safety	1. Follow safety rules, regulations, and procedures for filing and polishing a lathe.
Maintenance	2. Demonstrate preventive maintenance of the lathe, including cleaning, inspecting, lubricating, and setting up.
Operations	3. Demonstrate intermediate lathe operations, including calculating speed and feed per material and tooling, aligning the tailstock, reaming a hole, boring a hole, counterboring a hole, forming a cut, machining an O-ring groove, parting off the workpiece, turning a shaft between centers, and turning close-tolerance diameters. 4. Demonstrate intermediate boring, turning, facing, and tapping on a workpiece. *Examples: correctly set up a workpiece for parting/grooving, determine the taper calculation, correctly use tap guides, chamfer the edge of a hole* 5. Demonstrate advanced-level engine lathe operations, including calculating speed and feed for appropriate materials and tooling, turning multiple diameters, using a taper attachment, power tapping on a lathe, chasing right and left hand internal threads, boring a hole, and boring an internal angle. 6. Demonstrate advanced boring, turning, facing, and tapping on a workpiece according to NIMS Level I standards. 7. Demonstrate peck drilling.

Milling and Surface Grinder II

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Milling and Surface Grinder I

Milling and Surface Grinder II is designed to further the development of skills in milling and grinding operations, including higher-level milling and grinding tasks. Safety standards are stressed and are an important component of this course. Instruction in manufacturing reflects the national skills standards of the National Tooling and Machining Association (NTMA) and the National Institute for Metalworking Skills (NIMS). This course may be taken in the Modern Manufacturing program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

MILLING AND SURFACE GRINDER II
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Safety	1. Demonstrate care and safety procedures for operating milling machines. *Examples: operating, cleaning, lubricating, setting up*
Milling Operations	2. Demonstrate milling machine operations, including setting up and using a rotary table, machining a Woodruff keyway, cutting T-slots, centering a rotary table, boring and counterboring a hole, machining slots in a work piece, power tapping a hole, machining a close-tolerance square block, calculating speed and feed per material and tooling, milling multiple steps in a workpiece, and milling pockets on a workpiece. 3. Demonstrate operations for milling steps, slots, angles, and pockets in a work piece. 4. Demonstrate advanced milling operations, including calculating speed and feed for specified materials and tooling; power tapping a hole; indicating a round hole; milling a block square to close tolerance; milling precise angles on a workpiece; milling steps, slots, and pockets on a workpiece; and drilling a precise circular hole pattern. 5. Demonstrate procedures for milling advanced steps, slots, angles, and pockets in a workpiece according to NIMS Level I standards.
Grinding Operations	6. Demonstrate grinding techniques, including grinding a grooving tool, grinding an angle using a sine bar, and grinding a block square and parallel according to NIMS Level I standards. 7. Demonstrate safe methods of performing routine maintenance and care for a surface grinder. *Examples: operating, cleaning, lubricating, setting up*

Program: Robotics & Automated Manufacturing

Computer Integrated Design	
Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Computer Integrated Design emphasizes the use of modern technologies in the design and improvement of products. Three-dimensional CAD software is utilized to create, analyze, and document designs in accordance with standards set by industry. Safety in the modern manufacturing factory is also a component of the course.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COMPUTER INTEGRATED DESIGN
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Engineering Design Process	1. Create and maintain an engineering notebook for daily reflections, research, and prototype creation documentation. 2. Apply the design and problem-solving process as an iterative process incorporating science, mathematics, and engineering to optimally convert resources to meet a stated objective. 3. Communicate solutions utilizing technical writing skills, including correct spelling, proper grammar, and specialized vocabulary. 4. Assume and carry out a role in the smooth running of a team working toward the solution of a problem. 5. Produce a quantitative plan for the successful completion of a project. *Example: Gantt chart* 6. Assume responsibility for leadership roles and for actions, decisions, products, and policies in the governance of a project. 7. Evaluate the need for resources to complete a project and calculate their cost.
Sketching	8. Communicate ideas to a group through the use of sketches and other documentation. 9. Create necessary sketches to communicate ideas during the design process, utilizing basic shapes. *Examples: lines, circles, ellipses* 10. Apply isometric and orthographic sketches to add clarity to a design.

3D Solid Modeling Applications	11. Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas. 12. Create solid models utilizing concepts of parametric modeling. 13. Analyze models to determine whether necessary engineering design features are included. 14. Develop strategies for the rapid creation of design solutions by using solid models. 15. Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project. 16. Access, generate, process, and transfer information using appropriate technologies. 17. Design and create a model using additive manufacturing technology (rapid prototyping system). 18. Apply new principles to achieve more rapid and less costly development and deployment of new materials. 19. Utilize rapid prototyping (additive manufacturing) to create highly complex parts designed in a CAD system.
Mechanical Systems	20. Apply problem-solving methodology when devising solutions to mechanical motion problems. 21. Apply the design process in the development of a mechanical system. 22. Assign mathematical relationships to schematics that program machines to apply force. 23. Design a system that manages power to accomplish a task involving defined movement. 24. Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes. 25. Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open-ended problems.

Computer Integrated Production

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Computer Integrated Production highlights the technologies and production principles utilized in modern, clean production environments. The course emphasizes effective and energy-efficient control of conveyors and pneumatic control systems; the design and troubleshooting of data acquisition, programmable logic control, process monitoring, and automation and robotic systems; incorporating sensing and vision systems; and utilizing cameras and sensors to control automated systems.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COMPUTER INTEGRATED PRODUCTION CONTENT STANDARDS

Each content standard completes the stem *"**Students will**…"*

Computer Numeric Control (CNC) of Machines	1. Apply Cartesian coordinates to create toolpaths for machine tools. 2. Research and apply proper cutting tool speeds, feeds, and directions for manufacturing specified materials or products. 3. Create simple Numeric Control (NC) part programs using a text editor or a Computer-Aided Manufacturing package. 4. Analyze Numeric Control part program files to identify and correct errors. 5. Analyze part geometry to select appropriate cutting tools and fixturing devices needed to create a part using a CNC machine. 6. Edit the tool library of a CNC machine program to establish tool offset values.
Applying CAM Software to Create Problem Solutions	7. Design and prepare 3D models with appropriate units for use in toolpath generation. 8. Set up a CAM package by editing the material and tool libraries. 9. Generate tool paths from a CAD program and edit NC part program files to identify and correct errors.
Automation with Programmable Logic Controllers (PLCs)	10. Design and analyze an efficient electrical system to convert, transform, and transmit electricity. 11. Research and specify electrical devices necessary to fulfill power requirements. 12. Apply machine control systems, sensory feedback, and information processing to reduce the need for human work in manufacturing. 13. Use flow charts and state diagrams to apply logic in the design of control programs.

Applying Logic Software to Create Problem Solutions	14. Design a system of elements that manage power to accomplish a task involving defined movement. 15. Design a control system that uses feedback from the system to vary the speed and performance of a motor to achieve the greatest possible efficiency. 16. Formulate a system to utilize data collection and analysis to maintain and improve product quality and ensure that the product will satisfy design requirements. 17. Design and analyze the application of machine control systems, sensory feedback, and information processing to reduce the need for human work in manufacturing.
Pneumatics Design and Control	18. Construct systems that efficiently utilize a fluid (liquid or gas) under pressure to generate, transmit, and control power.
Work Cell Design	19. Design an integrated system of machines, machine tools, jigs, fixtures, instruments, and control programs to produce needed parts. 20. Create jigs, fixtures, alignment and drill guides, gauges, and other manufacturing and assembly tools with rapid prototyping (additive manufacturing) devices. 21. Research, construct, and evaluate a plan for an assembly line or work cell. 22. Identify systems, sub-systems, and typical components of an automated manufacturing operation. 23. Apply the necessary safety precautions associated with a fully automated system.
Business of Manufacturing	24. Research and categorize the activities that a business conducts to make discoveries that may lead to the development of new products or procedures or the improvement of existing products or procedures. 25. Research and evaluate the new approaches to rapid development and deployment of products that save time and increase efficiency. 26. Create a strategy to receive inventory just in time for the production process.

27. Evaluate the use of production, organization, planning, human and capital resources, and regulatory requirements to bring a product to market successfully and efficiently.
28. Create a quality management plan for an advanced manufacturing environment, including quality planning, quality control, quality assurance, and quality improvement.
29. Create a plan for protecting the health and safety of the people employed in a manufacturing environment.

Computer Integrated Automation

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Computer Integrated Automation covers designing cost-effective work cells incorporating automation and robotics to improve quality of final products, designing and creating mechatronic systems and automated tooling, and implementing maintenance principles in the modern manufacturing facility. The advanced production outlined in this course depends on the use and coordination of information, automation, network, vision, and sensing systems.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

COMPUTER INTEGRATED AUTOMATION
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Electrical and Control Systems	1. Design and analyze an efficient electrical system to convert, transform, and transmit electricity. 2. Create, read, and analyze schematics and provide a concise summary for documentation purposes. 3. Research and specify electrical devices necessary to provide power. 4. Apply machine control systems, sensory feedback, and information processing to increase the efficiency of automated manufacturing systems. 5. Use flow charts and state diagrams to apply logic in the design of control programs.
Sensors Logic and Data	6. Design a system using sensors to monitor changes and use that data to inform changes to the system. 7. Apply Boolean logic in the design of a system that monitors inputs. 8. Create programs to initialize, calibrate, and monitor system parameters. 9. Select and apply appropriate sensors to obtain data about system performance. 10. Design a system of elements that manages power to accomplish a task involving defined movement. 11. Design a control system to vary the speed and performance of a motor by utilizing feedback from the system to gain the most efficiency possible. 12. Formulate a system to utilize data collection and analysis to maintain and improve product quality and provide adequate confidence that the product will satisfy design requirements. 13. Design and analyze the application of machine control systems, sensory feedback, and information processing to increase efficiency.

Robotics	14. Design, construct, and operate a multi-axis robot for use in an industrial application. 15. Design and create the wiring diagrams for controlling the motion of a robotic arm. 16. Apply the degrees of freedom to describe arm movement used in the programming of the arm. 17. Integrate a robotic arm into an automated work cell to move and manipulate components. 18. Design and create grippers and other end effectors for custom use in an automated setting. 19. Create a system utilizing sensors to allow a robotic arm to make decisions based upon sensor input. 20. Design a system involving the integration of machines, machine tools, specialized dies, jigs, fixtures, and instruments used in production to create needed parts to make jigs, fixtures, alignment and drill guides, gauges, and other manufacturing and assembly tools with a rapid prototyping/additive manufacturing device.
Human-Machine Interface (HMI)	21. Design visual displays to obtain and display data from a process controlled by a programmable logic controller. 22. Create a system to view and remotely control a work cell. 23. Create a communication system to monitor and automatically capture data on demand for storage in a database. 24. Design a system to remotely monitor and display real-time machine parameters to allow for changes and updates to the operating parameters.
Internet of Things (IoT)	25. Analyze different types of network setups to select the most appropriate ones for specific tasks. 26. Compare network operating systems to select the most appropriate system for data networks. 27. Synthesize applications for use in gathering, analyzing, and display in information environments. 28. Design and implement a program for device security.

29. Evaluate various connectivity options for protocols for communication in the design stage of an automated workcell.
30. Create a method to collect, store, analyze, and display sensor data.
31. Apply network security systems and procedures to secure the elements of an IoT connected device.

Introduction to Robotics

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Introduction to Robotics is designed to introduce students to the fundamentals of robotics. The course emphasizes fundamentals of electrical current, digital circuits, electronic control systems, and the design and operation of robotic systems. This course may be taken in the Electronics program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**…"*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

INTRODUCTION TO ROBOTICS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Orientation	1. Gather and share information on how robotics has influenced the manufacturing process, citing real-world examples. a. List personal characteristics necessary to succeed in robotics. 2. Demonstrate how to program a robot, using safety devices and hand tools correctly.
Fundamentals of Electrical Current	3. Gather and share information on chemical, mechanical, and solar sources of electricity. 4. Explain the relationship of the atom to an electrical charge. 5. Gather and share information on electrical terms and units of measures, including direct and alternating current measured in amperes, the voltage measured in volts, the resistance measured in ohms, power measured in watts, and conductors and insulators. 6. Diagram components of a basic circuit. a. Design series, parallel, and combination circuits. b. Compute current, voltage, and resistance using available devices. 7. Construct electrical circuits utilizing soldering and breadboarding techniques. a. Measure current, voltage, and resistance in electrical circuits.
Digital Circuits	8. Gather and share information about basic digital principles, including signal levels and signal types. a. Explain various digital number systems. b. Interpret logic gate symbols used in digital circuits. c. Develop the truth table for each logic gate as specified in robotic applications.

Electronic Control Systems	9. Compare and contrast open- and closed-loop control systems. a. Document the differences between manual and automatic control systems. 10. Interpret symbols used in control circuit diagrams. a. Correlate construction, electrical, and mechanical schematic symbols to real-world devices. 11. Compare programming methods and the input and output devices used in motion control systems. a. Identify ways programmable logic controllers can be used. b. Develop a ladder logic diagram to perform a specific function. c. Model ladder logic programs for multiple programmable logic controllers.
Design	12. Explain and utilize robotics design terms, including *controller, teach pendant, manipulator, end-effector and end-of-arm tooling, degrees of freedom, work envelope,* and *power supplies*. 13. Compare and contrast types of robot configurations, including revolute, selective compliant assembly robot arm (SCARA), Cartesian, cylindrical, spherical, and jointed-arm. a. Describe the use of specialty robots in automated systems.
Operation	14. Demonstrate the proper use of input and output devices for performing robotic tasks. 15. Explain the operation of fluid power systems used in robotic systems. 16. Debug a robotic work cell. a. Identify robotic abnormalities. b. Change errors in robotics programs.

Robotics Applications

Course Credit	1.0
Grade Levels	10-12
Prerequisites	Introduction to Robotics

Robotics Applications standards mandate the design and construction of a robotic system with peripheral devices, including the design and creation of mechatronic systems and use of automated tooling. This course may be taken in the Electronics program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ROBOTICS APPLICATIONS
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Orientation	1. Implement safety procedures and rules in robotic applications. a. Maintain a safe work area around the robot and equipment. b. Demonstrate the correct use of hand tools used in robotics and surrounding systems.
Systems	2. Investigate and report on applications of a robotic system. a. Describe how robotic systems are incorporated into the manufacturing industry. 3. Compare uses of multiple robotic systems. 4. Formulate a plan to perform multiple robotic tasks, including a flow chart. a. Configure a robotic system plan to perform multiple tasks.
Peripheral Systems	5. Create plans and use them to program robots and peripheral devices to perform a variety of operations. 6. Plan a coordinated robotic system with peripheral devices. a. Outline a basic computer program to control robots and peripherals. b. List and explain applications of peripheral devices. 7. Verify the function of a coordinated robotic system.
Projects	8. Construct a robotic system with various peripheral devices. a. Program a coordinated robotic system. b. Test a coordinated robotic system. c. Test system performance of different robotic designs. 9. Predict system performance in a robotic device. 10. Verify system performance of different robotic designs.

Robotics and Automation

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Robotics and Automation is designed to enhance computer modeling skills by applying principles of robotics and automation to the creation of models of three-dimensional designs. Quality control measures in the modern manufacturing facility are also emphasized.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ROBOTICS AND AUTOMATION
CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Electronic Control Systems	1. Describe electronic control systems, including closed-loop and open-loop. 2. Explain functions of input and output devices used in electronic control systems, including switches, sensors, transducers, relays, timers, counters, motors, and actuators. 3. Interpret control ladder logic circuits. a. Correlate a ladder diagram to a flow chart.
Programmable Logic Controllers (PLCs)	4. Research and share information on possible uses of programmable logic controllers, including residential and commercial applications. 5. Integrate programmable logic controllers with input and output devices. a. Correlate inputs and outputs to real-world devices. 6. Program a controller to perform a specific task. a. Code ladder logic programs using programming software running on a personal computer.
Robotics	7. Interpret construction, electrical, and mechanical blueprints related to a variety of automated systems. 8. Utilize input and output devices for performing automated and robotic tasks. 9. Construct a robot to perform a specific task. 10. Diagnose problems with robotics systems and make necessary repairs.

Electronics and Control Systems

Course Credit	1.0
Grade Levels	9-12
Prerequisites	

Electronics and Control Systems provides instruction and experiences in electronic circuitry, emphasizing relays, sensors, variable frequency drives, and programmable logic controllers. This course may be taken in the Electronics program.

Foundational standards, shown in the table below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership qualities and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs), and learn and practice essential digital literacy skills. The foundational standards are to be incorporated throughout the course.

Each foundational standard completes the stem *"**Students will**..."*

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and handling hazardous materials and forces. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Advocate and practice safe, legal, responsible, and ethical use of information and technology tools specific to the industry pathway. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

ELECTRONICS AND CONTROL SYSTEMS CONTENT STANDARDS

Each content standard completes the stem *"**Students will**..."*

Safety	1. Adhere to safety rules for electronic power and control systems. a. Outline elements of a lockout/tagout (LOTO) program, describe the LOTO process, and test to ensure a zero energy state. b. Describe safety procedures for disconnecting or connecting electronic components. c. Summarize the NFPA 70E arc flash guidelines and explain their importance.
DC Power	2. Connect and test a DC power supply. a. Explain the operation of PN junction diodes, LEDs, Zener diodes, and voltage regulators. b. Describe the operation of half wave and full wave rectifiers. c. Measure output from a DC power supply to determine noise or quality of filtering.
Relays	3. Install and test a solid-state relay.
Sensors	4. Install and test analog electronic sensors. a. Document the operation of thermistors, RTD temperature sensors, and thermocouples. b. Document the operation of resistive, capacitive, and piezoelectric pressure sensors.
Variable Frequency Drives	5. Test capabilities of an AC variable frequency drive. a. Connect and operate an AC variable frequency drive (VFD) with an AC motor and relay control circuit.

Programmable Logic Controllers (PLCs)	6. Connect and transfer programs between a personal computer and a programmable controller via a serial, USB, or Ethernet connection. a. Demonstrate how programmable logic controllers are wired to power, input/output, and network devices. b. Create a basic programmable logic controller ladder-style program. c. Interpret programmable logic controller programs with internal and external contacts, timers, counters, non-retentive output coils, internal coils, subroutines, conditional commands, and math commands. d. Interpret programmable logic controller programs that control and sequence electric motors and fluid power systems. e. Explain the operation of basic programmable logic controller commands, including internal and external contacts, timers, counters, nonretentive output coils, and internal coils. f. Install and test a human-machine interface and programmable logic controller system.
Troubleshooting	7. Demonstrate basic electromechanical installation and troubleshooting. a. Make mechanical, electrical, and software adjustments to tune the performance of a machine run by a programmable logic controller. b. Plan and collaborate as a team to install, troubleshoot, and optimize systems.

BIBLIOGRAPHY

ACCCP Comprehensive Review and Orientation. Alabama Committee on Credentialing and Career Pathways. 6 Nov. 2019. m.nationalskillscoalition.org/resources/webinars/text/attachment-1.pptx. Accessed 13 Jan. 2020.

Alabama Course of Study: Career and Technical Education, 2008. Alabama State Department of Education, 2008. www.alsde.edu/sec/cte/CTE%20COS/2008%20Alabama%20Course%20of%20Study%20Career%20and%20Technical%20Education.pdf. Accessed 6 Jan. 2020.

Alabama Department of Labor, Alabama Labor Market Information Division. www2.labor.alabama.gov/workforcedev/AccelerateAL

Certified Production Technician. Manufacturing Skill Standards Council. www.msscusa.org/certification/production- certification-cpt/

CTE Career Pathways. Utah State Board of Education. www.schools.utah.gov/file/22c37e5d-1197-465a-9483-927693a64d3f. Accessed 6 Jan. 2020.

Engineering. Arizona State Department of Education. cms.azed.gov/home/GetDocumentFile?id=5a6b75683217e10b806cdf36. Accessed 12 Feb. 2020.

Ingenuity for Life: *Teachers' Edition.* Siemens Manufacturing and Automation, 2018. www.plm.automation.siemens.com/global/en/products/mechanical-design/.

Integrated Production Technologies Curriculum. Southern Regional Education Board. www.sreb.org/sites/main/files/file-attachments/ac_integrated_production_technologies.pdf?1458934898. Accessed 8 March 2020.

Introduction to Manufacturing Technology. Utah State Board of Education. www.schools.utah.gov/cte/manufacturing/courses?mid=5162&aid=1. Accessed 12 Feb. 2020.

Manufacturing Cluster. Ohio State Department of Education. education.ohio.gov/Topics/Career-Tech/Manufacturing- Technologies-Career-Field. Accessed 11 Feb. 2020.

Manufacturing Cluster. South Carolina Department of Education. www.ed.sc.gov/instruction/career-and-technical-education/programs-and-courses/career-clusters/manufacturing/. Accessed 12 Feb. 2020.

Manufacturing Cluster. West Virginia Department of Education. wvde.us/technical-education/curriculum-and-industry-credentials/manufacturing-cluster/. Accessed 11 Feb. 2020.

Manufacturing Cluster: CTE Programs and Standards. Arizona State Department of Education. www.azed.gov/cte/programs/.

Manufacturing Technologies Curriculum Framework. Nevada Department of Education. www.doe.nv.gov/uploadedFiles/ndedoenvgov/content/CTE/Programs/SkilledTechSciences/CurriculumFramework/Manufacturing-Technologies-CFWK-ADA.pdf. Accessed 12 Feb. 2020.

Mechanical Maintenance Technician. National Center for Construction Education and Research Curriculum. www.com.edu/ce/industrial-craft/mechanical-maintenance-technician. Accessed 8 March 2020.

Mississippi State University Research and Curriculum Unit. www.rcu.msstate.edu. Accessed 16 June 2020.

Production Standards: Manufacturing 1, Manufacturing 2, Manufacturing 3, Manufacturing 4. MSSC Proprietary Instructors Only Version. Manufacturing Skill Standards Council. www.msscusa.org/

Texas Essential Knowledge and Skills for Career and Technical Education. Texas Department of Education. ritter.tea.state.tx.us/rules/tac/chapter130/ch130m.html. Accessed 11 Feb. 2020.

2019 Alabama Manufacturing Facts. National Association of Manufacturers. www.nam.org/state-manufacturing-data/2019-alabama-manufacturing-facts/