CareerClusters™ PATHWAYS TO COLLEGE & CAREER READINESS
Manufacturing

Learning that works for Colorado CTE®

# Colorado CTE Course – Scope and Sequence

| Course Name | Manufacturing Technology II | Course Details<br>Course = 0.50 Carnegie Unit Credit | Credit= 1.0<br>Prerequisite: Manufacturing Technology I<br>CTE Credential: CTE Manufacturing |
|---|---|---|---|
| **Course Description** | Manufacturing Technology II is designed to provide students with the skills and knowledge to be effective in production environments as a machinist, CNC operator, or supervisor. Upon completion of this course, proficient students will demonstrate safety practices concerning machining technology, proper measurement and layout techniques, reading and interpreting drawings and blueprints, production design processes, and quality control procedures. Students will complete projects using various manufacturing techniques and build intermediate skills involving manufacturing techniques. Upon completion of this course, students will be knowledgeable about potential postsecondary education and career opportunities related to machining technology and will be prepared to enroll in more advanced machining courses in high school. | | |
| **Note:** | This is a suggested scope and sequence for the course content. The content will work with any textbook or instructional resource. If locally adapted, make sure all essential knowledge and skills are covered. | | |
| SCED Identification # | 13002 | Schedule calculation based on 60 calendar days of a 90-day semester. Scope and sequence allows for additional time for guest speakers, student presentations, field trips, remediation, or other content topics. | |

All courses taught in an approved CTE program must include Essential Skills embedded into the course content. The Essential Skills Framework for this course can be found at **https://www.cde.state.co.us/standardsandinstruction/essentialskills**

| Instructional Unit Topic | Suggested Length of Instruction | CTE or Academic Standard Alignment | Competency / Performance Indicator | Outcome / Measurement | CTSO Integration |
|---|---|---|---|---|---|
| **Career Development** | | Develop an education and career plan aligned with personal goals.<br><br>Understand and develop industry-desired employability skills.<br><br>Work productively in teams while integrating cultural | The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:<br><br>(A) determine advanced knowledge and skills required to gain | Investigate an assortment of occupations and manufacturing processes that rely on electromechanical principles and technologies, such as shipyard rigging, metalworking, agricultural mechanics, construction, and medical prosthetics. Write an informative text that summarizes the typical educational and certification requirements, working environments, and career | CTSO Personal and Workplace/Employability Skills Framework |

| | | | | | |
|---|---|---|---|---|---|
| | | and global competence.<br><br>Understand the MSSC and NIMS certification requirements. | industry-recognized certifications;<br><br>(B) identify employers' work expectations;<br><br>(C) demonstrate the standards required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, positive attitude, promptness, attendance, and integrity in a work situation;<br><br>(D) evaluate personal career goals; and<br><br>(E) demonstrate effective communication skills with individuals from varied cultures such as fellow workers, management, and customers.<br><br>The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and | opportunities for these occupations.<br>Demonstrate and practice teamwork, problem-solving, and decision-making skills required for success as a career machinist in a manufacturing environment.<br><br>Locate and assess the NIMS and MSSC websites and analyze its structure, policies, and requirements for their professional certifications. Explain what steps are required to obtain the certification, and how to prepare for the examination.<br><br>Analyze career and academic plan. Note any training or education deficiencies needed for entry-level employment and create a short and long-term action plan. Revise and update ICAP.<br><br>Identify desired qualifications for career advancement. Investigate opportunities to use the CTSO to develop and practice these identified workplace leadership skills. Identify other professional development organizations valued by the industry. | |

| | | | | | |
|---|---|---|---|---|---|
| | | | organizational skills. The student is expected to:<br><br>(A) use teamwork to solve problems;<br><br>(B) distinguish among team roles such as team leaders and team members;<br><br>(C) discuss Equal Employment Opportunity law in the workplace; and<br><br>(D) use time-management techniques to develop work schedules. | Investigate best practices for working in teams, including:<br><br>• how companies use teamwork to solve problems;<br>• how supervisors and project managers use time-management techniques to develop work schedules; and<br>• describe how teams measure results. | |
| **Safety** | | Interpret policies, procedures, and regulations for the workplace environment, including employer and employee responsibilities.<br><br>Identify regulations and safety standards that are implemented within manufacturing professions. | Comply with standard industry and classroom safety requirements. Student is expected to:<br><br>(A) understand and apply operational safety precautions for tools, equipment, and materials;<br><br>(B) apply Personal Protective Equipment (PPE) precautions; | Assess a given situation requiring the use of tools, equipment, and materials. Explain the applicability of various safety standards and procedures, and then safely demonstrate the use of the tools, equipment, and materials. For example, the hoisting of material requires lifting equipment of sufficient strength and applicability to the task, physical clearance from personnel, necessary alerting to others, and | |

| | | | | | |
|---|---|---|---|---|---|
| | | | (C) use health and safety practices for storing, cleaning, and maintaining tools, equipment, and supplies; and<br><br>(D) demonstrate skills related to health and safety in the workplace as specified by the Occupational Safety and Health Administration and other appropriate agencies. | authorization to use the required equipment, as well as conformance to Occupational Safety and Health Administration (OSHA) policies for avoiding and reporting accidents associated with this type of activity.<br><br>Assess a given situation requiring the use of hand and/or power tools. Select the proper tool and accessories, critique the readiness of the tool, use the tool to accomplish the desired task, and then return the tool and accessories to its proper storage. For example, creating a hole in aluminum requires the choice of the proper drill, drill bit, mounting hardware, lubricant, and safety procedures and precautions. The suitability of the drill bit is just one of many aspects that must be assessed and analyzed.<br><br>Analyze situations, create plans, and implement plans requiring the use of rigging to install and/or remove equipment and machinery. Perceive and critique the | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | safety risks involved in the job. For example, contrast the implications of lifting and positioning heavy objects of small compact shape versus those of large rotational moment.<br><br>Identify and evaluate situations that require electrical circuits and electromechanical principles. Develop and safely implement a plan to achieve the desired electromechanical objective. For example, recognize the power requirements for operating a 35 HP lathe, develop a wiring plan, and draft the details for a work order. | |
| **Applied Academic Skills** | | Analyze and apply appropriate academic standards required for successful industry sector pathway completion leading to postsecondary education and employment. | The student demonstrates applied academic knowledge for professional standards/employability skills as required by business and industry. The student is expected to:<br><br>(A) demonstrate the skills required in the workplace such as interviewing skills, | Apply mathematics concepts to solve electronics and manufacturing industry problems. For example, calculate the impact of the addition of random variables representing material dimensions that include several tolerances and dimensional allowances on the final combined work product. | |

| | | | | | |
|---|---|---|---|---|---|
| | | | flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;<br><br>(B) communicate effectively with others in the workplace to clarify objectives;<br><br>(C) apply mathematics to problems arising in everyday life, society, and the workplace;<br><br>(D) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution;<br><br>(E) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and | Create linear and angular drawings to represent real-world physical scenarios in two and three dimensions. For example, based on physical requirements for a bracket, develop a plan, and create a drawing based on the required geometry for accurately fabricating the bracket, including precise linear and angular measures. | |

| | | | | | |
|---|---|---|---|---|---|
| | | | techniques, including mental math, estimation, and number sense as appropriate, to solve problems;<br><br>(F) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate;<br><br>(G) create and use representations to organize, record, and communicate mathematical ideas;<br><br>(H) analyze mathematical relationships to connect and communicate mathematical ideas; and<br><br>(I) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. | | |

| | | | | | |
|---|---|---|---|---|---|
| **Software Design** | | Apply and identify the various phases of the product design development process to an existing or new product, product line, system design, or service.<br><br>Apply ideation techniques to explore and produce multiple concepts. | The student applies design skills to manufacturing. The student is expected to:<br><br>(A) use computer-aided design (CAD) software to complete a design;<br><br>(B) analyze the results of product testing in a simulated modeling environment;<br><br>(C) fabricate a prototype design of a mechanical part; and<br><br>(D) use computer-integrated manufacturing techniques to simulate a manufacturing process. | Create two-and three-dimensional scale drawings using accepted dimensioning rules and measurement systems. For example, as part of a project to fabricate a custom-shaped metal block, develop the complete drawings that specify the dimensional details for each step of the construction process. | |
| **CNC Operations** | | Produce parts to specifications or drawings provided on a computer numerical controlled (CNC) mill or lathe.<br><br>Demonstrate common functions or controls through manual input and | The student learns skills in production and programming of computer numerical control (CNC) operations. The student is expected to:<br><br>(A) design a project using computer-aided manufacturing (CAM) | Discuss and demonstrate the setup and safe operation of a CNC turning or milling center: the setup of tools in tool holders; referencing the vice or chuck to the machine's control; and referencing the cutting tool to the machine's control.<br><br>Demonstrate control panel commands to perform basic | |

| | | | | | |
|---|---|---|---|---|---|
| | | through programmed (stored) input.<br><br>Introduce basic G and M Code Programming focusing on the use of the Cartesian coordinate system and machine axis. | software for a CNC lathe;<br><br>(B) produce a product on a CNC lathe or simulator;<br><br>(C) design a project using CAM software for a CNC mill;<br><br>(D) produce a product on a CNC mill or simulator; and<br><br>(E) complete data sheets for plan, do, check, and act forms and projects. | milling or turning commands for motion of the tool path along the coordinate axis.<br><br>Convert a provided three-dimensional (3-D) or computer-aided design (CAD) data set to a set of machine instructions (G code) and then run the program producing the part to specifications provided.<br><br>Demonstrate a tooling change and tool selection to complete a multistep process on a<br>CNC milling or turning center. Produce a part with tight-radius pocket features by demonstrating proper cutting tool selection, proper tool-path, and proper speeds on a CNC milling machine. | |
| **PLCs and Electronics** | | Demonstrate understanding of the operation of electrical circuits and devices and relate it to the physical laws.<br><br>Understand how programmable logic controls are used in manufacturing production. | The student performs functions and solves problems involving control devices and electronics. The student is expected to:<br><br>(A) develop solutions to use control devices; and<br><br>(B) troubleshoot control devices such as | Demonstrate understanding of the operation of electrical circuits and devices and relate it to the physical laws (such as Ohm's Law, Kirchhoff's Law, and power laws) that govern the behavior of electrical circuits and devices. Accurately apply these physical laws to solve problems. For example, calculate and support the | |

| | | | | | |
|---|---|---|---|---|---|
| | | Apply technical knowledge of control devices and electronics to design and troubleshoot systems and equipment. | programmable logic circuit devices. | consequence of the maximum volume of air that can be moved by an AC-powered 50 HP electric motor.<br><br>Assemble the required connections of electronic test equipment to properly test the operation of basic electronic circuit behavior and performance, using equipment such as a digital multimeter, oscilloscope, and resistance bridge. For example, design, assemble, and verify a passive analog filter able to block at least 6 dB of audio-level signals of frequency greater than 500 Hz. | |
| **Mechanical and Fluid Systems** | | Understand and apply knowledge of mechanical fluid principles.<br><br>Understand how mechanical, pneumatic, and hydraulic devices are used in manufacturing production. | The student demonstrates an understanding of mechanical and fluid systems. The student is expected to:<br><br>(A) use mechanical devices;<br><br>(B) use pneumatics devices; and | Demonstrate understanding of the specific role of various mechanical components in mechatronic systems, discerning in a system schematic the effects of various design parameters on the system behavior. For example, predict the effect of a larger gear size. Compare and contrast these roles in the context of mechatronic systems, modules, and subsystems, explaining how | |

| | | | | | |
|---|---|---|---|---|---|
| | | | (C) use hydraulics devices. | designs vary within a given system or module.<br><br>Compare and contrast pneumatic and hydraulic systems. Identify the basic components of the systems and discuss how they are used in the manufacturing process. Identify the advantages and disadvantages for their use in a manufacturing facility.<br><br>Review drawings and interpret American National Standards Institute (ANSI) symbols to explain the function of a basic industrial hydraulic system. Develop a written text that outlines, describes, and logs recommended regular preventative maintenance on hydraulic equipment and controls. Use the text as a guide to execute the recommended procedures and record the details of the maintenance, explaining how the preventative maintenance will minimize failures in hydraulic equipment.<br><br>Identify and explain the operation and basic parts of gear, centrifugal, and positive | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | displacement pumps found in an industrial setting. Simulating a period of production downtime, safely and correctly disassemble and reassemble each type of pump (e.g., gear, centrifugal, and positive displacement) within a specified amount of time. | |
| **Electrical and Thermal Systems** | | Understand principles of electrical and thermal systems and how they are used in the manufacturing process. | The student demonstrates an understanding of electrical and thermal systems. The student is expected to:<br><br>(A) use electrical controls;<br><br>(B) analyze the effects of heat energy and temperature on products; and<br><br>(C) develop an understanding of ventilation such as heating, air conditioning, and refrigeration. | Create, measure, and analyze circuits prescribed by schematics to predict and verify the behavior of the electrical and physical properties of components (such as resistors, capacitors, diodes, transformers, relays, and power supplies). Report findings explaining the typical application and operation in circuits of the previously listed components, citing measurement and/or observed evidence supporting the explanation.<br>Explain the fundamental concepts of heating and combustion, including describing the processes by which heat is transferred. Illustrate the differences in heat transfer by conduction, convection, and radiation by performing | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | experiments related to manufacturing production. Record observations, citing evidence that heat is being transferred, identifying the heat source, noting the direction heat is moving, and determining the type of heat transfer taking place.<br><br>Relate the types of heat transfer to the various heating systems used within a building. Examine the basic layout of a heating system within a manufacturing building and note the movement of heat, identifying areas of heat loss and heat gain. Discuss how manufacturers control for heat generated by machines or systems.<br><br>Describe the relationship between temperature and pressure and relate it to use of refrigerant in cooling systems. Distinguish between absolute pressure and gauge pressure.<br><br>Summarize the processes involved in the basic mechanical refrigeration cycle, including the changes of state that occur and the | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | basic patterns of the refrigerant flow. Analyze the major components of cooling systems and how they function, including compressors, condensers, evaporators, and controls. Draw evidence from textbooks, professional journals, and instructional websites to discuss how manufacturing facilities use the refrigerant cycle and the functioning processes of cooling systems in manufacturing production. | |
| **Quality Control** | | Apply quality control tools and techniques to manufacturing processes, systems, and products.<br><br>Analyze production controls and manufactured parts specifications using quality control techniques and precision measuring tools. | The student analyzes quality-control systems and techniques. The student is expected to:<br><br>(A) understand and apply statistical process control;<br><br>(B) understand how blueprints and diagrams represent specifications;<br><br>(C) validate that a provided part meets specifications from its engineering drawing by comparing | Analyze and describe a variety of quality control constraints on manufacturing materials, parts, and processes that impact the suitability of a given electromechanical production process. Collect and interpret data that includes, but is not limited to, physical and electrochemical properties such as size, mass, hardness, pH, temperature, conductivity, rate, and so forth, and synthesize the results to yield a clear, written documentation of the findings. For example, assist a quality assurance inspector who must carefully complete | |

| | | | | | |
|---|---|---|---|---|---|
| | | | specifications (geometric dimensioning and tolerancing) and by demonstrating proper technique using appropriate precision measuring tools;<br><br>(D) examine quality control for diverse materials;<br><br>(E) determine hardness values of different materials; and<br><br>(F) analyze attribute and Pareto charts. | the steps of a standard inspection order to certify an incoming shipment of raw material by making several measurements and tests for conformance to specification.<br><br>Inspect and interpret blueprints, schematic diagrams, or written specifications for electromechanical devices and systems. Explain how pictorial representations relate to an actual project layout, verifying sufficient agreement as prescribed by specified tolerances. | |
| **Electrical Controls and Manufacturing Systems** | | Apply understand of electrical control and manufacturing devices to design a basic manufacturing system. | The student develops a system using electrical controls and pneumatics or hydraulics devices. The student is expected to:<br><br>(A) design a system that incorporates electrical controls and either a pneumatic or hydraulic device;<br><br>(B) build a system that incorporates electrical controls and either a | Identify and demonstrate basic troubleshooting strategies appropriate for evaluating Electronic circuits/systems and electromechanical devices. For example, in a relay-logic circuit with four display bulbs, develop and implement a troubleshooting strategy to remedy a bulb that fails to light.<br><br>Given a malfunctioning electromechanical system, use resources such as | |

| | | | | | |
|---|---|---|---|---|---|
| | | | pneumatic or hydraulic device; and<br><br>(C) test and troubleshoot the system that incorporates electrical controls and either a pneumatic or hydraulic device. | blueprints, diagrams, and equipment manuals to troubleshoot the machinery. Develop and graphically illustrate at least three possible solutions to the problem. Select the optimal solution and justify the selection with evidence drawn from the resources listed above. | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |