CareerClusters™ PATHWAYS TO COLLEGE & CAREER READINESS
Manufacturing

Learning that works for Colorado CTE®

Colorado CTE Course – Scope and Sequence

Course Name	Manufacturing Technology	Course Details	Credit = 1.0
		Course = 0.50 Carnegie Unit Credit	CTE Credential: CTE Manufacturing; CTE STEM
Course Description	This courses focuses on introducing and building basic to intermediate-level skills for manufacturing technicians. Students will learn about the operation of various manufacturing technologies and develop intermediate skills involving CNC machine operation and robotic machine operation.		
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		Identify types of technology required to perform workplace tasks in the Manufacturing industry including computerized systems and essential project management practices. Acquire and accurately use manufacturing sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats.	The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to: (A) explain the role of an employee in the manufacturing industry; (B) apply critical-thinking skills; (C) demonstrate the ability to solve problems using critical-thinking skills; and (D) demonstrate knowledge of basic	Describe strategies used to promote collaboration, trust, and clear communication among internal and external parties in the industry. Practice effective verbal, nonverbal, written, and electronic communication skills for working with colleagues, employers, clients, and other personnel while demonstrating the ability to: listen attentively, speak courteously and respectfully, resolve conflict, and respond to criticism.	

			computer systems and software application used in the manufacturing sector.	Investigate certifications that are required for various position levels within the industry. Compare the certification requirements. Scan job postings for software skill requirements. Analyze the skills companies are requiring and determine the recommendations for various levels of employment. Determine if skillsets within similar software products appear to be transferrable.	
Safety		Interpret policies, procedures, and regulations for the workplace environment, including employer and employee responsibilities.	Comply with standard industry and classroom safety requirements. Student is expected to: (A) locate, and adhere to, Safety Data Sheet (SDS) instructions; (B) apply Personal Protective Equipment (PPE) precautions; (C) use health and safety practices for storing, cleaning, and maintaining tools, equipment, and supplies;	Demonstrate adherence to industry standard practices regarding general machine safety, tool safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE) as recommended by Occupational, Safety & Health Administration (OSHA) regulations Adhering to proper safety guidelines, develop a schedule and create documents for a checklist to perform daily, weekly, and/or	

			(D) be informed of laws/acts pertaining to the Occupational Safety and Health Administration (OSHA).	monthly routine maintenance on hand tools, conventional machines, and computer numerical control (CNC) machine tools. The checklist should also include, but is not limited to, cleaning the work area and appropriately handling and disposing of environmentally hazardous materials	
Design Software		Understand the basic product design and development process as it relates to the design of a product, line of products, system design, or services. Understand and apply engineering software design and drafting tools. Design and create a product using the engineering design process (design, prototyping, testing, evaluation, and redesign).	The student applies software skills to manufacturing production and design. The student is expected to: (A) use computer-aided design (CAD) software to complete a design; (B) analyze the results of product testing in a simulated modeling environment; and (C) fabricate a prototype design of a mechanical part.	Demonstrate ability to use CAD software. Examples of assignments include: • Prepare isometric, pictorial drawings of machine parts utilizing AutoCAD. • Prepare auxiliary views of machine parts with AutoCAD that comply with the ASME Y14.3-2003 standard. • Create, insert and edit blocks with AutoCAD or SolidWorks. • Utilize AutoCAD or SolidWorks to prepare multi-sheet working drawings for machine assemblies that comply with the ASME Y14.34-2008 standard. • Create 3D models of machine parts utilizing	

				AutoCAD or SolidWorks software	
Additive Processes		Understand the additive manufacturing process. Understand the advantages and disadvantages of using additive manufacturing. Apply technical knowledge of additive manufacturing equipment operation.	Understand and apply knowledge of additive manufacturing processes. Student is expected to: (A) identify and describe additive manufacturing processes (e.g., casting, molding, and 3D printing); (B) develop a list of additive operations and identify the sequence needed to make a specific product; (C) construct a 3D model utilizing a design software; (D) print a 3D model utilizing the additive process; and (E) research plating and finishing techniques and their uses as an additive process.	Explain the processes used in additive manufacturing for a range of materials and applications. Create a list of additive operations and identify the sequence needed to make a specific product or for a particular machine. Understand the role of additive manufacturing in the design process and the implications for design. Describe additive manufacturing and explain its advantages and disadvantages. Research plating and finishing techniques and their uses as an additive process. Based on the research report on: • the effects of surface finish and microstructural properties on behavior for components produced using additive manufacturing • identify residual stresses that may occur during	

				additive manufacturing and their effects. Design and print a 3D model utilizing the additive process.	
PLCs		Understand how programmable logic controls are used in manufacturing.	The student gains skills in writing programmable logic controls so that a robot can work in coordination with a machine. The student is expected to: (A) use computer-integrated manufacturing techniques to simulate a manufacturing process; (B) Identify applications of control logic (C) Distinguish between programmable controllers, their components, and their functions (D) Interpret programming diagrams (e.g., flow charts) (E) Sketch programming diagrams for real world applications; and	Create a flowchart of a program for a robotic system. Convert the flowchart into a working program. Test, modify, and optimize the program. Write a technical report evaluating the performance of the program. Support all claims with specific examples. Log, store, and export data received from two or more sensors (for example, vision/light, audio, and touch) in a robotic or automated system. Explain why these procedures would be useful and provide specific examples.	

			(F) set up and test programmable logic circuit devices.		
Electronics		Demonstrate understanding of the operation of electrical circuits and devices and relate it to the physical laws. Apply technical knowledge of control devices and electronics to manufacturing systems and equipment.	The student performs functions and solves problems in the electricity and electronics field. The student is expected to: (A) research the use of control devices; and (B) demonstrate the use of control devices.	Demonstrate understanding of the specific roles of various electrical components discerned in a circuit schematic by correctly predicting the effects of changing selected parameter values. For example, predict the effect of halving a resistor's value. Compare and contrast these roles and explain how electronic designs vary within a given system or module. Create, measure, and analyze basic director current (DC) circuits prescribed by schematics using Ohm's law, Kirchhoff's law, and Watt's law to predict and verify circuit behavior. Apply understanding of these laws to troubleshoot simple circuits, and document the steps required to remedy the trouble. Create, measure, and analyze circuits prescribed by schematics to predict and verify the behavior of series versus parallel DC circuits or	

				resistances. Where unexpected behavior is observed, cite specific evidence to explain the observations. Using technical documentation, such as manuals and schematics, craft an informative narrative to explain the physical operation of electromagnetic and electrostatic components (such as coils, solenoids, relays, and various sensors) in a mechatronic system. Interpret resolved work orders by analyzing underlying issues and explaining the correct physical operation of the included components. 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.	

Subtractive Manufacturing Processes		Understand and apply knowledge of subtractive manufacturing processes, tools, and equipment.	The student learns skills in production and programming of computer numerical control (CNC) operations. The student is expected to: (A) design a product using computer-aided manufacturing (CAM) software for production on a CNC lathe; (B) produce a product on the CNC lathe or a simulation; (C) design a product using CAM software for production on a CNC mill; (D) produce a product on the CNC mill or a simulation; and (E) complete data sheets for plan, do, check, and act forms and projects. Utilize manual subtractive equipment to produce a specific product. Student is expected to:	Demonstration of CNC process knowledge and technical skills: • Identify and describe subtractive manufacturing processes • Explain the computer numerical control (CNC) processes and software requirements (e.g., Cartesian coordinates, numeric code, machine code, and import/export programs) • Perform safety inspections of subtractive equipment and accessories • Demonstrate the ability to use manual and computer numerical control subtractive equipment (e.g., oxy-fuel cutting, plasma cutting, mills, lathes, drill presses, saws, routers, and grinders) • Determine appropriate tooling, cutting speeds, and feed rates	

			(A) demonstrate use of manual subtractive equipment and tools to create or refine a product or part.	• Develop a list of manual material -cutting operations and identify the sequence needed to make a specific product • Develop a list of CNC material-cutting operations and identify the sequence needed to make a specific product • Utilize a model or drawing to develop and adjust a CNC tool path • Utilize CNC subtractive equipment to produce a specific product	
Mechanical and Fluid Systems		Apply fundamental power system principles for manufacturing applications.	The student knows mechanical and fluid systems. The student is expected to: (A) identify power systems; (B) identify, describe, and demonstrate the use of mechanical devices; and	Demonstrate understanding of power systems by being able to: • Define terms used in power systems (e.g., power, work, horsepower, and watts) • Identify the basic power systems • List the basic elements of power systems • Summarize the advantages and	

			(C) identify, describe, and demonstrate the use of fluid devices.	disadvantages of various forms of power • Define potential and kinetic energy • Identify forms of potential and kinetic energy • Calculate the efficiency of power systems and conversion devices • Demonstrate the use of an energy conversion device Demonstrate knowledge of Mechanical Systems: • Locate and explain examples of the six simple machines, their attributes and components • Measure forces and distances related to mechanisms • Calculate mechanical advantage • Design, construct, and test various basic mechanical systems Develop a system to demonstrate force, torque, work, and power acting upon	

				or being done by a robotic or automated system. Justify the design by creating mathematical models that show the calculations. Demonstrate knowledge of Fluid Systems: • Define fluid systems (e.g., hydraulic, pneumatic, and vacuum) • Identify and define the components of fluid systems • Compare and contrast hydraulic and pneumatic systems • Identify the advantages and disadvantages of using fluid power systems • Explain the difference between gauge pressure and absolute pressure • Discuss the safety concerns of working with liquids and gases under pressure • Calculate mechanical advantage using Pascal's law	

				• Calculate values in a pneumatic system, using the ideal gas laws • Design, construct, and test various fluid systems	
Electrical and Thermal Systems			The student knows electrical and thermal systems. The student is expected to: (A) identify and describe electrical devices; (B) demonstrate the use of electrical devices; and (C) research the effects of heat energy and temperature on products.	Demonstrate knowledge of Electrical Systems: • Define AC and DC electrical systems and terminology • Discuss the safety concerns of working with electricity • Describe the principles of generation, transmission, distribution, and storage of electricity • Compute values of current, resistance, and voltage using Ohm's law • Identify series, parallel and series- • parallel (combination) circuits • Solve series and parallel circuits using basic laws of electricity including Kirchhoff's laws	

				• Introduce single-phase and three-phase AC power • Construct and test simple electrical circuits from a schematic	
Quality Control		Understand and defend the purposes and processes of inspection and quality control in machining and forming processes. Identify and explain machining and forming imperfections and their causes. Identify and explain destructive and nondestructive examination practices.	The student understands quality-control systems. The student is expected to: (A) research and recognize industrial standards such as International Standards Organization and Military Specifications; (B) identify major quality control theories; (C) explain attribute and Pareto charts; (D) apply statistical process control; and (E) identify quality control testing methods including destructive and nondestructive.	Research how business operations contribute to quality control. Report on how business cycles in manufacturing operations are used for quality control purposes. Identify quality control theories: • Describe Lean manufacturing and explain its importance • Describe Just-in-Time systems • Identify and describe the importance of shift to shift communications Investigate the importance of quality assurance systems. Discuss the ramifications of inspecting for quality versus building in quality processes. Identify various quality control tools and techniques and give examples on how they are used. (Control charts,	

				Histograms, Pareto, Scatter diagrams, etc.) Research destructive and non-destructive testing techniques and compare and contrast their effectiveness.	