

Colorado CTE Course – Scope and Sequence

Course Name	Manufacturing Technology III		Course Details	Credit= 1.0-2.0 Prerequisite: Manufacturing Technology II CTE Credential: CTE Manufacturing	
			Course = 0.50 Carnegie Unit Credit		
Course Description	Manufacturing Technology III is an advanced level contextual course that builds on the introductory skills learned in the entry-level manufacturing and machining courses, stressing the concepts and practices in a production environment supported by advanced machining and engineering facilities. Students will design, produce, and maintain products that are defined by detailed technical specifications. Emphasis is placed on quality control, safety and engineering codes and standards, and production-grade machining systems. Upon completion of this course, proficient students will be able to examine blueprints and specification drawings to plan and implement the manufacture of products, machine parts to specifications using both manual and computer-controlled machine tools, and measure, examine, and test completed products to check for defects and conformance to specifications.				
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 and Employability Skills		Understand industry certification requirements. Develop an education and career plan aligned with personal goals. Work productively in teams while integrating cultural and global competence.	The student demonstrates career readiness and professional standards/employability skills as required by business and industry. The student is expected to: (A) determine advanced knowledge and skills	Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, and fire safety to protect all personnel and equipment. Demonstrate and practice teamwork, problem-solving, and decision-making skills required for success as a	SkillsUSA or TSA personal and workplace skills framework

			required to gain industry-recognized certifications; (B) identify employers' work expectations; (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; (D) evaluate personal career goals; (E) demonstrate effective communication skills with individuals from varied cultures such as fellow workers, management, and customers; and (F) describe the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills.	career machinist in a manufacturing environment. Investigate the top credentials required by the industry for various pathways in manufacturing or specific occupations. Locate and assess the credentialing body's websites and analyze its requirements for the certifications. Explain what steps are required to obtain the certification, and how to prepare for the examination. 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. 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. Explore work-based learning and employment opportunities. Review and	
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				update resumes and employment cover letters. Conduct mock-interviews.	
Safety		Identify regulations and safety standards that are implemented within the metal fabrication and machining professions.	Understand and apply practices towards creating and maintaining safe working environments. Student is expected to: (A) demonstrate skills related to health and safety in the workplace as specified by the Occupational Safety and Health equipment and other appropriate agencies; (B) use personal protective equipment; (C) demonstrate safe handling and use of tools, equipment, and materials; (D) research and apply technical and regulatory information for the safety and use of materials; and (E) dispose of environmentally hazardous materials associated with and used	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 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. Accurately read, interpret, and demonstrate adherence to safety rules, including rules published by the (1) National Science Teachers Association (NSTA), (2) National Electrical Code (NEC), (3) Occupational Safety and Health Administration (OSHA) guidelines, (4) American	

			in metal fabrication manufacturing.	Society for Testing Materials; ANSI Z49.1: Safety and Welding, Cutting, and Allied Processes, and (5) state and national code requirements. Be able to distinguish between rules and explain why certain rules apply. Identify and explain the intended use of safety equipment available in the classroom. For example, demonstrate how to properly inspect, use, store, and maintain safe operating procedures with tools and equipment.	
Welding Operations (Optional)		Identify materials and resources commonly used and recycled in welding and metal fabrication. Apply basic knowledge of using and maintaining professional welding and equipment. Identify and use the basic weld types, weld joints, and weld positions.	The student knows the function and application of the tools, equipment, technologies, and materials used in metal welding fabrication. The student is expected to: (A) operate various welding machines, cutting equipment, and grinding equipment commonly employed in metal fabrication;	Interpret and use a welding sketch or drawing to demonstrate the proper setup of a shield metal arc welder. Use the shielded metal arc welding (SMAW) process and make single-pass and groove welds in the following positions: a. Flat b. Horizontal c. Vertical d. Overhead Examine a given set of specifications for welding operations and properly set	

			(B) read and apply welding specifications, drawings, and blueprints; (C) understand and apply welding terminology; (D) demonstrate welding and joining techniques;	up a metal inert gas (MIG) welder to demonstrate the following five basic weld joint designs. Distinguish between the weld joint designs and provide various scenarios of how they are best applied. For example, edge joints are usually welded on one side, whereas a butt joint can be welded on both sides. - Lap joint - Butt joint - Corner joint - Edge joint - T-joint Demonstrate the proper use of various types of grinders, such as hand-held and pedestal bench. Compare and contrast the process to use each grinder when performing cutting, smoothing, and deburring operations on a piece of metal. For example, use a grinder to cut and bevel pipe and plate prior to welding. Manage and coordinate the operation of the cutting pieces, feeds, and mounts associated with both manual and computer-numerical-controlled (CNC) machining	
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				tools to complete projects involving: a. Milling machines, such as indexing operations using a dividing head and rotary tables b. Lathes, such as re-chase and internal threads, taper turning with taper attachments and compound rests, internal tapered surfaces, follower and steady rests For example, select the correct cutting tools and speeds for the CNC processes to create Delrin (plastic) shafts and gears for a class robotics project.	
Machining		Describe and demonstrate various machining techniques including procedures on lathe and milling machines.	The student applies the advanced concepts and technical knowledge and skills of the machining industry to simulated and actual work situations. The student is expected to: (A) use various work mounting procedures on appropriate machines; (B) examine the cutting operations on lathe and milling machines;	Manage and coordinate the operation of the cutting pieces, feeds, and mounts associated with both manual and computer-numerical-controlled (CNC) machining tools to complete projects involving: a. Milling machines, such as indexing operations using a dividing head and rotary tables b. Lathes, such as re-chase and internal threads, taper turning with taper attachments and compound rests, internal tapered	

			(C) execute lathe procedures such as cut threads, turn tapers, etc.; and (D) machine precision pieces.	surfaces, follower and steady rests For example, select the correct cutting tools and speeds for the CNC processes to create Delrin (plastic) shafts and gears for a class robotics project.	
Electrical Circuits		Apply the appropriate mathematical calculations and scientific principles used in servicing and repair of electrical systems and components. Apply Ohm's Law to calculate resistance, current flow, and voltage in series, parallel, and combination circuits.	The student learns the electrical concepts used in Ohm's law applied to direct current and series circuits and understands series parallel circuits, resistive circuits, Kirchhoff's voltage and current laws, and circuit analysis. The student is expected to: (A) recognize what atoms are and what atoms are composed of; (B) define voltage and identify the ways in which it can be produced; (C) explain the difference between conductors and insulators; (D) define the units of measurement used to measure the properties of electricity; (E) explain how voltage, current, and resistance	Identify the basic characteristics and distinguish between the operation of direct current (DC) and alternating current (AC) electricity. Explain how and why the different currents are used. Provide examples of devices that use AC and DC respectively. Demonstrate an understanding of Ohm's law, and apply it to solving given problems in electrical systems. Defend the solution using supporting evidence that explains the cause and effect relationship between Ohm's law and each of the following: - Voltage - Current - Resistance - Voltage drop	

			are related to each other; (F) calculate an unknown value using the formula for Ohm's law; (G) explain the different types of meters used to measure voltage, current, and resistance; (H) calculate the amount of power used by a circuit using the power formula; (I) explain the basic characteristics of a series, parallel, and combined series-parallel circuit; (J) calculate, using Kirchhoff's current law, the total current in parallel and series-parallel circuits; and (K) find the total amount of resistance in a series, parallel, or combined series-parallel circuit.	Examine electrical circuits and components. Solve various series-parallel circuit structures, using appropriate instruments to measure watts, volts, Ohms, and amps. Explain the multistep procedure used to solve each problem and justify the calculations using Ohm's law. Explain basic control wiring and wiring processes used in the electrical industry. Properly apply these processes by wiring and testing devices, control circuits, and systems. For example, wire and test electrical switches and devices used in a typical electromechanical system. Explain electron flow as it relates to electricity by creating a diagram or model to illustrate electron and induction flow. Use the model to also explain the role of magnetism and electromagnetic induction in electrical systems, including a comparison of the following magnetism concepts to their electrical counterparts: - Reluctance to resistance - Field distance to voltage	
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				c. Magnetic force to current	
Conductor Termination and Splices (Optional)		Understand the methods for preparing terminations and splices of electrical cable.	The student knows the methods of terminating and splicing conductors of all types and sizes and the preparation and taping of conductors. The student is expected to: (A) describe how to make a good conductor termination; (B) prepare cable ends for terminations and splices; (C) install lugs and connectors onto conductors; (D) train cable at termination points; (E) explain the role of the National Electrical Code in making cable terminations and splices; (F) explain why mechanical stress should be avoided at cable termination points; (G) describe the importance of using	Research the National Electrical Code (NEC) and local code requirements for the splicing, terminating, and insulating of conductors. Citing information found in code, write an explanation describing how and when it is appropriate to use wire nuts, crimp-on wire lugs, or mechanical compression connectors for making connections. Also include special considerations for making splices and connections to aluminum, as well as insulation systems applicable to common splices and terminations. Describe tools and techniques for stripping and training conductors. Explain why a good connection is important. Terminate conductors using selected crimp-type and mechanical-type terminals and connectors. Demonstrate how to reinsulate electrical connections using electrical tape, heat shrink insulators	

			proper bolt torque when bolting lugs onto bus bars; (H) describe crimping techniques; (I) select the proper lug or connector for the job; (J) describe splicing techniques; and (K) explain how to use hand and power crimping tools.	and motor connection kits. Explain the uses for each type. Explain why mechanical stress should be avoided at cable termination points.	
Fuses and Circuit Breakers (Optional)		Understand the operating principles of circuit breakers and fuses in electrical systems.	The student knows the practical application of fuses and circuit breakers. The student is expected to: (A) explain the necessity of overcurrent protection devices in electrical circuits; (B) define the terms associated with fuses and circuit breakers; (C) describe the operation of a circuit breaker;	Explore the characteristics and uses of fuses and circuit breakers. Apply this information to develop and explain a procedure that could be used to select a specific choice of fuse or circuit-breaker for over-current protection. Identify various examples of fuses and circuit breakers. Examine the markings printed on a fuse and identify the characteristics of a fuse needing replacement. Using physical observation and technical manuals, explain how to classify a circuit	

			(D) select the most suitable overcurrent device for the application; (E) describe the operation of single-element and time-delay fuses; (F) explain how ground fault circuit interrupters can save lives; (G) calculate short circuit currents; and (H) describe troubleshooting and maintenance techniques for overcurrent devices.	breaker by its voltage, current, and interrupting-capacity ratings. Following the correct electrical code practices for residential service, demonstrate the procedures to install, wire, test, and operate fuses and breakers in both single- and three-phase circuits. Demonstrate effective grounding practices, including the connection of ground wires and installation of bonding straps.	
Schematics		Interpret and apply information from technical drawings, schedules, and specifications used in the construction and manufacturing trades. Identify the elements used in technical drawings, including types of lines, symbols, details, and views. Identify plumbing, electrical, and mechanical symbols and other abbreviations used in	The student learns electrical symbols and their use in design drawings. Additionally, students learn to interpret schematics, one-line diagrams, and wiring diagrams. The student is expected to: (A) explain the basic layout of a design drawing;	Review a basic process instrument diagram (PID) and a basic electrical elementary print. Interpret the symbols to identify the actual field devices of a process loop (PID) and control loop (electrical elementary print). Explain and document the basic operation of the devices and equipment for both the process (PID) and control (electrical elementary print) loops.	

		construction and mechanical drawings.	(B) identify common symbols and the various types of lines used on drawings; (C) interpret electrical drawings such as site plans, floor plans, and detail drawings; (D) read equipment schedules found on electrical drawings; and (E) describe the type of information included in electrical specifications.		
Single-Phase Transformers		Understand the operating principles of single-phase transformers.	Apply knowledge of single-phase transformers to manufacturing systems and equipment. Student is expected to: (A) describe single-phase transformer operation; (B) list the different types of single-phase transformers; (C) identify the voltage relationships for single-phase transformers; and	Explain the operation of a basic single-phase transformer. Given the following scenarios, examine and confirm that the transformer is operating correctly. Write a brief justification supporting the conclusion of each examination. In groups or as a class, discuss results and provide constructive feedback. a. Single-phase step-up transformer b. Single-phase step-down transformer c. Single-phase isolation transformer	

			(D) discuss isolation and auto-transformer operation and applications.	d. Single-phase current transformer	
Computers and Electronics		Understand fundamental control system design and develop systems that complete preprogrammed tasks.	Understand fundamental control system design and develop systems that complete preprogrammed tasks. Student is expected to: (A) identify the elements and processes necessary to develop a controlled system that performs a task; (B) demonstrate the use of sensors for data collection and process correction in controlled systems; (C) perform tests, collect data, analyze relationships, and display data in a simulated or modeled system using appropriate tools and technology; (D) program a computing device to control systems or process; (E) use motors, solenoids, and similar	Given a set of logic statements and schematic circuits, construct the logic circuits described using the following: a. AND, OR, NOR, and XOR gates b. Flip-flops, counters, and gates Document and define each logic gate including a drawing, a description of its function in a short sentence or paragraph, a specification of each truth table, and the equation for each gate. Given a working programmable logic controller (PLC), an operator interface, and interfacing computer, safely set up a communication loop in order to view and explain the program's purpose. Identify and explain the functions and interrelationships among the following PLC components: a. Power supply b. CPU c. Input modules d. Output modules	

			devices as output mechanisms in controlled systems; (F) assemble input, processing, and output devices to create controlled systems capable of accurately completing a preprogrammed task.	e. Analog input and/or modules	
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Motors		Describe AC circuits and apply scientific principles to the operation of motors.	The student gains knowledge of alternating current and direct current motors with specific attention being given to main parts, circuits, and connections. The student is expected to: (A) understand terminology associated with AC/DC motors and operation; (B) describe the various types of motor enclosures; (C) describe how the rated voltage of a motor differs from the system voltage; (D) describe the basic construction and components of a three-	Given a specified application in an electromechanical system, properly select a motor based upon its intended use. Using resources such as technical manuals and industry standards, determine the size, speed, operating voltage, and National Electrical Manufacturing Association (NEMA) type for the required motor. Present a justification of the selection to classmates. Be prepared to answer any questions with evidence to support the selection. Consult multiple sources such as National Electrical Code (NEC), Occupational Safety and Health Administration (OSHA) regulations, and given installation drawings. Using this information, determine the required over-current protection, motor control circuits, conductor types and	

			phase squirrel cage induction motor; (E) explain the relationships among speed, frequency, and the number of poles in a three-phase induction motor; (F) describe how torque is developed in an induction motor; (G) explain how and why torque varies with rotor reactance and slip; (H) define percent slip and speed regulation; (I) explain how the direction of a three-phase motor is reversed; (J) describe the component parts and operating characteristics of a three-phase wound-rotor induction motor; (K) define torque, starting current, and armature reaction as they apply to direct current motors;	sizes, and conduit types and sizes for a given motor and application. Write a technical report that compares and contrasts the selections with those of other classmates. Provide supporting evidence for any selections that differ from classmates, and work together to come to a consensus on requirements and collaboratively write a final report. Plan and execute the selection, installation, and wiring of the following motors. Document the plan and explain the detailed multistep process used to complete the procedure by the requirements of the National Electrical Code (NEC) and Occupational Safety and Health Administration (OSHA) regulations. a. DC motor (other than a permanent magnet motor) b. Single-phase capacitor motor c. Reversing three-phase motor	
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			(L) explain how the direction of rotation of a direct current motor is changed; (M) describe the design and characteristics of direct current shunt, series, and compound motors; (N) describe dual-voltage motors and their applications; (O) describe the methods for determining various motor connections; (P) describe general motor protection requirements as delineated by the National Electrical Code; and (Q) demonstrate applications of Ohm's law to solve AC/DC calculations.		
Drive Systems		Understand and apply knowledge of drive systems and mechanical power concepts.	Understand and apply knowledge of drive systems. Student is expected to: (A) define a gear drive and give an application;	Identify and demonstrate an understanding of the components in typical mechanical drive systems (e.g., gear and belt drive) within an industrial setting.	

			(B) describe the functions of the main components in the gear drive system; (C) describe the function of the three basic components of a belt drive; (D) define pitch and explain its importance; (E) define the pitch circle, pitch diameter, and pitch length of a belt drive and explain their importance; and (F) list five belt drive and give an application of each.	Compare and contrast gear versus belt drives and explain the differences between them. Simulating a period of production downtime, safely and correctly disassemble and reassemble both a gear driven mechanical drive and a belt driven mechanical drive in a specified amount of time.	
Troubleshooting		Apply understand of electrical control and manufacturing devices to troubleshoot a basic electromechanical system.	The student use knowledge of electrical controls and electrical, mechanical, pneumatic, and hydraulic devices to troubleshoot electromechanical systems. The student is expected to: (A) read and apply knowledge of blueprints and schematics; and	Assess blueprints of a typical electromechanical system (e.g., motor driving a pump with a coupling, an instrumentation loop, etc.) and examine a given section of the system. Follow a troubleshooting procedure and identify the problems in a malfunctioning system within a specified time. Citing evidence from blueprints and other resources, document the problem(s), explain the	

			(B) test and troubleshoot the system that incorporates electrical controls and either a pneumatic or hydraulic device.	nature of the malfunction, and prescribe a recommended solution.	

Academic Standards Alignment

Colorado CTE courses are required to integrate academic and essential skills into course content. The following academic standards have been identified as aligned to this course and should be integrated throughout instruction.

[CO CTE Academic Standards Resources](#) (Rubrics, integration strategies, etc) [CDE Colorado Academic Standards Online](#) (Online standards lookup tool)

Reading, Writing, & Communicating

Standard 1: Oral Expression and Listening

- **Prepared Graduate 1:** Collaborate effectively as group members or leaders who listen actively and respectfully; pose thoughtful questions, acknowledge the ideas of others; and contribute ideas to further the group's attainment of an objective.
- **Prepared Graduate 2:** Deliver effective oral presentations for varied audiences and varied purposes.

Standard 2: Reading for All Purposes

- **Prepared Graduate 4:** Read a wide range of informational texts to build knowledge and to better understand the human experience.
- **Prepared Graduate 5:** Understand how language functions in different contexts, command a variety of word-learning strategies to assist comprehension, and make effective choices for meaning or style when writing and speaking.

Standard 3: Writing and Composition

- **Prepared Graduate 9:** Demonstrate mastery of their own writing process with clear, coherent, and error-free polished products.

Standard 4: Research Inquiry and Design

- **Prepared Graduate 10:** Gather information from a variety of sources; analyze and evaluate its quality and relevance; and use it ethically to answer complex questions.

Note: Mathematics and Science standards will be added in the future. Visit the [Colorado Academic Standards](#) page for the most current version.