Colorado CTE Course – Scope and Sequence

Course Name	CNC Manufacturing	Course Details	Credit = 1.0
		Course = 0.50 Carnegie Unit Credit	**Prerequisite: Manufacturing Technology I or Introduction to Machining** **CTE Credential: CTE Manufacturing**
Course Description	This course covers fundamentals of computer numerical control (CNC), basic programming, machine setup and operation of CNC machines. The course begins with manual programming practices so that the student will understand the programming code and its structure. G & M codes, control functions, the letter address system, and math issues related to CNC are included. Standard safety conventions will be introduced for safe programming practice. This course allows for the further development of CNC skills with hands-on instruction related to the CNC milling machines, and CNC turning centers. The lab work includes operation of CNC machines to demonstrate the programming skills.		
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 #	13203	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. Understand the industry environment and employment qualifications for CNC technicians/machinists. Integrate changing employment trends,	The student explores the employability characteristics of a successful worker in the global economy. The student is expected to: (A) determine academic knowledge and skills required for	Investigate local employment opportunities for CNC technicians/machinists. Write an informative text that summarizes the typical educational and certification requirements, working environments, and career opportunities.	CTSO Personal and Workplace/Employability Skills Framework

		societal needs, and economic conditions into career planning. Demonstrate career-ready skills and practices.	postsecondary education; (B) identify employers' expectations to foster positive customer satisfaction; (C) demonstrate the standards required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation; (D) evaluate progress toward personal career goals; (E) communicate effectively with others in the workplace to clarify objectives; and (F) demonstrate skills related to health and safety in the workplace as specified by appropriate governmental regulations.	Demonstrate and practice teamwork, problem-solving, and decision-making skills required for success as a career CNC machinist in a manufacturing environment. 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. 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. Investigate best practices for working in teams, including: • how companies use teamwork to solve problems; • how supervisors and project managers use time-management techniques to develop work schedules; and • describe how teams measure results.	
Safety		Interpret policies, procedures, and regulations for the workplace environment, including employer and employee responsibilities. Identify regulations and safety standards that are implemented within manufacturing professions.	Comply with standard industry and classroom safety requirements. Student is expected to: (A) understand and apply operational safety precautions for tools, equipment, and materials;	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	

			(B) apply Personal Protective Equipment (PPE) precautions; (C) use health and safety practices for storing, cleaning, and maintaining tools, equipment, and supplies; and (D) demonstrate skills related to health and safety in the workplace as specified by the Occupational Safety and Health Administration and other appropriate agencies.	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. 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.	

				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. 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.	
CNC Overview		Understand how CNC machines operate and are used to create machined-parts.	The student learns about standard computer numerical control (CNC)	Discuss and demonstrate the setup and safe operation of a CNC turning or milling center: the setup of tools in tool	

			machinery. The student is expected to: (A) research the history of numerical control machines; (B) distinguish among different types of CNC machines used in the industry; (C) demonstrate safety rules for CNC operation; (D) demonstrate the methods by which programs can be entered into a controller; and (E) use appropriate machining terminology to enhance CNC vocabulary.	holders; referencing the vice or chuck to the machine's control; and referencing the cutting tool to the machine's control. Demonstrate control panel commands to perform basic milling or turning commands for motion of the tool path along the coordinate axis.	
CNC Machine Essentials		Produce parts to specifications or drawings provided on a computer numerical controlled (CNC) mill or lathe. Demonstrate common functions or controls through manual input and	The student appraises various CNC systems to differentiate the development and implementation of those systems. The student is expected to:	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.	

		through programmed (stored) input. Introduce basic G and M Code Programming focusing on the use of the Cartesian coordinate system and machine axis.	(A) examine the types of drive motors used on CNC machinery; (B) explain the Cartesian coordinate system; (C) differentiate between absolute and incremental positioning; and (D) illustrate the difference between datum and delta dimensioning.		
Process Planning		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.	The student learns the process planning and tool selection within a CNC lab environment. The student is expected to: (A) develop a detailed process plan, including proper tool selection, feeds, and speeds, for the material being cut and finish specifications on the engineering drawing, logical sequence of operations, and appropriate inspection points;	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. 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.	

			(B) develop a logical sequence of operations and appropriate inspection points; (C) demonstrate use of carbide inserts; and (D) apply various carbide inserts by determining the correct type, grade, style, feed, and speed for the most common materials machined in a basic machine shop.		
Tool Change and Offset		Demonstrate a tooling change and tool selection to complete a multistep process on a CNC milling or turning center.	The student evaluates tool changing and tool offset registers in the CNC lab environment. The student is expected to: (A) perform various types of tool changes; (B) demonstrate quick change tooling used on CNC milling machines; (C) demonstrate appropriate tool storage;	Demonstrate a tooling change and tool selection to complete a multistep process on a 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.	

			(D) demonstrate the proper use of tool offset registers; (E) determine tool offset length; and (F) incorporate tool offsets for a set up.		
CNC Lathe		Demonstrate operation and maintenance of a CNC Lathe machine.	The student operates a CNC lathe. The student is expected to: (A) use equipment commonly associated with a CNC lathe in a safe manner; (B) recognize, name, and describe the function of the primary components of a CNC lathe; (C) perform preventative maintenance checks on a CNC lathe such as checking all fluid levels, system pressure, tooling wear, and component lubrication and cleaning;		

			(D) test the coolant for proper density and adjust accordingly in order to reach the correct mixture; (E) perform a power up on a standard CNC lathe; (F) demonstrate the use of the jog controls on the operator panel to jog the lathe's axes; (G) demonstrate the ability to locate, assemble, and measure tooling according to work instructions and job documentation; (H) install tools and tool holders in the automatic tool changer locations according to work instructions and job documentation; (I) locate and set workpiece to zero on a CNC lathe; (J) set any required work offsets for the part to be machined		

			after a basic tool setting process has been completed; (K) set the proper geometry/tool offsets for each tool in a standard tool setting process; (L) operate a CNC lathe in automatic mode; and (M) illustrate the proper power down process on a CNC lathe.		
CNC Mill		Demonstrate operation and maintenance of a CNC Mill machine.	The student operates a CNC mill. The student is expected to: (A) use equipment commonly found on and around a CNC mill in a safe manner; (B) recognize, name, and describe the function of the primary components of a CNC mill; (C) perform preventative		

			maintenance checks on a CNC mill such as checking all fluid levels, system pressure, tooling wear, and component lubrication and cleaning; (D) test the coolant for proper density and adjust accordingly in order to reach the correct mixture; (E) perform a power up on a standard CNC mill; (F) demonstrate the use of the jog controls on the operator panel to jog the mill's axes; (G) demonstrate the ability to locate, assemble, and measure tooling using a presetter or other means according to work instructions and job documentation; (H) install tools and tool holders in the automatic tool changer locations according to		

			work instructions and job documentation; (I) locate and set workpiece to zero on a CNC mill; (J) set any required work offsets for the part to be machined after a basic tool setting process has been completed; (K) set the proper geometry/tool offsets for each tool in a standard tool-setting process; (L) operate a CNC mill in automatic mode; and (M) illustrate the proper power down process on a CNC mill.		
Manual CNC Lathe Programming		Understand the process to manually program a CNC lathe machine.	The student learns to manually program a CNC lathe without the help of computer-aided design or manufacturing (CAD/CAM) software.		

			The student is expected to: (A) calculate trigonometry to determine coordinates from technical drawings to cut arcs and angles; (B) use trigonometry for determining cutter offsets; (C) use appropriate mathematical skills to solve problems while programming a CNC lathe; (D) write a simple program to face and turn; (E) write a simple program to cut radiuses, angles, grooves, and threads; (F) write a program using cutter radius compensation; (G) write a program using canned cycles such as G71; and		

			(H) write a program and produce a complex part such as a NIMS Level 1 CNC lathe part with zero defects.		
Manual CNC Mill Programming		Understand the process to manually program a CNC Mill machine.	The student learns to manually program a CNC mill (without the help of CAD/CAM software). The student is expected to: (A) use trigonometry to determine coordinates from technical drawings to cut arcs and angles; (B) use trigonometry for determining cutter offsets; (C) use appropriate mathematical skills to solve problems while programming a CNC lathe; (D) write a simple program to perform hole operations;		

			(E) write a simple program to cut radiuses and angles; (F) write a program using cutter radius compensation and ramping; and (G) write a program and produce a complex part such as a NIMS Level 1 CNC milling part with zero defects.		
Quality Control		Understand and defend the purposes and processes of inspection and quality control in machining and forming processes. Apply quality control techniques to CNC Milling and Lathe Operations.	The student develops a deeper understanding of quality control. The student is expected to: (A) evaluate engineering drawings using geometric dimensioning and tolerancing; (B) discuss the American Society of Mechanical Engineers (ASME) Y14.5M standard that defines geometric dimensioning and tolerancing; and	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	

			(C) appraise various quality control/management programs.	inspector who must carefully complete 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. 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. Perform continuous online quality control inspections of machined and formed parts.	
