Colorado CTE Course – Scope and Sequence

Course Name	Metal and Machining Fabrication II	Course Details Course = 0.50 Carnegie Unit Credit	Credit= 1.0-2.0 Prerequisites: Metal and Machining Fabrication I CTE Credential: CTE Manufacturing
Course Description	Metal Fabrication and Machining II builds on the knowledge, skills, and certifications students acquire in Metal Fabrication and Machining I. Students will develop advanced concepts and skills related to metal fabrication and machining. Topics include: blueprint planning and layout, advanced concepts in welding and machine processes and procedures, and advanced construction techniques in sheet metal manufacturing.		
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 and Employability Skills		Identify regulations and safety standards that are implemented within the metal fabrication and machining professions. Understand the AWS and NIMS certification requirements. Develop an education and career plan aligned with personal goals.	The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to: (A) determine advanced knowledge and skills required to gain industry-recognized certifications;	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. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by	SkillsUSA personal and workplace skills framework

		Work productively in teams while integrating cultural and global competence.	(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) demonstrate skills related to health and safety in the workplace as specified by the Occupational Safety and Health Administration and other appropriate agencies. The student describes the importance of	Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures and complete safety test with 100 percent accuracy. Demonstrate and practice teamwork, problem-solving, and decision-making skills required for success as a career machinist in a manufacturing environment. Locate and assess the American Welding Society and NIMS websites and analyze its structure, policies, and requirements for the AWS and NIMS certifications. Explain a welder certification document, 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.	

			teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to: (A) use teamwork to solve problems; (B) distinguish among team roles such as team leaders and team members; (C) discuss Equal Employment Opportunity law in the workplace; and (D) use time-management techniques to develop work schedules.	Investigate opportunities to use the CTSO to develop and practice these identified workplace leadership skills. Identify other professional development organizations valued by the industry.	
Metal Fabrication Workplace Fundamentals		Understand, interpret, analyze and apply units of measure, mathematics concepts, and science principles in order to solve problems in metal and machining fabrication. Use existing and emerging technology, to investigate, research, and produce products and services,	The student applies advanced academic skills to the requirements of metal fabrication and machining. The student is expected to: (A) use appropriate tools to make accurate measurements;	Determine the appropriate units and record accurate and repeatable measurements of length, diameter, and thickness to complete projects using: a. Rules, gages, calipers, and micrometers b. Tools equipped with dials, vernier scales, and digital readouts.	

		including new information, as required in the Manufacturing and Product Design sector workplace environment. Apply essential technical knowledge and skills common to all pathways in the Manufacturing and Product Design sector, following procedures when carrying out experiments or performing technical tasks.	(B) successfully complete work orders; (C) estimate labor costs using various algebraic formulas; (D) interpret advanced engineering drawings, charts, diagrams, and welding symbols; and (E) demonstrate calculation of precision measuring operations using algebra, geometry, and trigonometry. The student knows the advanced concepts that form the technical knowledge and skills of metal fabrication and machining. The student is expected to: (A) analyze the resources found in various manufacturing reference materials; and (B) validate that a provided part meets specifications from its engineering drawing by comparing specifications (geometric dimensioning	c. Both metric and English scales. d. Appropriate standards of accuracy and precision. e. Satisfactory tolerances permissible for a given task. For example, while grinding a piece to a specified thickness, measurements with a metric Vernier caliper are used to achieve a value within the tolerance specified by the drawing. Determine the appropriate units and record accurate and repeatable measurements of angles to complete projects by: a. Applying principles of trigonometry, Cartesian geometry, and/or polar geometry, distinguishing when and which principles apply to a given machining task.	

			and tolerancing) and by demonstrating proper technique using appropriate precision measuring tools.	b. Using angle gages, a plate protractor, a universal bevel protractor with vernier scale, square, and/or a sine bar and gage blocks or adjustable parallel. For example, measure the angle formed by two surfaces of a machined part to the nearest 0.01 degree using a sine bar. Determine the appropriate units and record accurate and repeatable measurements of material properties such as hardness, pH, and load/elongation test curves of stress, strain, modulus, and yield. Interpret test values and curves, and use calculated results to make informed decisions. For example, measure the Rockwell hardness of a piece of stainless steel to determine the recommended cutting speed with a carbide-tipped cutting tool.	

				Visualize and interpret engineering drawings for projects to a. Create an accurate bill of materials. b. Identify and interpret geometric dimensioning and tolerancing symbols and nomenclature. c. Identify primary and secondary datums. For example, lay out correctly dimensioned bolt holes in a radial pattern specified by a drawing, and select proper tools to complete the required operations. Accurately read, interpret, and demonstrate adherence to safety rules, including rules published by the Occupational Safety and Health Administration (OSHA) guidelines, American Society for Testing Materials; ANSI Z49.1: Safety and Welding, Cutting, and Allied Processes, And state and national code requirements. Be able to distinguish between rules and	

				explain why certain rules apply. Explain how these rules apply to various metal fabrication professions.	
Metalworking Technologies and Materials		Identify materials and resources commonly used and recycled in welding and machining. Apply basic knowledge of using and maintaining professional welding and machining equipment for metal fabrication. 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 fabrication and machining. The student is expected to: (A) operate various welding machines, cutting equipment, and grinding equipment commonly employed in metal fabrication; (B) demonstrate knowledge of computer numerical control (CNC) machines; (C) demonstrate knowledge of the concepts of automated welding machines; (D) demonstrate knowledge of emerging technologies that may affect metal manufacturing;	Anticipate the consequences and handling requirements of metals, alloys, ceramics, polymers, and composites to properly and safely handle and machine these materials. For example, research the material properties for the bill of materials for a project in preparation for choosing cutting tools, speeds, and handling. 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 advanced 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	

			(E) examine the advanced use of abrasives; and (F) dispose of environmentally hazardous materials associated with and used in metal fabrication manufacturing.	compound rests, internal tapered surfaces, follower and steady rests c. Grinders, such as grinding pieces between centers, operating radius dressers, cylindrical grinders, and inside diameter (ID) grinders. 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. Correctly, safely, and efficiently schedule, configure, administer, and verify heat-treatments to machined parts according to blueprint specifications. For example, while properly attired and equipped, use an oven or torch to harden and temper a W1-grade steel bolt to yield a hardened, tamper-proof bolt.	

Advanced Machining Concepts		Describe and demonstrate various machining techniques including procedures on drill press, lathe, saw, grinders, 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 such as drill press, lathe, saw, grinders, and milling machines; (C) execute lathe procedures such as cut threads, turn tapers, drills, reams, polishes, knurls, and bores; (D) mill flat surfaces, bevels, chamfers, grooves, and key-seats; and (E) machine precision pieces.	Solve manufacturing-related problems by analyzing and weighing the constraining factors including schedule, cost, materials, and equipment, as well as productivity, regulations, maintenance, and quality. For example, as part of an assigned machining project, draft, obtain approval, and implement a schedule for completion, including ordering materials, planning the sequence of machining and stepwise approvals, and determining a target for final delivery, justifying all recommendations with supporting evidence. Explore and develop one's skills with new and emerging machining and manufacturing technologies, such as 3D printing, laser etching, computer-controlled machining, and digital manufacturing methods. For example, produce a small plastic part using a 3D printer, and then produce the same part with a CNC production method using G-and M-codes; compare the material cost and waste, manpower,	

				scheduling, etc. of the two methods and provide written justification to persuade a prospective manufacturer, wholesaler, or other supplier why one method is more cost-effective, efficient, or profit-maximizing than the other. Demonstrate proper technique with layout tools and work-holding devices such as three- and four-jaw chucks, collet chucks, angle plates, sine bars, parallels, and v-blocks to machine a real part. Describe and demonstrate the engine lathe by grinding a high speed tool bit focusing on the tool cutting geometry and tip radius, speeds and feeds for the materials being cut and using their tool bit and precision measuring tool, machine a part within specifications. Demonstrate bending, shaping, other metal forming, and fabrication techniques, including processes such as basic hand filing, knurling on a lathe, forging metal shapes or objects, green sand casting, sheet metal machines, spot	

				welding equipment or rivets, cold form bending with cold forming machinery or homemade devices, and shapes (tooling) to achieve a specific design specification. Employ statistical quality control test methods and techniques, especially on large volume processes, to minimize defects and waste due to poor quality. For example, use statistical sampling, measuring, and charting to monitor and detect the need for corrective action on a mass production of thread cutting. Upon completion of testing, draft a written report documenting the findings in the proper format that a quality control inspector would deliver to a supervisor or other superior.	
Advanced Welding Concepts		Demonstrate the safe setting up and cutting process of oxy-fuel. Identify and demonstrate setting up plasma arc cutting equipment. Demonstrate knowledge of Shielded Metal Arc Welding	The student applies the advanced concepts and technical knowledge and skills of the welding industry to simulated and actual work situations. The student is expected to:	Identify components of oxy-fuel gas cutting system and demonstrate proper set-up procedures for oxy-fuel cutting process. Perform straight, shaped, and beveled cutting operations using both manual and machine-guided techniques.	

		(SMAW) including setting up of equipment. Understand and defend the purposes and processes of inspection and quality control in Welding manufacturing processes.	(A) demonstrate cutting processes such as oxy-fuel and plasma; (B) demonstrate the use of the common types of electrodes using the shielded metal arc welding process; (C) use shielded metal arc welding, gas metal arc welding, and gas tungsten arc welding to weld fillet and groove welds using various positions; and (D) Analyze and identify the steps to check for distortion, joint misalignment, and poor fit-up before and after welding for performing fillet welds in the flat, horizontal, vertical, and overhead positions to AWS code.	Properly use weld-washing techniques and visually examine cut surfaces for meeting the given specifications. Safely set up equipment for shielded metal arc welding (SMAW). Identify and explain the equipment, equipment setup, and the electrical current used in the welding process. Drawing on multiple resources, compare and contrast SMAW with other welding and cutting processes such as oxyfuel gas welding (OFW), gas metal arc welding (GMAW), flux-cored arc welding (FCAW), and gas tungsten arc welding (GTAW). Write a brief informative paper discussing the distinguishing characteristics and primary advantages of each. Demonstrate how to make single-and multiple-pass fillet welds and groove welds with backing on plain carbon steel in the following positions. Prior to welding, sketch a cross section, including the	

				dimensions of each weld demonstration. a. Flat b. Horizontal c. Vertical d. Overhead Using various electrodes, demonstrate how to make pad beads on plain carbon steel in the following positions. a. Flat b. Horizontal c. Vertical d. Overhead Summarize the demonstration results of using various electrodes and explain the findings using supporting evidence from the AWS metal classification system.	
Sheet Metal		Investigate sheet metal materials, tools, and equipment used in metal fabrication products. Identify and apply knowledge of sheet metal techniques for forming and cutting. Apply knowledge of welding processes and tools for sheet metal fabricated products.	The student applies the advanced concepts and technical knowledge and skills of the sheet metal industry to simulated and actual work situations. The student is expected to: (A) estimate labor costs; (B) use advanced mathematics in precision	Demonstrate bending, shaping, other metal forming, and fabrication techniques, including processes such as basic hand filing, knurling on a lathe, forging metal shapes or objects, green sand casting, sheet metal machines, spot welding equipment or rivets, cold form bending with cold forming machinery or homemade devices, and shapes (tooling) to achieve a specific design specification.	

			measuring operations; and (C) interpret industrial standard blueprints, drawings, charts, and diagrams. The student knows the advanced concepts and technical knowledge and skills of sheet metal manufacturing. The student is expected to: (A) analyze properties of sheet metal materials and fasteners; (B) analyze oxy-fuel processes as related to sheet metal; and (C) demonstrate knowledge of shielded metal arc welding, gas metal arc welding, and gas tungsten arc welding as related to sheet metal under AWS code. The student knows the function and application of the tools, equipment, technologies, and materials used in sheet		

			metal. The student is expected to: (A) use equipment commonly employed in sheet metal safely; (B) dispose of environmentally hazardous materials used in sheet metal manufacturing properly; and (C) demonstrate knowledge of emerging technologies that may affect sheet metal.		
Layout and Fabrication Techniques		Describe and layout a project according to specifications or engineering drawings. Utilize Sheet Metal Layout Principles and Practices. Demonstrate fabrication and fastening techniques for sheet metal- constructed products.	The student applies the advanced concepts and technical skills in simulated and actual work situations. The student is expected to: (A) draw advanced sheet metal layouts; (B) construct sheet metal seams; (C) construct transitions and offsets;	Applying the skills acquired in the previous standards, examine a given manufacturing problem to research and plan a solution that will result in the creation of a prototype for a manufactured product. This process will include but is not limited to the following: a. Reading and interpreting relevant engineering drawings c. Assessing prototyping processes	

			(D) use the gas tungsten arc welding process in sheet metal construction; (E) apply the principles of sheet metal construction to the fabrication of various sheet metal products; and (F) apply skills in sheet metal to career preparation learning experiences.	d. Using engineering drawings as a planning tool for programming software to design the prototype e. Crafting appropriate documentation and justification of decisions made in the design process, for the purposes of explaining as well as persuading f. Creating a presentation for the design and construction of the manufactured product	
