CareerClusters™ PATHWAYS TO COLLEGE & CAREER READINESS
Manufacturing

Learning that works for Colorado CTE®

Colorado CTE Course – Scope and Sequence

Course Name	Electromechanical Control Systems	Course Details	Credit= 1.0
		Course = 0.50 Carnegie Unit Credit	**Prerequisite: Mechatronics pathway level 3 course** **CTE Credential: CTE Manufacturing**
Course Description	Electromechanical Control Systems is designed to provide students with the knowledge and skills to effectively perform basic industrial maintenance procedures in an advanced manufacturing facility. Students in this course develop proficiency in a vast array of electromechanical domains, including: fundamental safety practices in electromechanical technology, electrical systems, AC and DC motors, calibrating instruments, drive systems, hydraulic systems, pumps, digital electronics, programmable logic controllers (PLC), and troubleshooting procedures. Upon completion of this course, proficient students will be prepared to pursue postsecondary electromechanical technology programs and entry-level industrial maintenance technology careers in the advanced manufacturing industry.		
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 #	13101	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 in a manufacturing environment. Investigate the top credentials required by the industry for the mechatronics pathway 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	

				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.	
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;	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	

			(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 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.	relationship between Ohm's law and each of the following: a. Voltage b. Current c. Resistance d. Voltage drop 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: a. Reluctance to resistance b. Field distance to voltage c. Magnetic force to current	
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 construction and mechanical drawings.	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; (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;	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.	

			(D) read equipment schedules found on electrical drawings; and (E) describe the type of information included in electrical specifications.		
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;	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	

			(D) program a computing device to control systems or process; (E) use motors, solenoids, and similar 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.	b. CPU c. Input modules d. Output modules e. Analog input and/or modules Demonstrate understanding of fundamental control system design and develop systems that complete preprogrammed tasks: a. Identify the elements and processes necessary to develop a controlled system that performs a task. b. Demonstrate the set up 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 to create a desired outcome or series of tasks.	

				e. Demonstrate how to use motors, solenoids, and similar 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.	
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	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	

			differs from the system voltage; (D) describe the basic construction and components of a three-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;	installation drawings. Using this information, determine the required over-current protection, motor control circuits, conductor types and 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	

			(K) define torque, starting current, and armature reaction as they apply to direct current motors; (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 and application; (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.	Identify and demonstrate an understanding of the components in typical mechanical drive systems (e.g., gear and belt drive) within an industrial setting. 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.	
Hydraulics and pumps		Apply principles of mechanics and fluid mechanics to the design and analysis of electromechanical systems.	Inspect and analyze hydraulic systems and components. Student is expected to: (A) demonstrate understanding of the interrelationships and	Measure and analyze basic physical properties of (electro) pneumatic and hydraulic components (such as cylinders, directional control valves, regulators, flow control valves, pumps, and motors) within a given system.	

			specific roles of (electro) pneumatic and hydraulic components and modules within a complex mechatronic system; and (B) measure and analyze basic physical properties of (electro) pneumatic and hydraulic components.	Interpret resolved work orders by analyzing underlying issues and explaining the correct physical operation of the included components. Citing evidence from a technical description or actual observation of a mechatronic system, describe the flow of fluid energy in a given mechatronic system or subsystem. Create a graphic illustration to represent the transfer of energy from one component to others in the system.	
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 (B) analyze, program, install, integrate, and troubleshoot automated systems.	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 nature of the malfunction, and prescribe a recommended solution.	

				Select and use troubleshooting techniques and test equipment to assess electromechanical systems, circuits, equipment, processes, and subsystems.	