CareerClusters™ PATHWAYS TO COLLEGE & CAREER READINESS
Manufacturing

Learning that works for Colorado CTE®

Colorado CTE Course – Scope and Sequence

Course Name	Robotics and Mechatronics	Course Details	Credit= 1.0
		Course = 0.50 Carnegie Unit Credit	**Prerequisite: Principles of Manufacturing and DC/AC Electronics and Electricity or Robotics and Automated Systems** **CTE Credential: CTE Manufacturing** **CTE Credential: CTE Manufacturing**
Course Description	Introduces industrial robotics as well as a survey of the technologies and equipment used in manufacturing automation and process control. Includes axis configurations, work envelopes, programming, troubleshooting, and maintenance. Incorporates a survey of automation topics including history, computer and hardwired controls, sensors and transducers, motors and actuators, fluid power, etc.		
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 #	21009	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
Mechatronics in Manufacturing		Understand the concept of mechatronics to control technological processes and systems in the manufacturing environment.	The student develops the ability to use and maintain technological products, processes, and systems. The student is expected to: (A) investigate mechatronic control systems; (B) demonstrate the use of computers to manipulate a robotic	Drawing on various media, including visual, quantitative, and written resources, trace the historical development of the four facets (mechanical systems, electronic systems, computers, and control systems) of a mechatronic system and explain their chief applications in modern society, citing specific textual evidence.	

			or automated system and associated subsystems; (C) maintain systems to ensure safe and proper function and precision operation; (D) describe feedback control loops used to provide information; and (E) describe types and functions of sensors used in robotic systems.	Citing specific evidence from a textual description or actual observation of a mechatronic system, describe the flow of electrical and mechanical energy in the system. Create a computational model to represent the transfer of energy from one component to others in a system.	
Safety		Demonstrate health and safety procedures, regulations, and personal health practices related to the Manufacturing sector workplace environment.	The student practices safe and proper work habits. The student is expected to: (A) master relevant safety tests; (B) comply with safety guidelines as described in various manuals, instructions, and regulations; (C) identify governmental and organizational regulations for health and safety in the workplace related to electronics;	Accurately read and interpret safety rules, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA), state and national code requirements. Apply them accordingly while working on electrical and mechanical components and explain why certain rules apply.	

			(D) identify and classify hazardous materials and wastes according to Occupational Safety and Health Administration (OSHA) regulations; (E) dispose of hazardous materials and wastes appropriately; (F) perform maintenance on selected tools, equipment, and machines; (G) handle and store tools and materials correctly; and (H) describe the results of improper maintenance of material, tools, and equipment.		
PLCs		Understand how programmable logic controls (PLCs) are used in the manufacturing industry to control processes and machinery.	The student creates a program to control a robotic or automated system. The student is expected to: (A) use coding languages and proper syntax; (B) use programming best practices for commenting and documentation;	Demonstrate knowledge and usage of programmable logic controllers for manufacturing systems. Examples include: • Describe the function and purpose of a programmable logic controller (PLC). • Compare hardwired and PLC systems. • Convert between number systems.	

			(C) describe how and why logic is used to control the flow of the program; (D) create a program flowchart and write the pseudocode for a program to perform an operation; (E) create algorithms for evaluating a condition and performing an appropriate action using decisions; (F) create algorithms that loop through a series of actions for a specified increment and for as long as a given condition exists; (G) create algorithms that evaluate sensor data as variables to provide feedback control; (H) use output commands and variables; (I) use selection programming structures such as jumps, loops, switch, and case; and	• Analyze a binary logic network. • Describe the purpose of the various power supplies used within a PLC. • Construct input/output (I/O) circuits. • Define the function of the PLC processor module. • Describe the interrelations between microprocessor components. • State the characteristics of the different types of memory. • Demonstrate the features of relay ladder logic instruction categories. • Demonstrate the principles used to correlate PLC hardware components to software instructions. • Convert a hardware ladder diagram to a PLC Ladder diagram. • Program PLC using the converted PLC Ladder diagram.	

			(J) implement subroutines and functions.		
Electronics and Applied physics Concepts		Understand how mathematics and physics principles are related to the control and function of mechatronic systems. Explain the physical operation of electromagnetic and electrostatic components in a mechatronic system.	The student demonstrates an understanding of advanced mathematics and physics in robotic and automated systems. The student is expected to: (A) apply the concepts of acceleration and velocity as they relate to robotic and automated systems; (B) describe the term degrees of freedom and apply it to the design of joints used in robotic and automated systems; (C) describe angular momentum and integrate it in the design of robotic joint motion, stability, and mobility; (D) use the impulse-momentum theory in the design of robotic and automated systems; (E) explain translational, rotational, and	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	

			oscillatory motion in the design of robotic and automated systems; (F) apply the operation of direct current (DC) motors, including control, speed, and torque; (G) apply the operation of servo motors, including control, angle, and torque; (H) interpret sensor feedback and calculate threshold values; (I) apply measurement and geometry to calculate robot navigation; (J) implement movement control using encoders; and (K) implement path planning using geometry and multiple sensor feedback.	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.	

Mechanical Components		Understand the specific role of various mechanical components in mechatronic systems.	The student develops an understanding of the characteristics and scope of manipulators, accumulators, and end effectors required for a robotic or automated system to function. The student is expected to: (A) demonstrate knowledge of robotic or automated system arm construction; (B) demonstrate an understanding and apply the concepts of torque, gear ratio, stability, and weight of payload in a robotic or automated system arm operation; and (C) demonstrate an understanding and apply the concepts of linkages and gearing in end effectors and their use in a robotic or an automated arm system.	Demonstrate understanding of the specific role of various mechanical components in mechatronic systems, discerning in a system schematic the effects of various design parameters on the system behavior. For example, predict the effect of a larger gear size. Compare and contrast these roles in the context of mechatronic systems, modules, and subsystems, explaining how designs vary within a given system or module. Create, measure, and analyze mechanical systems pre scribed by drawings to predict and verify the behavior of the physical operation of components in a mechatronic system, including but not limited to: a. Springs, and spring-like effects b. Dampers and energy dissipation c. Masses (weights) Craft an explanatory narrative to report findings and outline the typical application in systems of the components listed above, citing the	

				observed behavior to support explanations. Interpret technical information in design problems to analyze forces, speeds, torque, and power, for mechanical drives including: a. Gears, cams, screws, and levers b. Belt and chain drives c. Flywheels d. Motors and generators Explain the typical application and operation in systems of the components listed above, citing measurement and/or observed evidence to support explanations. Create equations that describe relationships to solve the design problems and justify the solutions.	
Motors		Understand how motors are related to the control of manufacturing mechatronic systems.	Demonstrate knowledge and usage of motors for mechatronics concepts. Student is expected to: (A) understand motor theory and define common terms; (B) describe basic construction and	Define common terms used in motor theory: a) Ampacity b) Branch circuit c) Circuit breaker d) Controller e) Duty f) Equipment g) Full-load amps h) Ground fault circuit interrupter	

			components of motors; (C) describe the characteristics and function various of three-phase motors; (D) explain how motors control speed and direction.	i) Interrupting rating j) Motor circuit switch k) Thermal protector l) NEMA design letter m) Non-automatic n) Overcurrent o) Overload p) Power factor q) Rated full-load speed r) Rated horsepower s) Service factor t) Thermal cutout u) Remote control circuit Research and measure the behavior of different types of alternating current (AC) motors and direct current (DC) motors, comparing and contrasting behaviors and drawing inferences from the observations to create a checklist for use by a technician to ensure proper functioning of equipment. Explain the relationship of speed frequency, torque, slip, current and armature reaction to motors. Referencing appropriate technical documents (such as data sheets, timing diagrams, operating manuals, and schematics), design an experiment to observe and	

				measure the mechanical properties and behavior of shafts, couplings, and sealing devices with and without proper lubrication. Document research and measurement results in a technical report to be used by other technicians. Demonstrate understanding of power transmission components, such as clutches and brakes, by measuring the operation of working automotive equipment. Create a graphic illustration showing the roles of each component and how they work together in a system. Assess the required maintenance for a variety of mechatronic system components in a mechatronic device, and carry out the necessary adjustments to the system. Document and justify the adjustments in an equipment log that can be easily referenced by technicians and engineers.	
Technical Documentation and Troubleshooting		Apply problem-solving techniques to trouble shoot issues related to mechatronic systems and controls. Read and apply technical information to assess a	The student learns the function and application of the tools, equipment, and materials used in robotic and automated systems through specific project-based	Consult technical documents (such as data sheets, timing diagrams, operating manuals, and schematics) to assess a mechatronic system and effectively troubleshoot the malfunctions in electrical	

		mechatronic system and effectively troubleshoot the malfunctions in electrical components. Maintain technological products, processes, and systems related to the control and function of manufacturing systems.	assessments. The student is expected to: (A) use and maintain tools and laboratory equipment in a safe manner to construct and repair systems; (B) Consult technical manuals for component and system setup information; (C) use precision measuring instruments to analyze systems and prototypes; (D) implement a system to identify and track all components of the robotic or automated system and all elements involved with the operation, construction, and manipulative functions; and (E) use multiple software applications to simulate robot behavior and present concepts. The student develops the ability to use and maintain technological	components. Record and analyze test results and prepare written testing documentation to justify a solution. Verify by observation and measurement the parts, relationships, and behavior depicted by the technical data sheets for the mechanical and electrical components within a mechatronic system. Use these data sheets to create a training document to instruct a new technician on maintaining and operating these components and drives.	

			products, processes, and systems. The student is expected to: (A) demonstrate the use of computers to manipulate a robotic or automated system and associated subsystems; (B) troubleshoot and maintain systems and subsystems to ensure safe and proper function and precision operation; (C) implement feedback control loops used to provide information; and (D) implement different types of sensors used in robotic or automated systems and their operations.		
Career Development		Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans. Identify career information available in the manufacturing trade and mechatronics career pathway.	The student demonstrates the skills necessary for success in a technical career. The student is expected to: (A) distinguish the differences among an engineering technician, engineering	Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Create a portfolio of work accomplished. Include photographs or illustrations and written descriptions of sequential progress in mechatronic projects.	Updates to ICAP SkillsUSA Personal and Workplace Skill Development

		Develop employability skills related to teamwork and communication.	technologist, and engineer; (B) identify employment and career opportunities; (C) identify industry certifications; (D) discuss ethical issues related to engineering and technology and incorporate proper ethics in submitted projects; (E) identify and demonstrate respect for diversity in the workplace; (F) identify appropriate actions and consequences relating to discrimination, harassment, and inequality; (G) explore robotic engineering careers and preparation programs; (H) explore career preparation learning experiences, including job shadowing, mentoring, and apprenticeship training.	Research local job and internship opportunities and requirements. Update resume and practice job interview skills. Participate in an actual or simulated manufacturing project related to mechatronics and the analysis of machines and processes in the workplace. Identify elements of project management. Explain how these processes are involved in business operations. Compare and contrast them to lean manufacturing concepts.	

			The student participates in team projects in various roles. The student is expected to: (A) explain the importance of teamwork in the field of robotics; (B) apply principles of effective problem solving in teams to collaboration and conflict resolution; and (C) demonstrate proper attitudes as a team leader and team member. The student develops skills for managing a project. The student is expected to: (A) implement project management methodologies, including initiating, planning, executing, monitoring and controlling, and closing a project; (B) develop a project schedule and complete work according to established criteria;		

			(C) participate in the organization and operation of a real or simulated engineering project; and (D) develop a plan for production of an individual product.		