CareerClusters™ PATHWAYS TO COLLEGE & CAREER READINESS
Manufacturing

Learning that works for Colorado CTE®

Colorado CTE Course – Scope and Sequence

Course Name	**Power and Energy Technology II (Industrial Maintenance)**	**Course Details** **Course = 0.50 Carnegie Unit Credit**	**Credit = 1.0** **Prerequisite: Power and Energy Technology I** **CTE Credential: CTE Manufacturing**
Course Description	Students will study concepts in industrial maintenance for manufacturing and power and energy systems. Technical aspects of electromechanical systems and machines will be explored and students will develop technical skills in hardware repair, welding, blueprint reading, preventative maintenance and repair of hydraulics, pneumatics, electrical control systems and components. Students are introduced to different job skills in the three sectors of the industrial maintenance industry: Machinery maintenance workers, Industrial machinery mechanics, and General maintenance and repair workers.		
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 #	20101	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		Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans.	Investigate employment opportunities and requirement for industrial maintenance. Student is expected to: (A) describe the types of work performed by millwrights, industrial maintenance technicians, power and energy field technicians, and engineers;	Investigate an assortment of occupations and manufacturing processes that rely on electromechanical principles and technologies, such as shipyard rigging, metalworking, agricultural mechanics, construction, and power and energy. Write an informative text that summarizes the typical educational and certification requirements, working	CTSO Personal and Workplace/Employability Skills Framework Updates to ICAP

		Identify and describe careers and the entry requirements for occupations in the industrial maintenance pathway.	(B) identify career opportunities available in industrial maintenance pathways; (C) identify training and education programs and options; and (D) explain the responsibilities and characteristics of a good industrial maintenance craft worker; (E) explain the importance of safety in relation to industrial maintenance craft workers; and (F) describe the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills; and (G) demonstrate effective communication skills with individuals from varied cultures such as fellow workers, management, and customers.	environments, and career opportunities for these occupations. Demonstrate and practice teamwork, problem-solving, and decision-making skills required for success in a manufacturing or power and energy career. Investigate industry certifications that are valued by employers. Locate and assess the Industry certification websites (SMRT, IMI, IFMA, etc.) and analyze their 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; (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.	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. 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.	
Industrial Maintenance Tools		Understand and apply knowledge of hand and power tools used in industrial maintenance and repair. Perform mathematic	Demonstrate the safe use of hand and power tools used in industrial maintenance and repair. Student is expected to: (A) explain the purpose of each of the tools commonly used by industrial maintenance craft workers;	Demonstrate the use and maintenance of various hand and power tools found in the industrial maintenance and HVAC trade. ** Tool list will vary by maintenance area focus but should include basic tools for electrical, HVAC, plumbing, and mechanical repair. Sample: Have the student evaluate hand tools that have safety hazards such as frayed	

		calculations relating to the installation and service trade.	(B) describe how to maintain each of the tools used by industrial maintenance craft workers; (C) demonstrate ability to apply mathematical constructs to materials and tools; (D) demonstrate the proper use and basic maintenance of selected industrial maintenance tools; and (E) identify sources for guidance in the repair and maintenance of specific systems and equipment.	cords, cut or nicked wiring, ladders with cracked rails, chisels with mushroomed heads, and screwdrivers with chipped tips. Have the students select a drill for drilling holes in concrete. The students should justify why they suggest a particular drill, how much the drill costs, and where the tool can be bought. Demonstrate how to calculate problems and how they relate to job tasks in the installation and service trade. Add, subtract, multiply, and divide whole numbers, decimals, and fractions; convert whole numbers to fractions, convert fractions to whole numbers; convert decimals to percentages and percentages to decimals; convert fractions to decimals; compare fractions; and convert fractions to percentages. Use a tap and drill chart to convert decimals to fractions and vice versa. Have students convert fractional drill sizes to decimal equivalents and vice-versa. Have students then relate the drill size to various fractions' representations.	
Fasteners and Anchors		Apply knowledge of fasteners for various applications.	Apply knowledge of fasteners for various applications and equipment. Student is expected to: (A) identify and explain the use of threaded fasteners;	Identify and select fasteners for various applications, taking into account the effects of corrosion on each, including threaded fasteners, nuts, washers, rivets, locking pins, keys, self-tapping screws, locking-nut fasteners, and self-retaining nuts.	

			(B) identify and explain the use of non-threaded fasteners; (C) identify and explain the use of anchors; (D) select the correct fasteners and anchors for given applications; and (E) install fasteners and anchors.	Describe the techniques and liability issues regarding retrofitting fasteners for ease of removal. Lay out various fasteners such as 1/4-20 cap head bolt, socket head bolt, various washers and nuts, carriage bolt, shoulder bolt, lag bolts, No. 8 pan head sheet metal screw, and No. 8, No. 10, and No. 12 flat-head brass wood screws. The students are to select, explain the use of, and install threaded fasteners, non-threaded fasteners, and anchors. Let the students reference the Internet to determine what the bolts are and how they are used. You may reference http://www.boltdepot.com/Fastener-Information/Type-Chart.aspx. Explain each fastener's use, its weaknesses, and its strengths. Make sure to use various drivers such as flat, Phillips, torx, hex, and Allen head styles. Demonstrate how to determine various grades of bolts and where they are used. Lay out various grades of bolts on a workbench, and discuss the thread, shoulder, head, diameter, and length of the bolts.	
Oxy-fuel Cutting		Identify and explain the use of oxy-fuel cutting equipment. Demonstrate how to use an oxy-fuel torch.	Demonstrate safe use of oxy-fuel cutting and welding tools and equipment. Student is expected to: (A) identify and explain the use of oxy-fuel cutting equipment;	Using a teacher assessment, test the students on the safety rules associated with oxy-fuel cutting. Demonstrate the assembly, operation, and disassembly of the oxy-fuel equipment. Demonstrate a neutral, oxidizing, and carbonizing flame.	

			(B) state the safety precautions for using oxy-fuel equipment; (C) set up oxy-fuel cutting equipment; (D) light and adjust an oxy-fuel torch; (E) shut down oxy-fuel cutting equipment; (F) disassemble oxy-fuel cutting equipment; (G) change empty cylinders; (H) perform oxy-fuel cutting: • Straight line and square shapes • Piercing and slot cutting • Bevels • Washing (I) apply a rosebud flame to remove frozen components (also for preheat and expanding larger fittings); and (J) operate a motorized, portable oxy-fuel gas cutting machine.	Explain and demonstrate how to cut straight lines and square shapes, piercing, and slot cutting.	
Gaskets and Packing		Identify the various types and materials of gaskets.	Student is expected to: (A) identify the various types of gaskets and explain their uses; (B) identify the various types of gasket materials and explain their applications;	Describe the difference between gasket and packing material. Show different types of gasket material, and explain where each type is used in the installation and service industry. Lay out, cut, and install a flange gasket. Use the following Web site as a reference: http://www.fluidsealing.com/pubimg/gasketpamphletcropped.pdf	

			(C) lay out, cut, and install a flange gasket; (D) describe the use of O-rings; (E) explain the importance of selecting the correct O-ring for an application; (F) select an O-ring for a given application and install it; and (G) describe the uses and methods of packing.	Explain the importance of selecting the correct O-ring for an application, and select an O-ring for a given application and install it. Demonstrate how to use O-ring material and make a new O-ring for an application. Identify the various types of packing material and where they are used in the installation and service industry. Research packing material and create a picture poster using old trade magazines. Explain the posters and explain why packing is used rather than gaskets or O-rings.	
Blueprints		Identify and interpret terms and symbols commonly used on blueprints.	Student is expected to: (A) explain the basic layout of a blueprint; (B) describe the information included in the title block of a blueprint; (C) identify the types of lines used on blueprints; (D) identify common symbols used on blueprints; (E) understand the use of architect's and engineer's scales; and (F) demonstrate the use of an architect's scale.	Relate information on prints to real parts/models, describe the information in a title block, and design a blueprint. Explain what the title block and parts list encompass. Explain the scale that applies to the physical part as compared to the paper blueprint. Show and explain lines found on a blueprint (i.e., centerline, dimension, hidden line, object lines, extension line, break lines, etc.) that represent how a part is visualized.	
Hydraulics and Pneumatics		Discuss the principles	Identify, discuss, and explain hydraulic and pneumatic system safety, the	Develop a hydraulic circuit that will lift a 5-kg weight. Draw the circuit, size all	

		of industrial hydraulics and pneumatics. Identify, discuss, and explain hydraulic and pneumatic system safety, the principles of hydraulics, hydraulic fluids, and hydraulic system parts. such as pumps, motors, valves, piping, hoses, and tanks.	principles of hydraulics, hydraulic fluids, and hydraulic system parts such as pumps, motors, valves, piping, hoses, and tanks. Student is expected to: (A) recognizes pneumatic and hydraulic safety hazards and how to reduce the risk of exposure to those risks; (B) apply pneumatic and hydraulic theory and laws; (C) identifies components of pneumatic and hydraulic circuits; (D) explore different types and configurations of pneumatic and hydraulic circuits; and (E) practice pneumatic and hydraulic maintenance procedures.	components, and build if components are available. Lay out hydraulic components on a workbench. Label the components, and have the students draw the schematic symbol for the component and write a short description of what the device does in the circuit. Using the two-syringe setup, have the students calculate the volume of air in the extended cylinder. Use the equation: V = Diameter x Length (http://grapevine.abe.msstate.edu/~fto/tools/vol/cylinder.html and http://www.rcs.k12.va.us/csjh/vol_calculator.htm). Have students answer the following question: If the retracted plunger is held down, will the extended plunger move when pushed? Answer: Yes. The gaseous fluid inside the chamber and connecting tube will compress contrary to a liquid fluid.	
Pumps and Drivers		Apply knowledge of fluid and pressure to maintenance and repair of pumps and valves.	Identify types of pumps and prime movers, and explain pressure differential between inlet and outlet of pumps. Student is expected to: (A) identify and explain centrifugal pumps; (B) identify and explain rotary pumps; (C) identify and explain reciprocating pumps;	Identify and explain centrifugal, rotary, reciprocating, metering, and vacuum pumps. Sketch the internal parts of a centrifugal pump. Label the parts of the pump, the flow of fluid through the pump, and the direction of rotation of the pump. Explain net positive suction head and cavitation. Write a short paragraph	

			(D) identify and explain metering pumps; (E) identify and explain vacuum pumps; (F) explain net positive suction head and cavitation; and (G) identify types of drivers.	about cavitation and the effects of cavitation on a fluid system. Determine the types of drivers on a piece of Equipment; explain how the driver is coupled to the machine gears or pump, and identify the horsepower of the driver (if available on the name plate).	
Introduction to Valves		Understand why valves are important to control the flow of fluids and gases.	Understand how valves are used to regulate pressure and flow of fluids. Student is expected to: (A) identify types of valves that start and stop flow; (B) identify types of valves that regulate flow; (C) identify valves that relieve pressure. (D) identify valves that regulate the direction of flow. (E) explain how to properly store and handle valves; and (F) explain valve locations and positions.	Identify types of valves that start, stop, regulate, relieve pressure, and regulate direction of flow. Explain how each valve works and how the valves are connected within the circuit and how they operate. Discuss the volume of flow that is possible through the valves. For example, a 1/2-in. valve will allow using Web sites such as http://www.pumpuniversity.com:8080/pumpu/calculators/formula.jsp?id=13&name=Pressure+drop+across+a+valve+and+flow+rate+through+that+valve to determine flow rate through the valve body. Discuss and demonstrate how to store valves such as gate and ball valves in a toolbox. Install a ball valve in the vertical position located next to a wall. Note: The valve must be positioned correctly so that the valve handle can be manipulated.	

Testing Equipment		Apply scientific knowledge and understanding of industrial metering tools to troubleshoot and repair mechanical, electrical, and electromechanical systems.	Apply scientific knowledge and understanding of industrial metering tools to troubleshoot and repair mechanical, electrical, and electromechanical systems. Student is expected to: (A) Explain the operation of and describe the following pieces of test equipment: • Tachometer • Pyrometers • Multimeters • Automated diagnostics tools • Wiggy® voltage tester • Stroboscope (B) explain how to read and convert from one scale to another using the above test equipment; (C) define frequency and explain the use of a frequency meter.	Identify and explain the use of various test equipment used in the trade, differentiate between analog and digital meter readouts, and properly test circuits and mechanisms using available school metering devices. Demonstrate how to use the solenoid tester in a simple parallel lighting circuit. The students should write each step in testing the parallel circuit on a sheet of paper. At the end of class, have the students orally report on their steps used in testing the circuit. Make sure the students use proper terminology when describing the circuit. Given a pictorial of an analog scale, determine the meter setting.	
Electrical Control Devices		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. Student is expected to: (A) recognizes electrical safety hazards and how to reduce the risk of exposure to those risks; (B) explore different types of switching devices; (C) examine the characteristics of overload protection devices;	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,	

			(D) explain the characteristics of solenoids and relays; (E) demonstrate how to install AC and DC controllers; and (F) practice troubleshooting common electrical control device issues.	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 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.	
PLCs		Understand how programmable logic controls (PLCs) are used in industry to control processes and machinery.	Understand how programmable logic controls (PLCs) are used in industry to control processes and machinery. Student is expected to: (A) recognize the basic function of Programmable Logic Controllers; (B) identify the function of input and output devices and the controller; (C) understand the fundamentals of logic; and (D) examines the basics of programming the Programmable Logic Controllers.	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. • Describe the purpose of the various power supplies used within a PLC. • 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.	
Mobile Equipment and Tools		Identify and explain safe rigging practices, load distribution, hand signals, and	Identify and explain safe rigging practices, load distribution, hand signals, and rigging equipment. Student is expected to:	Using industry pictures of safe rigging from textbooks, trade publications, and other sources of rigging equipment, identity, inspect, and explain the techniques of safe rigging. Demonstrate	

		rigging equipment.	(A) state the safety precautions associated with the use of motor-driven equipment in industrial plants; (B) explain the operation and applications of the following motor-driven equipment commonly used in industrial plants: • Portable generators • Air compressors • Aerial lifts • Forklifts • Mobile cranes (C) operate and perform preventive maintenance on the following equipment: • Portable generators • Air compressors • Aerial lifts	how to make rigging knots for moving equipment. Demonstrate tying different types of knots such as a double overhand, half hitch, square, chain hitch, and a sailor's knot. Perform proper crane signals. State and explain the safety precautions, operation, and application associated with the use of motor-driven equipment commonly used in industrial plants, such as the following: • Portable generators • Air compressors • Aerial lifts • Forklifts • Mobile cranes Allow the students to adjust and test the electric generator while using the multimeter to adjust the output voltage. Connect a light bulb to the generator output so that the students can optically view the effects of the change in voltage on the light bulb caused by manipulating the generator throttle. The students should calculate the current flow through the light bulb at 90 V, 108 V, 115 V, and 125 V. Once these currents are calculated, have the student verify their calculations by testing the current flow through the bulb using an amp meter. The students should log the calculated current flow for each voltage	

				and the actual current flow read with the meter.	
Machine lubricants		Understand the safety factors associated with lubricants. Understand different lubricants for different applications.	Describe and explain lubricant classification, additives, uses, and environments regulation regarding disposal of oils and greases Student is expected to: (A) explain OSHA hazard communication as pertaining to lubrication; (B) read and interpret a material data safety sheet (MSDS); (C) explain the EPA hazardous waste control program; (D) explain lubricant storage and handling; (E) explain lubricant classification and function; (F) explain properties of lubricants; (G) explain properties of greases and their application; (H) explain how to select lubricants; (I) identify the types, advantages, and functions of lubricant additives; (J) identify and explain types of lubricating oils and their purposes;	Create student pairs to compare an SAE 40-weight motor oil and 90-weight gear oil by using four bottles to test viscosity. Using one bottle, drill a small hole in the cap of the bottle. Fill the bottle with SAE 40-weight oil. Turn the oil-filled bottle bottom up and allow draining into an empty bottle. Repeat this process for the 90-weight oil. Have one of the students time how long it takes for each bottle to empty into the other empty bottle. Create a poster consisting of various lubricant types, their uses, and how the lubricants are produced. Explain lubricant film protection, identify and use lubrication equipment to apply lubricants, and read and interpret a lubrication chart. Discuss the storage, classification, properties, selection, additives, and types of lubricating oils and greases. Explain the types of classes of lubricants and how they are packaged in their respective containers. Elaborate on the uses of each lubricant and types of additives that are added to the lubricant for treatments such as anti-corrosiveness, freeze protection, and moisture-resistive additives. The following Web sites may be useful:	

			(K) explain the types of oil filters and their uses; (L) identify and use lubrication equipment to apply lubricants; and (M) read and interpret a lubrication chart.	http://www.chevron.com/products/oronite/products/lubricant.html http://www.rtvanderbilt.com/petro.htm http://www.usace.army.mil/publications/engmanuals/em1110-2-1424/c-7.pdf http://www2.dupont.com/Lubricants/en_US/index.html http://www.thomasnet.com/products/lubricants-44830206-1.html	
Resources:			http://findarticles.com/p/articles/mi_hb5645/is_/ai_n23674427 http://www.ncbi.nlm.nih.gov/pubmed/8899580 http://www.safetytoolboxtalks.com/index.php?option=com_content&task=view&id=105&Itemid=2 http://www.boltdepot.com/Fastener-Information/Printable-Tools/Type-Chart.pdf http://www.boltdepot.com/Fastener-Information/Printable-Tools/Default.aspx http://www.nutsandbolts.com/videos.html http://www.bikernet.com/garage/fastenertech.asp		

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