Massachusetts Career Technical Education

Robotics and Automation Technology

2014

DESE is in the process of updating all CTE Frameworks. This framework was adopted in 2014. More information about the process to update frameworks will be provided in DESE’s CCTE Newsletter.

# [Strand 2: Technical Knowledge and Skills](#_bookmark0)

###### Robotics and Automation Technology Safety Health and Skills

* + 1. Obtain OSHA 10 Hour General Certification.
			1. Implement safety knowledge obtained on a continuous basis.
			2. Identify safety hazards in the shop, remove hazards and develop continuous improvement solutions.
			3. Implement a tag-out and lock-out shop procedure.
		2. Performance Example:
			- Student will obtain an OSHA 10-hour general industry certificate.
		3. Read and implement shop safety manual.
			1. Demonstrate safety procedure(s) for maintaining machinery and equipment.
			2. Demonstrate safety procedure(s) for operating machinery and equipment.

###### Tools & Instrumentation

* + 1. Demonstrate the use of tools, fasteners, and equipment.
			1. Demonstrate and explain the use of threaded fasteners.
			2. Demonstrate and explain the use of non-threaded fasteners.
			3. Demonstrate and explain the use and types of anchors.
			4. Install fasteners and anchors.
			5. Demonstrate operation of power and power actuated tools according to current industry and OSHA standards and manufacturers’ specifications.
		2. Performance Example:
			- Drill and tap at least 3 different size holes into a material and tap the holes using appropriate size tap. Use common size holes. (8-32, 10-32, ¼-20)
		3. Use electrical test equipment.
			1. Perform measurement of current using the ammeter / clamp-on.
			2. Perform measurement of voltage using the voltmeter.
			3. Perform measurement of resistance using the ohmmeter.
			4. Measure circuit properties using the volt-ohm-multimeter (VOM).

2.B.02 Performance Example:

* Design a simple electrical circuit and measure ohms, volts and amperage using DVM.
	+ 1. Use electronic hand tools and equipment.
			1. Identify and apply standard methods of attaching and making electrical connections; i.e. soldering, crimping, wire nuts and lugs.
			2. Solder and de-solder electronic components.
			3. Select and use basic hand tools and equipment used for electronic circuits including needle nose pliers, nut drivers, screwdrivers, wire cutters, wire strippers, and torque drivers.
			4. Use advanced hand tools and equipment for assembling electronics circuits such as a Greenlee punch, taps and dies, hand drills, drill presses, and tools and riveters.

2.B.03 Performance Example:

* Design and build a simple electrical circuit consisting of stripped wires and soldered connections. Solder and de-solder and use all hand tools as needed.
	+ 1. Use measurement devices.
			1. Identify and utilize both English and International (SI) measurement systems.
			2. Define attributes, units, and systems of measurement used in Mechanical Engineering Technology (MET) fields.
			3. Apply a variety of techniques, tools and formulas for determining measurements.
			4. Identify appropriate electronic device/gauge for specific tasks.
			5. Calibrate and use electronic devices and/or gauges accurately.

2.B.04 Performance Example:

* Measure a part using a 6 inch scale, micrometer and verniers.

###### Engineering Design Process

* + 1. Explain and demonstrate knowledge of the design process.
			1. Identify the components of the design process.
			2. Articulate the steps of the design process.
			3. Use the design process to identify the problem(s) to be solved and evaluate the solutions to be tried.
		2. Performance Example:
			- Research different layout designs for the Design Process and explain the similarities and differences between them.
			- Discuss and develop preliminary criteria that relate to the problem.
		3. Create The Problem Statement.
			1. Identify and define the problem in a written format.
			2. Identify potential solutions through brainstorming.

2.C.02 Performance Example:

* Discuss and document as much as you can prior to doing research into a given problem.
* Write a Problem Statement to match the problem.
	+ 1. Research the related areas.
			1. Identify the major areas to be researched.
			2. Do background research into the problem.
			3. Identify resources needed (supplies, personnel, equipment).

2.C.03 Performance Example:

* Determine the research needed, the process to be used, and then document the process and the finding from the research work done.
* Read and fully cite the relevant information that pertains to the problem.
* Present to peers a Problem Statement Review with background research represented and document the groups questions as additional research needed, i.e.: reiterative process.
	+ 1. Build and test a prototype; document the solution.
			1. Develop solutions using a structured problem solving process.
			2. Identify the components and process of the system.
			3. Build a prototype or model.
			4. Test product to verify that it meets customer specifications, regulations, etc.
			5. Use appropriate testing equipment and tools for diagnosing the problem.
			6. Document the solution; write a report.

2.C.04 Performance Example:

* Present a Design Review with all solutions represented to peers and document the group’s questions for further consideration, i.e.: reiterative process.
* Develop and use a Decision Matrix based on relevant criteria to choose a final design solution.
* Present a Final Design Review with all background research represented and documented testing procedures and data to peers.

###### Technical Communications

* + 1. Develop working knowledge of various types of written technical communications.
			1. Read and interpret technical reports, trade journals, machine manuals, Safety Protocols (SDS) and web sources.
			2. Generate a technical report.
		2. Performance Example:
			- Write an abstract based on a technical document.
			- Present a technical review based on a technical document.
			- Participate in an on-line chat or a Blog site about a technical topic. Summarize your findings.
		3. Demonstrate visual communications within the Electrical and Electronics fields.
			1. Identify, read, and interpret electrical schematics and block diagrams.
			2. Identify the schematic symbols and wiring diagrams for the major international standards: IEEE, International Organization for Standardization (ISO), American National Standards Institute (ANSI), etc.

2.D.02 Performance Example:

* Look-up and review different type of electrical & electronic schematics symbols and match them to the actual component.
* Research the different International Organizations that have different electrical and electronic symbols.
	+ 1. Demonstrate visual communications within the process control systems and/or programming.
			1. Identify and interpret the standard flow charts symbols for the major international standards: IEEE, International Organization for Standardization (ISO), American National Standards Institute (ANSI), etc.
			2. Read and interpret process control flow charts.
			3. Identify and use appropriate symbols to develop a process diagram of a given process.

2.D.03 Performance Example:

* Research and report on the different International Organizations that have different flow chart symbols.
* Identify and follow a process using a flow chart for a given system.
* Develop a flow for an Automated Work Cell and use it to explain the job function(s).
	+ 1. Hand sketch drawings.
			1. Define, and describe orthographic projections.
			2. Produce fully annotated orthographic projections of a part.
			3. Produce a free hand drawing of a mechanical component.
			4. Produce sketches by integrating sketching techniques and styles.
			5. Select and produce the appropriate pictorial style to best communicate solutions in the design process.

2.D.04 Performance Example:

* Generate orthographic hand sketches of different 3D object and fully denote all relevant dimensions
* Generate pictorial hand sketches of different 3D object to show part orientation.
	+ 1. Demonstrate basic use of a CAD system.
			1. Create 2D-Orthographical drawings and pictorial drawings from CAD software.
			2. Read and interpret detail blue prints or technical processes.
			3. Define various geometric shapes and relationships and use appropriate geometry tools to draw basic shapes.
			4. Distinguish among and define geometric constraints.
			5. Identify and use the following geometric constraints in given three- dimensional models: horizontal, vertical, parallel, perpendicular, tangent, concentric, collinear, coincident, and equal.
			6. Use the appropriate form of the Cartesian coordinate system to measure and plot a model.

2.D.05 Performance Example:

* Using a CAD design package, generate fully annotated orthographic drawing of different 3D object and show all relevant dimensions
* Using a CAD design package, generate pictorial drawing of different 3D object.
* Generate shop drawing to be used to produce the part.

###### Mechanical Concepts

* + 1. Design and build a mechanical transfer system.
			1. Identify and describe all six simple machines (SM).
			2. Develop working knowledge for the terms: Ideal Mechanical Advantage (IMA), Actual Mechanical Advantage (AMA), Power & Power Transfer, Efficiency, Compound Machine, Work In-put and Work Out-put.
			3. Define each of the SM and give examples of their uses.
			4. Build and demonstrate a SM.
			5. Calculate the IMA & AMA for the different SM.
			6. Design, build and operate a Compound Machine.
			7. Identify the role that friction plays in SM operation.
		2. Performance Example:
			- Build a simple machine that turns rotary motion into linear motion.
		3. Design and build a hydraulic system.
			1. Identify and apply all safety protocols for hydraulic systems.
			2. Identify the parts of a typical hydraulic cylinder and their designated uses.
			3. Identify the various types of hydraulic pumps and their designated uses.
			4. Identify the various types of hydraulic accumulators and their designated

uses.

* + - 1. Identify the various types of actuators and their designated uses.
			2. Identify the various types of hydraulic motors and their designated uses.
			3. Identify the schematic symbol for each part of a hydraulic system.
			4. Identify the operation of relief valves, pressure compensated flow control valves, check valves, directional control valves and servo control valves as used in a hydraulic system.
			5. Design and build (or simulate) and operate a hydraulic system.

2.E.02 Performance Example:

* Design a simple hydraulic diagram for the operation of a dump truck bed.
	+ 1. Design and build a pneumatic system.
			1. Identify and apply all safety protocols for pneumatic systems.
			2. Identify the most commonly used components (including gases) used in a pneumatic system.
			3. Identify the various types of compressors and their designated uses/operations.
			4. Identify and describe the operation of desiccant dryers, receiver tanks, pressure switches and pressure regulators as used in a pneumatic system.
			5. Identify the schematic symbols for compressors, safety release valves, single action spring return cylinders, after coolers, receivers, dryers, pilot regulators, slave regulators, exhaust center directional control valves, pressure center directional control valves, lubricators, filters and blocked center directional control valves as used in a pneumatic system.

2.E.03 Performance Example:

* Design and build a pneumatic system that can clamp a part using a single actuator controlled by a manual valve.
	+ 1. Identify and describe basic machine operations.
			1. Identify and describe the use of a vertical mill.
			2. Identify and describe the use of a lathe.
			3. Identify and describe the use of power tools.

2.E.04 Performance Example:

* Explain how a machined part for a piece of equipment is made, show examples for milling and turning, and cutting.

###### Electrical Concepts

* + 1. Describe electrical current and electron theory.
			1. Label the parts of an atom.
			2. Explain the differences between an insulator and conductor.
			3. Explain the difference between “Conventional Current Flow” and “Electron Flow” theories.
			4. Describe the difference between direct and alternating current.
			5. Describe the difference between analog and digital signals.
		2. Performance Example:
			- Explain the difference between
				* “Conventional and Electron “ Current Flow
				* AC and DC Electricity
				* Analog and Digital signals
		3. Demonstrate knowledge of basic electronic components.
			1. Identify switches and explain their functions (NO, NC, SPST, SPDT, DPST, DPDT, Multi-selector).
			2. Identify and explain the function of resistors and potentiometers.
			3. Identify resistors using the color code.
			4. Identify and explain the function of capacitors.
			5. Identify and explain the function of inductors and transformers.
			6. Identify and explain the function of diodes.
			7. Identify and explain the function of transistors (BJTs and FETs).
			8. Identify and explain the function of LEDs and lamps.

2.F.02 Performance Example:

* Given a set of electronic components, identify each and briefly describe their function and application
	+ 1. Build, simulate and test basic electric circuits.
			1. Construct a series circuit and investigate Ohm’s Law.
			2. In a series circuit, measure voltage and current at various points in the circuit.
			3. In a series circuit, investigate Kirchoff’s Voltage Law by measuring voltages.
			4. Construct a parallel circuit and describe its relation to Ohm’s Law.
			5. In a parallel circuit, measure voltage and current at various points in the circuit.
			6. In a parallel circuit, investigate Kirchoff’s Current Law by measuring currents.
			7. Construct a series-parallel circuit and describe its relation to Ohm’s Law.
			8. In a series-parallel circuit, measure voltage and current at various points in the circuit.
			9. Calculate power dissipated using Watt’s Law.

2.F.03.10 Identify and interpret relay wiring diagrams.

2.F.03.11 Identify and interpret ladder logic diagrams.

2.F.03 Performance Example:

* Given and electric circuit and measuring devices, determine voltage, current, resistance and power consumption at various points in the circuit
	+ 1. Test, use, and calculate magnetic devices.
			1. Identify and explain magnetic principles and theorems.
			2. Determine the effect of turns on an electromagnet.
			3. Determine the effect of wire diameter on an electromagnet.
			4. Determine the effect of current on an electromagnet.
			5. Test and use a relay.
			6. Describe, calculate, simulate and measure transformer characteristics including turns ratio, voltage, current, power and efficiency.

2.F.04 Performance Example:

* Explain the operation of and use a transformer in a circuit.
	+ 1. Explain the scientific principles of and use AC circuits.
			1. Calculate RMS, Peak, Peak to Peak, and average values of a periodic waveform.
			2. Calculate frequency, period and duty cycle of a periodic waveform.

2.F.05 Performance Example:

* Measure the period, peak value and peak to peak value of a sine wave with an oscilloscope.
	+ 1. Design, build and test electronic circuits using diodes and transistors.
			1. Explain how a PN junction works.
			2. Design, simulate, build, and test a half wave rectifier.
			3. Design, simulate, build, and test a full wave rectifier.
			4. Design, simulate, build and test a transistor as a switch.
			5. Explain transistor bias point and how it relates to cutoff and saturation.

2.F.06 Performance Example:

* Design, build and test a full wave rectifier.
	+ 1. Explain the principles and characteristics of different types of electric motors.
			1. Name and explain the function of the main parts of a DC motor – field, armature, brushes, commutator.
			2. Explain the operation of DC motors, both self-excited and separately excited.
			3. Explain the performance characteristics of series wound, shunt wound, and compound wound of DC motors.
			4. Name and explain the function of the main parts of an AC motor, both rotor and stator (squirrel cage).
			5. Differentiate between both induction and synchronous AC motors.
			6. Explain the concept of three phase motors.

2.F.07 Performance Example:

* Disassemble and explain the parts of an electric motor.
	+ 1. Explain the basics of electric power transmission and distribution.
			1. Explain the basics of power generation.
			2. Explain the basics of three phase power.
			3. Explain the basics of power transmission.
			4. Explain the various high voltage values used in transmission.
			5. Explain the various voltage values used in local distribution.
			6. Explain the local distribution of power.

2.F.08 Performance Example:

* Explain the generation and distribution of electrical power.
	+ 1. Explain, design, simulate, and build combinational digital logic circuits.
			1. Find and read specification sheets for various ICs.
			2. Explain the basic gates AND, OR, INVERT, NAND, NOR, XOR.
			3. State and use truth tables for the basic gates.
			4. Create a truth table from a given word problem.
			5. Create Sum of Products (SOP) Boolean expressions from a given truth table.
			6. Simulate the logic diagram.
			7. Build and test the logic diagram.
			8. Troubleshoot the circuit.
			9. Convert the SOP circuit to NAND gates.
			10. Convert the SOP circuit to NOR gates.
			11. Use DeMorgan’s Laws to convert and build an alternative implementation of a circuit.
			12. Design circuits using reprogrammable logic devices.

2.F.09 Performance Example:

* Design, build, test, troubleshoot and analyze a Combinational Logic Circuit.
	+ 1. Explain, design, simulate, and build sequential digital logic circuits.
			1. Create timing diagrams and truth tables for D flip-flops and JK flip-flops.
			2. Design, simulate and build up/down asynchronous and synchronous counters using D/JK flip-flops.
			3. Build similar circuits using MSI circuits.

2.F.10 Performance Example:

* Design, build, test, troubleshoot and analyze a Sequential Logic Circuit.
	+ 1. Use and convert integers within the given number systems.
			1. Perform conversions from decimal to binary and from binary to decimal.
			2. Perform conversions from decimal to hex and from hex to decimal.
			3. Perform conversions from binary to hex and from hex to binary.

2.F.11 Performance Example:

* Convert numbers between the three number systems and explain where each would be used.

###### Fundamentals of Sensor Technologies

* + 1. Explain the characteristics and operation of position sensors.
			1. Describe the operation and use of a potentiometer to measure mechanical movement in a control system.
			2. Design and build a circuit used to demonstrate the use of a potentiometer to measure mechanical movement in a control system.
			3. Describe the operation and use of absolute and incremental optical rotary encoders.
			4. Design and build a circuit using absolute and incremental optical rotary encoders.
		2. Performance Example:
			- Students will draw schematic symbols of potentiometers, describe their operation, and give examples of their use in mechanical systems used to measure mechanical movement. Students will also describe the use of incremental and absolute encoders used to measure mechanical movement.
		3. Explain the characteristics and operation of velocity sensors.
			1. Describe the operation and use of optical tachometers.
			2. Design and build a circuit used to demonstrate the operation of optical tachometers.
			3. Describe the operation and use of direct current transformers.
			4. Design and build a circuit used to demonstrate the operation of direct current tachometers.

2.G.02 Performance Example:

* Students will design, build, and test a circuit using a velocity sensor.
	+ 1. Explain the characteristics and operation of proximity sensors.
			1. Describe the operation and use of a mechanical limit switch in a control system.
			2. Describe the operation, use of, and modes of operations for optical proximity sensors, including photo resistors, photodiodes, phototransistors and photovoltaic cells.
			3. Describe the operation and use of ultrasonic proximity sensors in a control system.
			4. Describe the operation and use of inductive and capacitive proximity sensors.
			5. Describe the operation and use of hall-effect proximity sensors.
			6. Design and build a circuit using one or more of the above proximity sensors.

2.G.03 Performance Example:

* Students will design, build and test a circuit using any type of proximity sensor.
	+ 1. Explain the characteristics and operation of load and force sensors.
			1. Describe the operation and the use of strain gauges in a control system.
			2. Design and build a circuit used to demonstrate the use of a strain gauge in a control system.

2.G.04 Performance Example:

* Students will design, build and test a circuit using a strain gauge.
	+ 1. Explain the characteristics and operation of pressure sensors.
			1. Describe the operation and use of a pressure sensor in a control system.
			2. Design and build a circuit used to demonstrate the use of a pressure sensor in a control system.

2.G.05 Performance Example:

* Students will design, build and test a circuit using a pressure sensor.
	+ 1. Explain the characteristics and operation of temperature sensors.
			1. Describe the operation and use of a RTD in a temperature control system.
			2. Design and build a circuit used to demonstrate the operation and use of a RTD (Resistor Temperature Device) in a temperature control system.
			3. Describe the operation and use of a thermistor in a temperature control system.
			4. Design and build a circuit used to demonstrate the operation and use of a thermistor in a temperature control system.
			5. Describe the operation and use of a thermocouple in a temperature control system.
			6. Design and build a circuit used to demonstrate the operation and use of a thermocouple in a temperature control system.
			7. Describe the operation and use of an integrated-circuit temperature sensor in a temperature control system.
			8. Design and build a circuit used to demonstrate the operation and use of an integrated-circuit sensor in a temperature control system.

2.G.06 Performance Example:

* Students will design, build and test a circuit using a temperature sensor.

###### Programmable Logic Controller Foundations and Programming Concepts

* + 1. Name and explain the basic building blocks of a programmable logic controller (PLC).
			1. Identify the major advantages in the use of PLCs in automation.
			2. Identify the major components of a PLC.
			3. Define fixed and modular PLCs and give advantages of both types.
			4. Identify the various programming devices used to program a PLC.
			5. Explain the various modes of operations of a PLC.
			6. Identify the criteria used in categorizing PLCs including functionality, number of inputs and outputs, cost, and physical size.
		2. Performance Example:
			- Students will develop a schematic diagram of a typical PLC system and identify all components and describe their function.
		3. Identify and explain PLC hardware components.
			1. Identify the input/output (I/O) section of a PLC and field device connections.
			2. Describe PLC I/O addressing formats.
			3. Describe the specifications, use and operation of Discrete I/O modules.
			4. Describe the specifications, use and operation of Analog I/O modules.
			5. Describe the specifications, use and operation of Specialty I/O modules.
			6. Identify the Central Processing Unit (CPU) of a PLC.
			7. Identify the power supply of a PLC and its specifications.
			8. Identify PLC memory types and designs.
			9. Describe the various Terminal Programming Devices used to program PLCs.

2.H.02.10 Explain Human Machine Interfaces (HMI’s) and their applications.

2.H.02 Performance Example:

* Students will develop a schematic diagram of typical Input and Output configurations and correctly address using the specific manufacture’s addressing formats.
	+ 1. Demonstrate an understanding of the fundamentals of PLC Logic.
			1. Explain the Binary Concept and its use in PLC applications.
			2. Explain the basic digital gate functions, AND, OR, INVERTER, and their applications in PLC logic.
			3. Identify the role of Boolean algebra and its application in PLC logic simplification.
			4. Develop equivalent PLC logic from Logic Gate Circuits derived from Boolean Expressions.
			5. Develop equivalent PLC logic from Boolean Expressions derived from Logic Gate Circuits.
		2. Demonstrate an understanding of the fundamentals of PLC programs and PLC wiring diagrams.

2.H.03 Performance Example:

* Students will develop simple PLC logic programs to replicate digital gate functions, i.e. AND, OR, and INVERTER functions. Students will further develop PLC logic programs derived from Boolean Expressions and Logic Gate Circuits.
	+ - 1. Explain the role of electromagnetic relays and their role in PLC programming and PLC wiring diagrams.
			2. Explain the NO and NC contacts and develop equivalent PLC programming and PLC wiring diagrams.
			3. Develop PLC programming and PLC wiring diagrams using motor starters and contactors.
			4. Develop PLC programming and PLC wiring diagrams using manually operated switches.
			5. Develop PLC programming and PLC wiring diagrams using various sensors.
			6. Develop PLC programming and PLC wiring diagrams from electromagnetic relay logic.
			7. Develop PLC programming and PLC wiring diagrams directly from a narrative description.
			8. Develop PLC programs using various delay and retentive timers.
			9. Develop various PLC programs using various counters.
			10. Develop PLC programs using Program Control Instructions, Master Control Reset, Jump, and Subroutines.
			11. Develop PLC programs using Data Manipulation and Data Compare Instructions.
			12. Develop PLC programs using basic Math Functions.
			13. Develop PLC programs using Sequencer and Shift Register Instructions.
			14. Develop PLC programs using programming blocks for analog inputs and outputs and PID (Proportional Integral Derivative ) control.
			15. Develop HMI (Human Machine Interface) programs to allow the user to view the PLC operation in real time, change timer or counter values and replace hardwired input and output devices.

2.H.04 Performance Example:

* Students will wire Inputs and Output devices to a PLC system. Students will develop PLC logic programs from a narrative description using timer, counter and advanced ladder programming instructions to automate a system. System may include the use of a Human Machine Interface HMI) device to complete the given task.

###### Robotics Technology

* + 1. Name and explain the basic building blocks and critical specifications of an industrial robot.
			1. Identify classification by arm geometry.
			2. Define the following robot terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point.
			3. Define and give an example of the following specifications for industrial robots: payload, repeatability, memory capacity, and environmental requirements.
			4. Identify the various actuators used by a typical industrial robotic arm.
			5. Identify the various drive mechanisms used by a typical industrial robotic arm.
			6. Identify the various controllers used by a typical industrial robot.
			7. Identify the various power sources used by a typical industrial robot.
			8. Describe various end-of-arm tooling used by an industrial robot.
			9. Identify various teaching and programming devices used to accurately program an industrial robot.

2.I.01.10 Describe various data storage devices used by a typical industrial robot.

* + 1. Performance Example:
			- Students will draw and label the basic building blocks of an industrial robot using the appropriate robotic terminology. Drawings will include examples of degrees of freedom, work envelope, position axes, actuators, drive mechanisms, controllers, power sources, and end of arm tooling.
		2. Explain industrial robot characteristics and classifications.
			1. Describe open-loop and close-loop control systems.
			2. Identify an industrial robot’s classification.
			3. Describe the various arm geometries employed in industrial robots.
			4. Describe the various power sources used by industrial robots.
			5. Explain the various path control techniques used by industrial robots.

2.I.02 Performance Example:

* Students will draw and label electrical diagrams showing open-loop and close-loop industrial robot systems.
	+ 1. Explain the use of industrial robot work-cell sensors.
			1. Describe the operation and use of simple contact sensors.
			2. Describe the operation and use of simple noncontact sensors.
			3. Describe the operation and use of process control sensors.

2.I.03 Performance Example:

* Students will develop and test simple industrial robot programs designed to show the operation of contact and noncontact sensors used with industrial robots.
	+ 1. Explain various end-of-arm tooling with industrial robots.
			1. Define given tooling terms.
			2. Identify various tooling power sources.
			3. Identify various grippers: standard, servo, nonservo, vacuum, and magnetic.

2.I.04 Performance Example:

* Students will develop and test simple industrial robot programs designed to show the use of various end-of-arm tooling used with industrial robots.
	+ 1. Explain robot teaching and programming techniques.
			1. Identify the complexities of work-cell programming.
			2. Identify the functions of the controller used.
			3. Explain on-line programming, methods used to and how it is accomplished.
			4. Explain off-line programming, methods used to and how it is accomplished.

2.I.05 Performance Example:

* Students will develop and test a fully automated industrial robot program designed to operate a close-loop industrial robot system derived from a narrative description or system design specifications.
	+ 1. Build and program a mobile robot.
			1. Assemble and build a mobile robot.
			2. Create and load code to operate the mobile robot.
			3. Control the robot using a remote control unit.
			4. Control the robot; move forward, backward, turn and use different power levels in autonomous mode.
			5. Use sensors to detect external conditions and to control the robot’s operation.
			6. Use loops and conditional statements in the program.

2.I.06 Performance Example:

* Students will design, build, program and test a mobile robotic system.

###### Automated Systems

* + 1. Design, simulate, build, or research at least two of the following industrial systems.
			1. Motor Control application.
			2. Punch press application.
			3. Clamp and drill routine.
			4. Injection molding machine.
			5. Robot gripper and control routine.
			6. Palletizing routine.
			7. Batch Process routine.
			8. Sorting process.
			9. Mobile robot application.

2.J.01.10 Robotic work station.

* + 1. Performance Example:
			- Research and design a power point presentation to explain at least (2) of automation systems given.

# [Embedded Academic Crosswalks](#_bookmark0)

### [Embedded English Language Arts and Literacy](#_bookmark0)

|  |  |  |
| --- | --- | --- |
| **CTE****Learning Standard Number** | **Strand Coding Designation Grades ELAs****Learning Standard Number** | **Text of English Language Arts Learning Standard** |
| 2.C.02.01 | W.2 Grade 9 - 12 (a, d, e)* 1. Grade 9 – 12
	2. Grade 9 - 12
 | Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content* Introduce the topic; organize complex ideas, concepts, and information to make important connections and distinctions
* Use precise language and domain-specific vocabulary to manage the complexity of the topic
* Establish and maintain a formal style and objective tone while attend to the norms and conventions of the discipline in which they are writing

Demonstrate command of the conventions of standard English grammar and usage when writingDemonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing |
| Performance Example: | * Write a report that defines the design problem.
 |  |
| 2.C.04.06 | * 1. Grade 9 – 12 (a, c, d, e)
	2. Grade 9 – 12
	3. Grade 9 - 12
 | Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sand sufficient evidence.Introduce precise claimsUse words, phrases and clauses to link major sections of the text Establish and maintain a formal style and objective tone Provide a concluding statement or section that follows from and supports the argument presentedDemonstrate command of the conventions of standard English grammar and usage when writingDemonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing |
| Performance Example: | * Write a report that documents the solution(s) to the design problem.
 |  |
| 2.D.01.02 | W.7 Grade 9 – 12W.2 Grade 9 – 12 (a, b,d,e) L.1 Grade 9 – 12L.2 Grade 9 - 12 | Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.Write informative/explanatory texts to examine and convey complex ideas, concepts and information clearly and accurately through the effective selection, organization, and analysis of content.Introduce the topic; organize complex ideas, concepts, and information to make important connections and distinctions Develop the topic with well-chosen, relevant, and specific facts, |
|  |  | extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences’ knowledge of the topicUse precise language and domain-specific vocabulary to manage the complexity of the topicEstablish and maintain a formal style and objective tone while attend to the norms and conventions of the discipline in which they are writing.Demonstrate command of the conventions of standard English grammar and usage when writingDemonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing |
| Performance Example: | * Write a technical report that synthesizes information found in different sources (magazines, web, manuals, reports) on the same subject as it relates to Technical Communications.
 |  |
| 2.D.01.01 | RI.1 Grade 9 - 12RI. 2 Grade 9 - 12RI.4 Grade 9 - 12 | Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from text.Determine the central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.Determine the meaning of words and phrases as they are used in a text including technical meaning. |
| Performance Example: | * Read various types of written technical communications including, but not limited to, technical reports, trade journals and magazines, machine manuals, safety protocols and web sources.
 |  |
| 2.D.01.02 | R1.2 Grade 9 - 12RI. 3 Grade 9 - 12RI. 4 Grade 9 - 12 | Determine the central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.Analyze how the author unfolds and analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them.Determine the meaning of words and phrases as they are used in a text including technical meaning |
| Performance Example: | * Read a flow chart and interpret the process.
 |  |
| 2.F.09.01 | R1.2 Grade 9 - 12RI. 4 Grade 9 - 12 | Determine the central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.Determine the meaning of words and phrases as they are used in a text including technical meaning |
| Performance Example: | * Read a spec sheet for an IC found in your design.
 |  |
| 2.I.01.02 | L.4 | Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade [9 – 10 or 11 – 12] reading and content, choosing flexibly from a range of strategies. |
| Performance Example: | * Write down the definition of the following robotic terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point
 |  |
| 2.J.01 | W.7 Grade 9 – 12W.8 Grade 9 – 12W.5 Grade 9 - 12* 1. Grade 9 – 12
	2. Grade 9 - 12
 | Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.Demonstrate command of the conventions of standard English grammar and usage when writing |
| Performance Example: | * Write a 5 page research report on motor control application.
 |  |

### [Embedded Mathematics](#_bookmark0)

|  |  |  |
| --- | --- | --- |
| CTELearning Standard Number | Math Content Conceptual Category and Domain Code Learning Standard Number | Text of Mathematics Learning Standard |
| 2.B.04.01 | 4.MD-1 | Know relative sizes of measurement units within one system of units, including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two- column table. *For example, know that 1 ft is 12 times as long as 1 in.**Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs* (*1, 12*)*,* (*2, 24*)*,* (*3, 36*). |
| Performance Example: | * Take measurements of a physical object in order to include them on a drawing.
 |  |
| 2.D.05.05 | 4.G-1 | Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. |
| Performance Example: | * Draw perpendicular and parallel lines in a CAD drawing.
 |  |
| 2.F.03.042.F.03.07 | 5.NF-15.NF-2 | 1 .Add and subtract fractions with unlike denominators (including mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference |
|  |  | of fractions with like denominators.2. Solve word problems involving addition and subtraction of fractions referring to the same whole, including cases of unlike denominators, e.g., by using visual fraction models or equations to represent the problem. Use benchmark fractions and number senseof fractions to estimate mentally and assess the reasonableness of answers. |
| Performance Example: | * Solve for equivalent resistance for parallel and series-parallel resistor networks.
 |  |
| 2.F.04.03 | 6.G-1 – MA.1.a6.G-1- MA.1.b7.G-4 | 6.G-1-MA.1.a.Use the relationships among radius, diameter, and center of a circle to find its circumference and area.6.G-1-MA.1.b. Solve real-world and mathematical problems involving the measurements of circles.7.G-4 Know the formulas for the area and circumference of a circle and solve problems; give an informal derivation of the relationship between the circumference and area of a circle. |
| Performance Example: | * Calculate the cross sectional area of copper wire.
 |  |
| 2.E.01.05 | 6.RP-16.RP-2 | 6.RP-1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities6.RP-2. Understand the concept of a unit rate ***a***/***b*** associated with a ratio *a*:*b* with *b* ≠ 0, and use rate language in the context of a ratiorelationship. |
| Performance Example: | * Calculate the mechanical advantage of a simple machine as a ratio or fraction.
 |  |
| 2.F.05.01 | 6.SP-5c | Summarize numerical data sets in relation to their context, such as by: Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which thedata were gathered. |
| Performance Example: | * Calculate an average.
 |  |
| 2.F.05.02 | 4.NF-54.NF-6 | 1. Express a fraction with denominator 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100.
2. Use decimal notation for fractions with denominators 10 or 100.
 |
| Performance Example: | * Convert the period of a waveform to a period by taking the reciprocal value.
 |  |
| 2.F.11.012.F.11.022.F.11.03 | 5.NBT-1 | Recognize that in a multi-digit number, a digit in one placerepresents 10 times as much as it represents in the place to its right and **1**/**10** of what it represents in the place to its left. |
| Performance Example: | * Use the place value concept learned in decimal arithmetic to calculate the value of binary and hexadecimal numbers.
 |  |

### [Embedded Science and Technology/Engineering](#_bookmark0)

#### [Physical Science (Chemistry)](#_bookmark0)

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| --- | --- | --- |
| **CTE****Learning Standard Number** | **Subject Area, Topic Heading and****Learning Standard Number** | **Text of Chemistry Learning Standard** |
| 2.F.1 | 2. Atomic Structure and Nuclear Chemistry | 2.1 Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of atom), and understand how each discovery leads to moderntheory. |
| Performance Example: | * Students will be able to identify the parts of an atom through an understanding of the scientific process that has resulted in our modern theory of the atom.
 |  |

#### [Physical Science (Physics)](#_bookmark0)

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| --- | --- | --- |
| **CTE****Learning Standard Number** | **Subject Area, Topic Heading and****Learning Standard Number** | **Text of Physics Learning Standard** |
| 2.D.22.F.22.F.3 | 5. Electromagnetism | * 1. Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm’s law).
	2. Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand

the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram. |
| Performance Example: | * Students will be given a diagram of a simple 2 battery LED flashlight and will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through a circuit. Students will predict the effect connecting batteries in series and parallel has on the voltage of the
 | flashlight. Students will also be expected to build and test their predictions with measurement tools. |
| 2.F.1.2 | 5. Electromagnetism | 5.1 Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges. |
| Performance Example: | * Students will be able to identify the properties of insulators and conductors and identify examples of each.
 | Students will be able to explain the behavior static electricity on insulators and conductors and apply that knowledge to the flow of electricity in electrical current. |
| 2.F.42.F.72.F.8.1 | 5. Electromagnetism | 5.6 Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces. Recognize that the interplay of electric and magnetic forces is the basis for electricmotors, generators, and other technologies. |
| Performance Example: | * Students will be able to understand how electric current creates a magnetic field and how this is used in technologies such as electromagnets, solenoid relays, transformers and electric motor/generators.
 |  |
| 2.F.5 | 4. Waves | 4.1 Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonicmotion. |
| Performance Example: | * When given a periodic waveform, students will be able to determine the basic characteristics of the wave through measurement and calculation.
 |  |
| 2.F.8 | 5. Electromagnetism | 5.5 Explain how electric current is a flow of charge caused by apotential difference (voltage), and how power is equal to current multiplied by voltage. |
| Performance Example: | * Students will understand why different voltage values are used in power transmission and how these values help to minimize the loss of energy in high voltage transmission lines.
 |  |

#### [Technology/Engineering](#_bookmark0)

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| --- | --- | --- |
| **CTE****Learning Standard Number** | **Subject Area, Topic Heading and****Learning Standard Number** | **Text of Technology/Engineering Learning Standard** |
| 2.A.2.22.B.1 | 1. Materials, Tools, and Machines | * 1. Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use.
	2. Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other

mechanical fasteners) needed to construct a prototype of an engineering design. |
| Performance Example: | * Students will be able to apply knowledge of materials, tools, and equipment to safely perform tasks related to robotics and engineering technology.
 |  |
| 2.C.12.C.22.C.4 | 2. Engineering Design | * 1. Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.
	2. Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.
	3. Describe and explain the purpose of a given prototype.
	4. Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.
	5. Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given

prototype. |
| Performance Example: | * Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. The students will determine the best materials for the design considering factors such as cost, availability, reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the design and determine overall cost. Students will also maintain a
 | journal documenting the steps of their process. |
| 2.D.4 | 2. Engineering Design | 2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiviewdrawings. |
| Performance Example: | * Students will be able to communicate the solution of a design problem by accurately drawing their solution using a variety of formats.
 |  |
| 2.B.12.B.32.E.12.E.22.E.3 | 2. Construction Technologies | 2.5 Identify and demonstrate the safe and proper use of common hand tools, power tools, and measurement devices used in construction. |
| Performance Example: | * Students will be able to apply knowledge of materials, tools, and equipment to safely perform tasks related to robotics and engineering technology.
 |  |
| 2.B.2 | 5. Energy and Power Technologies—Electrical Systems | 5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage,current, power consumption, and resistance. |
| Performance Example: | * Students will be capable of using a multimeter to safely determine the characteristics of the components of a electrical circuits.
 |  |
| 2.C.12.C.22.C.3 | 1. Engineering Design | * 1. Identify and explain the steps of the engineering design process: identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct prototypes and/or models, test and evaluate, communicate the solutions, and redesign.
	2. Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify examples of technologies, objects, and processes that have been

modified to advance society, and explain why and how they were modified. |
| Performance Example: | * Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. The students will determine the best materials for the design considering factors such as cost, availability, reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the design and determine overall cost. Students will also maintain a
 | journal documenting the steps of their process. |
| 2.C.4 | 1. Engineering Design | 1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models. |
| Performance Example: | * Given the drawing of a prototype solution, students will be able to work in a group to build individual parts, conduct final assembly, and test the prototype while documenting their progress.
 |  |
| 2.C.4 | 1. Engineering Design | * 1. Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques.
	2. Interpret and apply scale and proportion to orthographic projections and pictorial drawings (e.g., ¼" = 1'0", 1 cm = 1 m).
 |
| Performance Example: | * Students will be able to produce accurate scale drawings of a mechanical component using a variety of formats including hand sketching and CAD.
 |  |
| 2.E.2 | 3. Energy and Power Technologies—Fluid Systems | * 1. Explain the differences and similarities between hydraulic and pneumatic systems, and explain how each relates to manufacturing and transportation systems.
	2. Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change.
 |
| Performance Example: | * Students will be tasked with designing a hand lift for a small automobile considering hydraulic and pneumatic solutions. Students will be able to determine the amount of force multiplication necessary,
 | determine the necessary parts and create a design solution. |
| 2.E.2 | 7. Manufacturing | 7.2 Identify the criteria necessary to select safe tools and |
| 2.E.3 | Technologies | procedures for a manufacturing process (e.g., properties of materials, required tolerances, end-uses).7.3 Describe the advantages of using robotics in the automation of manufacturing processes (e.g., increased production, improvedquality, safety). |
| Performance Example: | * Students will observe the use of assembly line automation in the various industries and then design and build (or simulate) an assembly line process for the automotive industry that operates a pneumatic and
 | hydraulic system. |
| 2.F.1.4 | 5. Energy and Power Technologies—Electrical Systems | 5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each. |
| Performance Example: | * Students will explain the reason AC is needed in power transmission and observe the prevalence of DC electronics in the home. Students will observe AC and DC current on an oscilloscope to demonstrate the
 | differences in waveform |
| 2.F.2 | 5. Energy and Power Technologies—Electrical Systems | 5.2 Identify and explain the components of a circuit, including sources, conductors, circuit breakers, fuses, controllers, and loads. Examples of some controllers are switches, relays, diodes, andvariable resistors. |
| Performance Example: | * Students will be able to interpret an electrical wiring diagram of a car and be able to identify the major electrical components.
 |  |
| 2.F.3 | 5. Energy and Power Technologies—Electrical Systems | * 1. Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage, current, power consumption, and resistance.
	2. Identify and explain the components of a circuit, including sources, conductors, circuit breakers, fuses, controllers, and loads. Examples of some controllers are switches, relays, diodes, and variable resistors.
	3. Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm’s law.
 |
| Performance Example: | * Students will be given a diagram of a simple 2 battery LED flashlight and will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through a circuit. Students will predict the effect connecting batteries in series and parallel has on the voltage of the
 | flashlight. Students will also be expected to build and test their predictions with measurement tools. |
| 2.F.1.5 | 6. Communication Technologies | 6.2 Differentiate between digital and analog signals. Describehow communication devices employ digital and analog technologies (e.g., computers, cell phones). |
| Performance Example: | * Students will list and explain the benefits and drawbacks to switching from analog to digital communications. Students will apply this to explain why the 2008 regulatory decision by the FCC to switch
 | from analog to digital cellular signals in the US. |

[Industry Recognized Credentials](#_bookmark0) (Licenses and Certifications/Specialty Programs)

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