AUTOMATION AND ROBOTICS 14.4201.00 TECHNICAL STANDARDS

An Industry Technical Standards Validation Committee reviewed, updated, and validated these standards on April 15 and May 6, 2025. The Arizona Career and Technical Education Quality Commission, the validating authority for the Arizona Skills Standards Assessment System, reviewed these standards on July 13, 2025.

Note: Arizona's Professional Skills are taught as an integral part of this program.

The Technical Skills Assessment for Automation and Robotics is available SY 2026-2027.

Note: In this document i.e. explains or clarifies the content and e.g. provides examples of the content that must be taught.

STANDARD 1 .0 EXAMINE THE INTERCONNECTION OF AUTOMATION AND ROBOTICS AND THE IMPACT OF NEW TECHNOLOGIES ON BOTH

1.1 Explain how the manufacturing industry uses automation and robotics to perform routine tasks such as welding, material handling, and assembly (e.g., automation uses software, machines, or other technology to carry out tasks; robotics combines engineering and computer science to design and build robots to perform tasks)

1.2 Describe artificial intelligence (AI), machine learning (ML), and robotic process automation (RPA) and their results on manufacturing (i.e., to enable machines to learn, adapt, and perform complex tasks leading to increased efficiency, precision, and safety; to predict maintenance and quality control; to streamline workflow and enhance production; to improve data collection and analysis; etc.)

1.3 Discuss challenges associated with AI, ML, RPA (e.g., limited talent, personnel training, keeping up with advancements, ability to manage and troubleshoot tasks, and such issues as privacy, data inaccuracies, ethical considerations, and safety concerns)

1.4 Identify skills needed by automation and robotics technicians (i.e., ability to visually inspect, test, and assemble components using approved procedures; experience with and ability to use computers to perform tests and diagnostics, download information, analyze data acquisition, and record data; ability to use hand tools, machine tools, and various equipment; ability to solve problems, organize work, and communicate with others, etc.)

1.5 Discuss education and training programs for individuals interested in a career in automation and robotics (e.g., completion of the automation robotics or engineering CTE program; apprenticeship in automation engineering; on-the-job training emphasizing hands-on experience with automation systems, programming, and maintenance; and/or further training in community college or university in areas such as mechanical or electrical engineering, computer science, or robotics)

STANDARD 2.0 MAINTAIN A SAFE WORK ENVIRONMENT

2.1 Comply with Occupational Safety and Health Administration (OSHA) health and safety standards [i.e., safe work attire and personal protective equipment (PPE), fall protection requirements, lifting procedures, fire protection plan, emergency plan, Safety Data Sheets, etc.)

2.2 Identify and describe key elements of safe work conditions with automation and robotics (i.e., physical barriers and work zone safety, detection sensors, emergency stop buttons, visual and audible warning systems, lockout/tagout procedures, compliance with standards ANSI/RIA R15.06 for industrial robots, ergonomics, etc.)

2.3 Identify and describe key elements of safe work conditions in the electronic technology environment [i.e., electrical safety (power down equipment before working on it, use insulated tools and equipment, use grounding procedures for sensitive components, avoid working on wet environments); chemical safety (proper ventilation, labeled chemicals, appropriate handling and disposal procedures); clear room protocols and procedures, etc.]

2.4 Explain the "fail safe" component integrated in robotic and automated systems (i.e., emergency shutdowns, interlocks, and sensor-based stops, etc.)

2.5 Utilize drawings, instrument data, prints, and manufacturer's recommendations to install, repair, and store tools and equipment

2.6 Follow good housekeeping procedures (e.g., follow clean work area protocols, eliminate potential hazards, perform safety checks, document equipment repairs and maintenance activity, and report injuries, incidents, and near misses)

STANDARD 3.0 USE SCHEMATICS, TECHNICAL DRAWINGS, MATHEMATICAL PROCESSES, AND MEASUREMENT TECHNIQUES

3.1 Describe different types of visual representations used to convey information about systems or processes (e.g., schematics, blueprints, and technical drawings)

3.2 Interpret dimensions, symbols, legends, scales, and directions on schematics, blueprints, and technical drawings

3.3 Explain tolerance on blueprints, technical drawings, and graphic representations used to express problems

3.4 Demonstrate drawing and visualization skills including the use of computer-aided design (CAD) tools and electrical drawings [i.e., simple starter circuits, programmable logic controller (PLC) output, etc.]

3.5 Solve basic mathematical equations and identify the relationship/dependency of variables within the equation

3.6 Explain the functions of common electrical measurement tools [i.e., multimeter: ammeter, voltmeter, ohmmeter, fuse tester; meter tester panel: current (Amps), voltage (Volts), power (Watts), energy (kWh); etc.]

3.7 Use the appropriate measurement technique for a specific measurement (e.g., consider size, what's being measured, and level of precision)

3.8 Describe dimensioning, tolerancing, and quality control

3.9 Differentiate among theoretical, simulation, and real-world scenarios and tests

STANDARD 4.0 ANALYZE AND APPLY FOUNDATIONAL CONCEPTS OF ELECTRICAL AND ELECTRONIC CIRCUITS

4.1 Distinguish between electrical and electronic circuits and explain their role in modern automation systems across industries (i.e., manufacturing, energy, transportation, robotics, etc.)

4.2 Explain common electrical components (e.g., resistors, transistors, capacitors, inductors, and diodes)

4.3 Explain fundamental quantities in a charge and measurement system performance [e.g., charge (coulomb), current (ampere), voltage (volt), power (watt), and energy (joule), with frequency measured in hertz]

4.4 Explain key units and their relevance in circuits [e.g., ampere (A) for current, volt (V) for voltage, watt (W) for power, and coulomb (C) for electrical change; also, hertz (Hz) for frequency, farad (F) for capacitance, henry (H) for inductance, and siemens (S) for conductance]

4.5 Use ammeters and voltmeters to measure voltage and amperage

4.6 Define, calculate, and apply Ohm's law (E/I x R) and Kirchhoff's law (the sum of the currents) of energy and power

4.7 Distinguish between AC and DC circuits including series and parallel circuits

4.8 Describe types of electronic circuits and their function [e.g., permanent live (PL) which involves resistor and inductor; RC (resistor-capacitor) circuits which involve a resistor and capacitor; and Full Load Current (FLC) circuits which involve a resistor, inductor, and capacitor]

4.9 Analyze frequency oscillators (e.g., electronic circuits that generate periodic signals such as sine waves or square waves from a DC source, and how they are used for a wide range of applications, including clock generation, signal generation, and frequency control in devices such as computers and radios)

4.10 Describe the role of integrated circuits in powering control systems, sensors, and smart devices across industrial sectors (e.g., miniaturizing electronic circuits onto a small semiconductor chip, typically silicon, and enabling complex functionalities in a compact space)

4.11 Analyze the difference between signal processing analog and digital circuit (i.e., electronic circuits designed to analyze, modify, and synthesize signals, which can be audio, video, sensor data, or other forms of information, etc.)

STANDARD 5.0 IMPLEMENT AND TEST CONTROL CIRCUITS USING DIODES AND SEMICONDUCTOR COMPONENTS

5.1 Explain what a diode is and its function in an electronic control circuit (e.g., a type of semiconductor device that allows current to flow primarily in one direction, acting as a one-way switch for electricity)

5.2 Describe insulators, conductors, N- and P-types, diodes, semiconductors, and transistors and the effect temperature has on these materials

5.3 Explain the operation of thyristors and relays in a control circuit

5.4 Illustrate and explain electron and hole currents in semiconductor materials and how they relate to the function of diodes and transistors

5.5 Describe and calculate decibel gain and loss of amplifiers and power gain

5.6 Calculate transistor biasing currents including cutoff, saturation, active states, and linear region

5.7 Build a basic transistor circuit and diode circuit using an oscilloscope and digital multimeter (DMM)

5.8 Explain the importance of impedance matching and its impact on signal clarity in electronic control systems

5.9 Investigate cascade amplifiers and calculate voltage gain

5.10 Identify and troubleshoot circuits for component-level defects using diagnostic tools (i.e., voltage meters, oscilloscope, etc.)

STANDARD 6.0 BUILD, MEASURE, AND TEST ELECTRICAL AND ELECTRONIC CIRCUITS

6.1 Determine voltage, current, resistance, and power in AC and DC circuits (i.e., oscilloscope, volt/ohm, meter, etc.)

6.2 Build DC series, parallel, and series parallel circuits and verify circuit behavior by taking measurements

6.3 Assemble RC, RL, and RLC circuits

6.4 Explain transformer operations and its application within automation and robotics

6.5 Explain power supply operations and its application within automation and robotics

6.6 Analyze magnetic circuit performance using magnetic quantities and units

6.7 Troubleshoot voltage, current, and power in AC and DC circuits

6.8 Identify and troubleshoot components and connections using diagnostic tools (i.e., signal probes, voltage meters, oscilloscope, etc.)

STANDARD 7.0 ANALYZE FLUID POWER SYSTEMS INCLUDING HYDRAULICS AND PNEUMATICS

7.1 Differentiate between hydraulic and pneumatic systems and explain where and how they are used in industry (i.e., pressure differences, power, inertia, strength, mass, density, etc.)

7.2 Describe the benefits of integrating hydraulic and pneumatic systems with robotic systems

7.3 Explain the principles of fluid power systems behavior (e.g., water cannot be compressed)

7.4 Follow safety protocols for fluid and air power systems

7.5 Operate and observe simulated industrial grade pneumatic and electro-pneumatic devices and circuits (i.e., change physical parameters and observe system responses, etc.)

7.6 Describe the fundamental uses of vacuum technology (i.e., cleaning and packaging to semiconductor manufacturing and scientific research, etc.)

7.7 Identify power supplies for different fluid power systems

7.8 Build and examine the performance of a hydraulic circuit

7.9 Build and examine the performance of a pneumatic circuit

7.10 Troubleshoot hydraulic and pneumatic circuits (i.e., flow controls, valve functionality, pressure sensors, etc.)

STANDARD 8.0 PROGRAM AND TEST PLC (PROGRAMMABLE LOGIC CONTROLLER) SYSTEMS

8.1 Explain PLC functionality (i.e., relate schematics to PLC inputs/outputs, program flow, etc.)

8.2 Interpret and apply ladder logic and other commonly used industrial languages

8.3 Develop a flowchart that identifies and solves an automation problem

8.4 Upload and download an existing logic program to and from a PLC

8.5 Diagnose and troubleshoot problems within PLC input and output modules (AC and DC)

8.6 Write and apply a PLC program using ladder logic

STANDARD 9.0 DESCRIBE THE OPERATION AND USE OF VARIOUS ELECTRICAL MOTORS

9.1 Explain the “safety by design” concept to ensure operator and workspace safety

9.2 Identify how motors are controlled [i.e., capacitor (CAP) start, variable, frequency drives, start stops, etc.]

9.3 Explain the operation and use of DC motors in automation controls

9.4 Explain the operation and use of stepper motors in automation scenarios

9.5 Explain the different types of AC motors and when they should be used in automation assemblies (e.g., three phase, single phase, and split phase)

9.6 Explain the operation, use, and advantages of brushless motors in automation and robotics

9.7 Describe how servos are used in automation and robotics (e.g., robot arms, legs, and steering)

9.8 Describe the use of electrical generators (AC and DC generators)

STANDARD 10.0 PERFORM MECHANICAL SYSTEMS LINKAGES TASKS

10.1 Explain the difference between the gear reduction and gear ratio

10.2 Install, troubleshoot, and test a belt system

10.3 Install, troubleshoot, and test a chain drive system

10.4 Install, troubleshoot, and test a gear train system

10.5 Calculate revolutions per minute (RPM) output based on RPM input

10.6 Calculate the gear ratio of a gear train system

10.7 Explain the importance of vibration analysis and describe how it affects mechanical systems

STANDARD 11.0 PERFORM DRAFTING TASKS USING COMPUTER-AIDED DRAFTING (CAD)

11.1 Make freehand sketches (e.g., line weights, hidden lines, center lines, and dimensioning) and translate them to create a CAD drawing

11.2 Explain and use geometric dimensioning in a CAD drawing

11.3 Determine shapes and sizes of surfaces from alternative views (e.g., orthographic, projection view, first angle projection, and third angle projection)

11.4 Apply 2D sketching techniques in CAD then convert to 3D part

11.5 Create a 4-view drawing from a 3D part using dimensional standards (e.g., ANSI and include title blocks)

11.6 Create a CAD drawing and schematic of a working robotic workcell

STANDARD 12.0 EXAMINE TYPES AND TASKS PERFORMED BY ROBOTIC SYSTEMS

12.1 Describe common robot types used in industry and classify them based on their structure and degrees of freedom (e.g., SCARA, Articulated, Cartesian, and Delta Robots)

12.2 Differentiate robotics programming languages, open-source vs proprietary

12.3 Determine factors that influence robotic performance and how criteria such as speed, accuracy, and payload are used to evaluate suitability for tasks

12.4 Describe how robots are connected to external systems such as sensors, conveyors, or controllers

12.5 Use simulation tools to model robotic tasks, verify sequences, and improve design decisions in automation workflows

12.6 Explain how end effectors (e.g., grippers, tools, and sensors) interact with the environment to perform tasks

STANDARD 13.0 EXAMINE DATA COMMUNICATIONS METHODOLOGIES

13.1 Select data communication protocols and associated connectors (i.e., TCP/IP for the internet, USB for peripherals, and I2C for embedded systems)

13.2 Compare and contrast wired and wireless data communication protocols to understand tradeoffs (benefits and shortfalls)

13.3 Explain Internet of Things (IoT) and Industrial Internet of Things (IIoT) in relation to robotic systems

13.4 Identify cybersecurity systems used in robotics (e.g., protecting computer systems and data from digital attacks and threats)

13.5 Identify cybersecurity concerns within robotic systems (i.e., data breaches, malware and system manipulations, ransomware, social engineering, etc.)

STANDARD 14.0 UTILIZE SENSOR SOLUTIONS

14.1 Select sensors for use in a feedback control loop

14.2 Construct and operate a system with a feedback control loop

14.3 Calibrate and align sensors to their application

14.4 Gather statistical data and analyze performance on a control loop (Proportional Integral Derivative PID)

14.5 Explain analog to digital and digital to analog conversions and how these relate to cybersecurity concerns

14.6 Compare and contrast common sensors used in robotics systems (i.e., flow, vision, level, temperature, force and torque, metallic, proximity, pressure, etc.)

14.7 Explain how a smart sensor system uses and collects data in an automation system

STANDARD 15.0 EXAMINE COMMON MANUFACTURING PROCESSES IN AUTOMATION

15.1 Describe machining processes [i.e., traditional machining, Computer Numerical Control (CNC), etc.]

15.2 Explain how robotic systems enhance and improve the efficiency of machining processes

15.3 Describe basic material properties used in manufacturing processes (i.e., aluminum, steel, titanium, silicon, copper, germanium, composites, etc.)

15.4 Demonstrate the steps in the CNC process [e.g., design the part, generate a CNC program (G-code), set up the machine, and execute the machining operations]

15.5 Explain the benefit of 3D printing used by manufacturing companies (e.g., can quickly build prototypes for testing and quality assurance)

15.6 Demonstrate the basic steps of 3D printing (e.g., modeling, printing, and finishing)

15.7 Explain additive versus subtractive manufacturing and when each process is beneficial

15.8 Describe basic fabrication principles and how they are applied (i.e., laser, water jet, plasma, welding, cutting, etc.)

15.9 Explain material handling and related safety protocols [i.e., conveyers, bowl feeders, manufacturing, microchip industry, Automated Guided Vehicle (AGV), etc.]

STANDARD 16.0 DESIGN AN AUTOMATION SYSTEM

16.1 Recognize automation system constraints (i.e., timeline, budget, environment, skill level, etc.)

16.2 Develop a process flowchart for an automation system (i.e., steps and tasks, decisions and directions, input / output, etc.)

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16.3 Identify peripheral equipment and related software to complete specific tasks (i.e., robotic system, rotary table, conveyor, sensors, PLCs, end effectors, actuators, quality control camera, etc.)

16.4 Use a simulation to develop and validate a design for an automation system utilizing program subroutines, variables, and appropriate remarks

16.5 Integrate and build an automation system using peripheral equipment and related software to complete a specific task

16.6 Test and improve the automation system based on the objectives, test cases, and right tools