Instructional Framework

Automation and Robotics

14.4201.00

This Instructional Framework identifies, explains, and expands the content of the standards/measurement criteria, and, as well, guides the development of multiple-choice items for the Technical Skills Assessment. This document corresponds with the Technical Standards endorsed on January 27, 2021.

Domain 1: Mechanical Properties **Instructional Time: 40 - 50%**	
STANDARD 2.0 PERFORM ELECTRICAL AND ELECTRONIC TASKS	
2.1 Measure and determine voltage, current, resistance, and power in AC and DC circuits (i.e., oscilloscope, volt/ohm, meter, etc.)	• Oscilloscope • Ohm's Law • Digital multimeter
2.2 Troubleshoot voltage, current, and power in AC and DC circuits (i.e., fuse, continuity, etc.)	• Fuse • Continuity • Circuit breaker

2.3 Identify and troubleshoot components and connections	• Components
	• Connections
	  ○ Series
	  ○ Parallel

2.4 Read electrical drawings (i.e., simple starter circuits, PLC output, etc.)	• Simple starter circuits • PLC output • Electrical symbols
2.5 Explain the role of electronic devices in automation and robotics (i.e., common problems, common scenarios, etc.)	• Common problems • Common scenarios
STANDARD 3.0 ANALYZE HYDRAULIC AND PNEUMATIC SYSTEMS	
3.1 Describe the relevance of material properties to robotics (e.g., inertia, velocity, mass, density, and strength)	• Inertia • Velocity • Mass • Density • Strength

	• Hydraulic or pneumatic
3.2 Examine the performance of hydraulic circuits	• Hydraulic circuits • Pressure
3.3 Examine the performance of pneumatic circuits	• Pneumatic circuits • Pressure
3.4 Troubleshoot hydraulic and pneumatic circuits (i.e., flow controls, valve functionality, pressure sensors, etc.)	• Flow controls • Valve functionality • Pressure sensors • Hoses ○ Airline • Safety release valve • Pneumatics diagrams hydraulics • Schematics
3.5 Describe the fundamentals of vacuum technology	• Vacuum technology
STANDARD 5.0 DESCRIBE THE OPERATION AND USE OF VARIOUS FORMS OR ELECTRICAL MOTORS	

5.1 Explain the “safety by design” concept to ensure operator and workspace safety	• “Safety by Design”
	• Hazards
	  ○ Identify
	  ○ Pinch point
	  ○ Reduce/eliminate
	• Prevention through Design

5.2 Explain the operation and use of DC motors in automation controls	• DC motors
5.3 Explain the operation and use of stepper motors in automation scenarios	• Stepper motors
5.4 Explain the operation and primary use of AC motors in automation assemblies	• AC motors • Pumps • Blowers • Conveyors • Industrial machinery
5.5 Explain the operation, use, and advantages of brushless motors in automation and robotics	• Brushless AC/DC motors • Transfer current

	• Electronic mechanisms • Actuation applications • Efficiency

5.6 Describe how servos are used in automation and robotics (e.g., robot arms, legs, and steering)	• Robot
	  ○ Arms
	  ○ Legs
	  ○ Steering
	• Servo motor
	• Degrees of Freedom

STANDARD 6.0 PERFORM MECHANICAL SYSTEMS LINKAGES TASKS	
6.1 Explain gear reduction and install a belt or chain drive	• Gear reduction • Belt installation • Chain drive installation • Adding gears/sprocket • Changing gear size • Compound gears • Gear box
6.2 Explain gear ratio and install a gear train	• Gear ratio • Changing gear size • Compound gears • Torque • Speed • Drive ratio
6.3 Compute mechanical advantage of a belt or chain drive	• Belt mechanical advantage • Chain drive mechanical advantage
6.4 Compute mechanical advantage of a gear train	• Gear train mechanical advantage • Speed • Force • Gear ratios

Domain 2: Automation and Programming **Instructional Time: 25 - 30%**	
STANDARD 4.0 ANALYZE PROGRAMMABLE LOGIC CONTROLLER (PLC) SYSTEMS	
4.1 Explain PLC functionality (i.e., relate schematics to PLC inputs/outputs, program flow, etc.)	• Relate schematics to PLC inputs/outputs • Program flow
4.2 Interpret ladder logic and other commonly used industrial languages	• Ladder logic • Ladder logic symbols
4.3 Develop a flowchart that identifies and solves the automation problem	• Automation problem ○ Problem solving

4.4 Upload/download a logic program into a PLC	• Logic program
	  ○ Upload
	  ○ Download

4.5 Troubleshoot input/output modules (AC and DC)	• AC/DC
STANDARD 10.0 APPLY SENSOR SOLUTIONS	
10.1 Select sensors for use in a feedback control loop	• Sensors • Feedback control loop
10.2 Construct and operate a system with a feedback control loop	• Feedback control loop system
10.3 Calibrate sensors	• Calibrating sensors
10.4 Gather and statistically analyze performance data on a control loop	• Control loop performance analyzation
10.5 Explain analog to digital and digital to analog converters	• Analog to digital and digital to analog converters
STANDARD 13.0 DEMONSTRATE SAFE AND PROPER USE OF ELECTRONIC AND OTHER LABORATORY EQUIPMENT, TOOLS, AND MATERIALS	
13.1 Explain and apply proper ground requirements	• Proper ground requirements • OSHA 10

13.2 Specify safety conditions when working with automation and robotics (e.g., arc flash, high voltage, pneumatics, hydraulics, and stored energy)	• Arc flash • High voltage • Pneumatics • Hydraulics • Stored energy
13.3 Identify and properly use common electrical and electronics hand tools	• Common electrical and electronics hand tools • Proper tool use • Use the right tool for the right job
13.4 Follow laboratory safety rules and procedures	• Laboratory safety rules and procedures
13.5 Describe the concept of “fail safe” and how such components are integrated into robotic systems	• “Fail safe”
13.6 Explain modern safety hardware and circuits (i.e., light curtains, safety fences, safety relays, etc.)	• Light curtains • Safety fences • Safety relays

Domain 3: Industrial Applications **Instructional Time: 25 - 30%**	
STANDARD 7.0 PERFORM DRAFTING TASKS	

7.1 Make freehand sketches (e.g., line weights, hidden lines, center lines, and dimensioning)	• Line weights
	• Hidden lines
	• Center lines
	• Dimensioning
	• Views
	  ◦ Top
	  ◦ Side
	  ◦ Front
	  ◦ Isometric

7.2 Make CAD representations from freehand sketches	• CAD vs. Freehand • Parts to assemblies

7.3 Determine shapes and sizes of surfaces from alternative views (e.g., orthographic, projection view, first angle projection, and third angle projection)	• Orthographic • Projection view • First angle projection • Third angle projection
7.4 Make CAD drawings using geometric construction techniques	• CAD drawings

7.5 Make dimensional CAD drawings (e.g., 2D and 3D)	• 2D
	  ○ Sketch
	• 3D
	  ○ Sketch

7.6 Explain basic knowledge of geometric dimensioning and tolerancing	• Geometric dimensioning and tolerancing
7.7 Interpret electrical drawings and architectural plans	• Electrical drawings • Architectural plans
STANDARD 8.0 IDENTIFY INDUSTRIAL ROBOT TYPES AND THE TASKS THEY PERFORM	
8.1 Identify robot types and degrees of freedom (i.e., SCARA, articulated, cartesian, delta, etc.)	• SCARA • Articulated • Cartesian • Delta • Degrees of freedom
8.2 Measure robotic performance against specified criteria	• Robotic performance
8.3 Interface a robot to real or simulated external equipment	• Real or simulated external equipment
8.4 Simulate a solution	• Simulate a solution • Run through • Fluid simulation • Software simulation • Prototype
STANDARD 9.0 EXAMINE DATA COMMUNICATION METHODOLOGIES	
9.1 Select data communication protocols and associated connectors	• Data communication protocols • Associated connectors

9.2 Identify tradeoffs among wired and wireless data communication protocols	• Wired data communication protocols • Wireless data communication protocols
9.3 Explain IOT (Internet of Things) and IIOT (Industrial Internet of Things)	• IOT (Internet of Things) • IIOT (Industrial Internet of Things)
STANDARD 11.0 DESCRIBE COMMON MANUFACTURING PROCESSES IN AUTOMATION	

11.1 Describe machining processes (i.e., traditional machining, CNC, etc.)	• Traditional machining
	  ○ Milling
	  ○ Lathing
	  ○ Drilling
	• CNC
	• CAM
	• G-code

11.2 Describe basic material properties used in manufacturing processes (i.e., aluminum, steel, titanium, etc.)	• Aluminum • Steel • Titanium
11.3 Explain the impact of 3D printing on rapid prototyping	• 3D printing on rapid prototyping
11.4 Explain additive manufacturing versus subtractive manufacturing	• Additive manufacturing • Subtractive manufacturing

11.5 Describe basic fabrication principles (i.e., laser, sheet metal, welding, cutting, etc.)	• Fabrication processes
	  ○ Laser
	  ○ Sheet metal
	  ○ Welding
	  ○ Cutting
	  ○ Plastic injectors
	  ○ 3D printing

11.6 Describe material handling [i.e., conveyors, bowl feeders, AGV (Automated Guided Vehicle), etc.]	• Conveyors • Bowl feeders • Automated Guided Vehicle (AVG)

Domain 4: Innovation **Instructional Time: 5 - 10%**	
STANDARD 1.0 EXAMINE THE IMPACT OF NEW TECHNOLOGIES ON AUTOMATION AND ROBOTICS	
1.1 Describe the principles, processes, and practices of AI (artificial intelligence), ML (machine learning), and RPA (robotic process automation)	• Artificial intelligence • Machine learning • Robotics process automation
1.2 Discuss how the application of AI, MI, and RPA have changed existing business (i.e., enhanced efficiency, increased work performance, reduced human error, simplified interactions, speedier processes, improved customer experience, etc.)	• Enhanced efficiency • Increased work performance • Reduced human error • Simplified interactions • Speedier processes • Improved customer experience
1.3 Give examples of how AI, ML, and RPA are used in services, manufacturing, and healthcare [i.e., social media, virtual/personal assistant (Alexa and Siri), financial fraud detection, self-driving cars, medical diagnosis and prediction. etc.]	• Social media • Virtual/personal assistant (Alexa and Siri) • Financial fraud detection • Self-driving cars • Medical diagnosis and prediction
1.4 Relate the Three Laws of Robotics (Asimov's Laws) to future technology applications	• Asimov's Laws
1.5 Discuss ethical challenges associated with AI, ML, and RPA (i.e., privacy, data inaccuracies, future loss of jobs, how machines affect human behavior and interaction, etc.)	• Privacy • Data inaccuracies • Future loss of jobs • How machines affect human behavior and interaction
STANDARD 12.0 DEVELOP ROBOTICS APPLICATION SYSTEMS	
12.1 Describe robotics operating systems [i.e., ROS (robot operation system), Linux, etc.]	• Robot operation system (ROS) • Linux
12.2 Identify a problem and develop a flowchart for software development (i.e., Boolean logic, ladder, etc.)	• Boolean logic • Ladder logic

12.3 Identify peripheral hardware required to complete the task (i.e., vision systems, 3D scanners, end-of-arm tools, force sensing, etc.)	• Vision systems • 3D scanners • End-of-arm tools • Force sensing
12.4 Develop or reuse software components (i.e., modular software design, etc.)	• Modular software design
12.5 Use software tools to develop a robotics application	• Software tools • Block code • G-code • Slicer
12.6 Use a simulation to develop and validate a design for a robotics problem	• Simulation • Prototype
12.7 Use a test-driven development approach	• Test-driven development approach
12.8 Demonstrate a methodical approach to process development	• Process development
12.9 Describe integration technologies (i.e., CNC, AI, RPA, ML, etc.)	• CNC • AI • RPA • ML
12.10 Describe robotics project constraints (i.e., timeline, budget, environment, skill level, etc.)	• Timeline • Budget • Environment • Skill level • Engineering notebook