# Industrial Robotics Technology

**8558 36 weeks / 280 hours**

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## Acknowledgments

The components of this instructional framework were developed by the following curriculum development panelists:

- MJ Ghahrai, Instructor, Hanover High School, Hanover County Public Schools
- Vukica Jovanovic, Associate Professor, Old Dominion University, Norfolk
- Paul E. Lathrop, Instructor, Chesterfield Technical Center at Hull Street, Chesterfield County Public Schools
- Chung-Chee Tai, Vice President of Engineering, BluePrint Automation, South Chesterfield
Course Description

Suggested Grade Level: 11 or 12
Prerequisites: 8547

This course provides instruction in programming robots used in assembly and manufacturing settings. Students will work with various power systems while acquiring machining, welding, material handling, and system engineering skills. This course leads to industry certification options to further validate student mastery of related skills.

Task Essentials Table

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- Tasks/competencies designated by minus icons (⊖) are omitted
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**Legend:** 🌟Essential 🌡Non-essential ⏰Omitted

**Curriculum Framework**

**Applying General Safety Standards (Core Safety)**

**Task Number 39**

**Comply with federal, state, and local safety legal requirements.**

**Definition**

Compliance should include the Occupational Safety and Health Administration (OSHA), Virginia Occupational Safety and Health (VOSH) program, and the U.S. Environmental Protection Agency (EPA) and

- identifying the Hazard Communication Standard (HCS)
- interpreting the information included on safety data sheets (SDS)
- describing the responsibilities of employers and employees under HCS.
Process/Skill Questions

- What information can be found on an SDS?
- What does SDS stand for?
- Where should hazardous materials be stored?

Task Number 40

Maintain a safe working environment.

Definition

Maintenance should result in identifying potential hazards on a jobsite or in the lab, such as

- unstable or improperly erected scaffolding
- electrical hazards
- jobsite debris
- improperly stored materials
- air-quality hazards.

When hazards are present, measures should be taken to remedy them (e.g., robot shut-down procedures), in compliance with school and instructor guidelines.

Process/Skill Questions

- What are examples of jobsite hazards?
- Why is it important to adhere to safety standards on a jobsite?
- Why is it important to store materials and tools?
- Why is it important to have procedures in place for robot work cell entry and emergency shut down?

Task Number 41

Explain safe working practices around electrical hazards.

Definition

Explanation should include

- identifying equipment used to test electrical circuits
- identifying potential arc flash hazards
- describing safe working conditions
- demonstrating safe work habits.
Process/Skill Questions

- What is the definition of *proximity work*?
- What are safe working clearances, according to the National Electric Code (NEC) and the local code?
- What are considered safe working conditions and safe working habits?
- What is the unseen hazard with electrical work?

**Task Number 42**

**Identify emergency first-aid procedures.**

**Definition**

Identification should include standard first-aid procedures and school policies regarding accidents involving

- bodily fluids
- electrical injuries
- hydraulic fluid
- eye injuries
- falls
- burns
- cuts.

**Process/Skill Questions**

- What are the steps that should be followed when an accident occurs?
- Why is knowing cardiopulmonary resuscitation (CPR) an important skill within the construction trades?
- Why is it important to be certified to administer first aid?
- Why is hydraulic fluid so dangerous to humans?
- What are the different classifications (i.e., degrees) of electrical burns?

**Task Number 43**

**Identify the types of fires and the methods used to extinguish them.**

**Definition**

Identification should include
• the classifications of fires (Classes A, B, C, and D)
• causes of fires
• prevention of fires
• types of extinguishers
• the use (when possible) of a fire extinguisher, in accordance with government regulations and instructor guidelines.

Process/Skill Questions

• Why do fires and extinguishers have different classifications, and what are they?
• What are the fire triangle and the fire tetrahedron?
• What are the three things necessary to start a fire?
• Why is it important to know the classification of a fire when trying to extinguish it?
• Why should extinguishers be inspected, and how often should they be inspected?

Task Number 44

Identify personal protective equipment (PPE) requirements.

Definition

Identification should include procedures for inspecting, wearing, and removing

• eye protection
• respirator
• hard hat
• gloves
• safety harness
• hearing protection
• safety shoes.

Process/Skill Questions

• What are some dangerous effects of sun exposure, and how can these risks be diminished?
• Why is wearing jewelry prohibited in the lab or on the jobsite?
• How is foam hearing protection used?

Task Number 45

Inspect course-specific hand and power tools to visually identify defects.
Definition

Inspection of hand and power tools should include

- identifying components of machinery (e.g., guards, blades, moving parts, start/stop switches)
- identifying standard safety procedures (i.e., lab practices and manufacturer recommendations)
- observing the safe use of each piece of machinery in the lab
- identifying tool defects.

Process/Skill Questions

- What are the basic power tools used in construction?
- What are the actions to take before using a power circular saw?
- Why should a power tool always be grounded?

Task Number 46

Demonstrate lifting and carrying techniques.

Definition

Demonstration should include lifting and carrying materials and equipment while

- lifting with the legs
- keeping the back straight
- holding the load close to the body
- getting help, if necessary.

Process/Skill Questions

- What are common injuries associated with improper lifting techniques?
- How can injury be prevented?
- How does proper positioning affect proper technique?

Task Number 47

Demonstrate safe laddering techniques.
Definition

Demonstration should include using appropriate conduct and safety procedures while

- using aluminum ladders (e.g., three-point contact)
- carrying ladders (e.g., two people at all times)
- erecting and setting ladders
- identifying types of ladders and the components and safety features of each (e.g., wall or straight, extension, roof, attic, special-purpose, solid-beam, wood/aluminum, wood/aluminum truss, fiberglass).

Process/Skill Questions

- Why are ladders rated for certain weights?
- Why is the apex (i.e., highest point) of a stepladder not considered a step?
- Why are aluminum ladders considered unsafe for electrical work?

Task Number 48

Report personal injury and environmental and equipment safety violations.

Definition

Report should include

- identifying the violation
- documenting the date of the violation
- submitting the report to the instructor, supervisor, or local OSHA inspectors.

Process/Skill Questions

- Why is it important to report injuries?
- What are common reporting procedures?
- What is workers’ compensation?

Understanding Digital Logic Systems

Task Number 49
Identify digital circuitry and signals.

Definition

Identification should include

- defining
  - integrated circuit (IC)
    - flat pack
    - digital
    - linear
  - dual in-line package (DIP)
- drawing the block diagram of a 14-pin DIP IC and labeling the pin numbers in order
- explaining the difference between a digital and an analog signal
- listing devices that use digital circuits
- drawing a digital signal that is 3 volts in amplitude and labeling it as binary 0 and 1
- constructing a free-running clock circuit and measuring its frequency.

Process/Skill Questions

- What are examples of digital circuits used in everyday life?
- What is the range of voltage (highs and lows) in transistor-transistor logic (TTL) circuits?

Task Number 50

Analyze digital integrated circuits.

Definition

Analysis should include

- classifying integrated circuits by locating integrated circuits in the reference manual and noting on a data sheet
  - supply voltage
  - operating temperature range
  - grounds
  - power dissipation
  - linear or nonlinear classification
- determining operational amplifier (op amp) characteristics by
  - constructing an op amp circuit (according to schematic specifications)
  - verifying operation
  - calculating voltage gain (within five percent of ideal value).

Process/Skill Questions
• What are the most common logic families?
• What are the two most important factors when interfacing between logic families?
• How is voltage gain of an op amp calculated?

Task Number 51

Convert numbers to digital numbering systems.

Definition

Conversion should include

• defining terms
  o binary
  o octal
  o hexadecimal
  o base numbers
  o encoder
  o decoder
  o bit
  o byte
• converting decimal numbers to binary numbers
• converting decimal numbers to hexadecimal numbers
• converting binary numbers to hexadecimal and to decimal numbers
• explaining the function of an encoder and decoder
• adding, subtracting, multiplying, and dividing binary numbers.

Process/Skill Questions

• What device converts decimal numbers to binary numbers?
• Why should technicians learn the binary numbering system?
• What numbers are in the octal numbering system?

Task Number 52

Interpret logic gate symbols, Boolean expressions, and truth tables.

Definition

Interpretation should include
• drawing Boolean expressions, logic gate symbols, and truth tables for basic logic gates (e.g., AND, OR, NOT, NOR, NAND, XOR, XNOR)
• explaining how a NAND gate can be used to construct other gates
• explaining how a truth table is constructed
• designing a Karnaugh map from a truth table
• differentiating between positive and negative logic
• explaining the differences between TTL and complementary metal-oxide semiconductor (CMOS) circuits
• listing IC handling and soldering safety procedures.

Process/Skill Questions

• Where did Boolean algebra get its name?
• What are some methods used to simplify Boolean expressions?
• How does the NOR gate differ from the NAND gate?

Task Number 53

Construct logic circuit truth tables.

Definition

Construction should include

• differentiating between positive and negative logic
• converting from a logic circuit diagram
• converting from Boolean expression
• using a 1 or 0 in table cells to represent outputs for all possible input, based on a specific circuit.

Process/Skill Questions

• What are the most common ways to represent logic circuits?
• What are some methods used to simplify Boolean expressions?
• How does the NOR gate differ from the NAND gate?

Task Number 54

Construct encoder and decoder circuits.

Definition
Construction should include

- converting decimal numbers to binary-coded decimal (BCD)
- wiring a seven-segment LED to display all segments
- explaining the function of decoder/driver and drawing a pinout diagram
- troubleshooting an encoder and a decoder circuit drawing
- explaining the function of a multiplexer and a demultiplexer and drawing a pinout diagram for each
- troubleshooting a multiplexer and demultiplexer circuit drawing.

Process/Skill Questions

- What steps are required to convert BCD to decimal on paper?
- What is ASCII?
- How does a fragment display work?
- What is the difference between a multiplexer and a demultiplexer?

Identifying Computer Integration in Robotics

Task Number 55

Explain basic computer architecture.

Definition

Explanation should include

- defining terms
  - motherboard
  - central processing unit (CPU)
  - random access memory (RAM)
  - read-only memory (ROM)
  - input/output (I/O)
  - power supply
- listing ways digital information is processed
- describing how a computer might be used to time or sequence events
- providing examples of computers that are used as industrial monitoring and control devices.

Process/Skill Questions
• What are the basic functions of a computer?
• Why is the CPU considered the brain of a computer?
• What is the role of the interface component in industrial monitoring and control systems?

Task Number 56

Use dedicated microcontrollers.

Definition

Use should include

• identifying applications of dedicated microcontrollers in consumer products
• identifying the main types of microcontrollers on the market
• programming a microcontroller to perform specific tasks.

Process/Skill Questions

• How does a robotic vacuum work?
• How are dedicated microcontrollers used in industrial robotics? What are the benefits?
• Which components or devices might be used to interface with dedicated microcontrollers?

Task Number 57

Connect peripheral devices to robotics equipment.

Definition

Connection should include

• identifying peripheral devices (e.g., interfacing cables, sensors, conveyors, linear slides)
• defining terms related to peripherals
• explaining interface protocol (e.g., universal serial bus [USB], parallel)
• interfacing peripheral devices with a microcontroller
• demonstrating functional operation of peripheral device.

Process/Skill Questions

• What are the most common peripherals used with robotic equipment?
• What is protocol?
• What is the importance of configuration of peripheral interface?
Task Number 58

Operate dip switches and interface controls.

Definition

Operation should include

- establishing the binary address
- setting the dip switch to the binary address
- testing the interface control.

Process/Skill Questions

- What are three uses for dip switches in electronic circuits?
- What are the two positions of a dip switch?
- What decimal value does a dip switch set at ON-ON OFF-OFF represent?

Understanding Graphic Communication in Robotics

Task Number 59

Interpret schematics, technical drawings, and flowcharts.

Definition

Interpretation should include

- reading and verifying the symbols and legends used in schematics, technical drawings, and flowcharts
- applying the interpretation of a flowchart to write a computer program
- applying the interpretation of technical drawings to build or assemble a product or circuit
- following electrical schematics to breadboard a circuit
- converting schematic into a printed circuit board (PCB) layout.

Process/Skill Questions
• What does the term *schematic* mean?
• When might technicians need to read flowcharts, technical drawings, or schematics?

**Task Number 60**

**Create schematics, technical drawings, and flowcharts.**

**Definition**

Creation should include using standard symbols and legends.

**Process/Skill Questions**

• What are the standard symbols used in electrical schematics? Pneumatic schematics?
• What are common types (e.g., exploded assembly diagram, isometric) of mechanical drawings?
• How might a flowchart aid the design of a computer program?

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**Using and Programming Robotic Equipment**

**Task Number 61**

**Write programs to control robots.**

**Definition**

Writing should include

• using open-source and proprietary languages
• describing basic programming commands
• explaining the functions of the commands
• practicing computer language commands
• compiling and executing the program.

**Process/Skill Questions**

• What is the function of a loop command?
• What is the function of a subroutine?
Task Number 62

Manipulate a robot, using a teach pendant.

Definition

Manipulation should include

- applying all safety precautions and procedures (e.g., safety glasses, emergency stop button, placement of equipment safety guards)
- demonstrating the function of the keys on a teach pendant
- demonstrating how functions of the keys are shifted among primary, secondary, and tertiary
- demonstrating the method to teach points
- demonstrating the method to jog each robot axis.

Process/Skill Questions

- What is the difference between a HARD home and a SOFT home?
- What is meant by transferring points?
- How does one determine the orientation of the X, Y, and Z axes?

Task Number 63

Manipulate a robot, using a PC host computer.

Definition

Manipulation should include

- applying all safety precautions and procedures (e.g., safety glasses, emergency stop button, placement of equipment safety guards)
- demonstrating the function of the keys on a PC
- shifting keys for primary, secondary, and tertiary functions
- teaching points
- jogging the robot axis.

(Anthony, THIS DEF is essentially the same as the previous task’s - is this correct? I changed "teach pendant" to PC in bullet #2)

Process/Skill Questions
• What role does the mouse play in manipulating a robot through a PC host computer?
• What are the advantages/disadvantages between the manipulations of a robot through PC host computer vs. the teach pendant?
• How does one control the robot fluid power device with a PC host computer?

Task Number 64

Program a robot, using a teach pendant.

Definition

Programming should include

• applying all safety precautions and procedures (e.g., safety glasses, emergency stop button, placement of equipment safety guards)
• inputting a simple program, using pick-and-place machines
• saving the program
• running the program
• editing the program.

Process/Skill Questions

• How is the teach pendant used for short-term memory of a computer program?
• How do you execute a program, using a teach pendant?
• How do you edit a program, using a teach pendant?
• What is online robot programming?

Task Number 65

Program a robot, using a PC host computer.

Definition

Programming should include

• applying all safety precautions and procedures (e.g., safety glasses, emergency stop button, placement of equipment safety guards)
• coding the program
• running the program
• editing the program.

Process/Skill Questions
• What is offline robot programming?
• How would a flowchart help program through a PC host computer?
• What is involved in editing a program?
• What are the options for saving the program?

Task Number 66

Describe how robots can be interfaced to communicate across a network to function in a workcell.

Definition

Description should include

• the basic concept of networking computers, hard automation, and robots
• the different media used in networking
• how the network connections among computers, hard automation, and robots are made
• how robots are networked or linked together in a workcell
• consideration of the Internet of Things (IoT).

Process/Skill Questions

• What type of network cable is the most common in creating a functional workcell network?
• What is the 560A/560B pinout of a cable?
• What type of connector is used in Ethernet cable?

Understanding Simple Machines and Mechanisms

Task Number 67

Write a computer program to solve a physics problem.

Definition

Writing should include
• explaining how a flowchart can help solve a physics/mathematical problem (e.g., What is the velocity of a robot that travels 10 feet in five seconds?)
• translating the flowchart using computer programming language
• executing the program by inputting the variables.

Process/Skill Questions

• What are variables, and how are they designated in an equation?
• How are input statements written?

Task Number 68

Design a mechanical system, using the principles of simple machines.

Definition

Design should include applying the design process by

• addressing the engineering challenge
• determining the characteristics needed in the mechanical system (e.g., travel speed, distance, range of motion)
• combining simple machines
• solving problems, using the concepts of mechanics
• evaluating the system’s ability to meet the challenge.

Process/Skill Questions

• How can a gear train provide required output speed? Torque?
• How is mechanical advantage calculated?
• What is a four-bar linkage, and how would it be used?
• How can circular motion be converted to linear motion, or vice versa?
• What is direct kinematics, and what is inverse kinematics?

Understanding Power Systems in Robotics

Task Number 69

Differentiate between servo and non-servo electrical-drive systems.
Definition

Differentiation should include

- comparing the two drive systems
- comparing advantages and disadvantages for applications
- determining the selection of the robot to be used in a project.

Process/Skill Questions

- What are the similarities and differences between a servo and non-servo electrical-drive system?
- Which drive system is assumed to be more accurate?
- Which type of robot, servo or non-servo, can respond to multiple point-to-point transfer?
- Which drive system is the easiest to maintain?

Task Number 70

Perform a lab activity, using electrical motor-control systems.

Definition

Performance should include wiring a basic motor-control circuit.

Process/Skill Questions

- How might a START/STOP motor-control circuit be illustrated?
- How might electrical motor-control circuits be used in a robotic workcell?
- What are the three main components of a motor-control system?

Task Number 71

Describe motor-control systems.

Definition

Description should include

- identifying the devices used
- demonstrating the wiring method for a simple motor-control circuit
• explaining the differences between an automated and non-automated control system
• demonstrating the use of a programmable logic controller (PLC) to turn robots on and off
• analyzing safety factors
• examining the efficiency of automated and non-automated control systems.

Process/Skill Questions

• What are the differences between an automated and a non-automated control system?
• What is an example of an application for a non-automated control system?
• What is an example of an application for an automated control system?

Task Number 72

Troubleshoot electrical motor-control systems.

Definition

Troubleshooting should include

• discussing the modular nature of motor-control systems
• incorporating safety precautions and procedures
• implementing troubleshooting techniques for an automated and a non-automated control system.

Process/Skill Questions

• What is the technique for troubleshooting a motor starter coil?
• What might be concluded when a module in a PLC malfunctions?
• What is the procedure for troubleshooting motor windings?

Task Number 73

Explain the principles of fluid power.

Definition

Explanation should include

• the principles of physics
• liquids and gasses
• hydraulic and pneumatic components and systems
• schematic symbols, valves, and power sources.

Process/Skill Questions
• How might the operation of a hydraulic actuator be illustrated?
• Which is more powerful, a hydraulic or a pneumatic system? Explain.
• What are advantages and disadvantages of hydraulic and pneumatic systems?

Task Number 74

Describe the use of a fluid-power device in a robotic workcell.

Definition

Description should include examples of fluid-power devices in robotic workcells.

Process/Skill Questions

• What is a double-acting cylinder?
• What is a 3/2 valve?
• What is the purpose of a pressure regulator?

Task Number 75

Troubleshoot a fluid-power system.

Definition

Troubleshooting should include

• accessing standard troubleshooting techniques for fluid-power systems
• taking safety precautions
• explaining the modular nature of fluid-power systems
• diagnosing component problems.

Process/Skill Questions

• What are the methods used to diagnose problems within the fluid-power system?
• How are leaks detected in a pneumatic or hydraulic system?
• What are the typical problems encountered when troubleshooting a fluid-power system?

Understanding PLC/Industrial Controls
Task Number 76

Describe the use of essential machines and basic measuring tools found in a machining lab.

Definition

Description should include identifying

- major machines found in a machining lab, such as
  - mill
  - lathe
  - band saw
  - drill press
  - grinder
- basic tools found in a machining lab, such as
  - micrometer
  - calipers.

Process/Skill Questions

- Which machine is associated with producing cylindrical products?
- What is the difference between a lathe and a mill?
- What are two typical part orientations found in a milling machine?
- What are some of the uses of micrometers and calipers?

Task Number 77

Use computer numerical control (CNC) to interface with a robot.

Definition

Use includes

- processing inputs and outputs
- programming
- writing programs.

Process/Skill Questions

- What computer language is best suited for interfacing the CNC machine and the robot?
- What do the codes G and M stand for in CNC machining?
• What industrial application would result from a machine and a robot being interfaced?

**Task Number 78**

**Produce a finished machine part.**

**Definition**

Production includes following the steps required to create a finished machine part and incorporating the uses of measuring tools.

**Process/Skill Questions**

- What is the difference between accuracy and precision in measurement?
- How many thousandths of an inch are there in 5/8 inch?
- What is more accurate for outside diameter measurement, a micrometer or a dial caliper?

---

**Task Number 79**

**Produce a part using a three-dimensional (3D) printer.**

**Definition**

Production includes:

- taking a 3D part designed using computer-aided design (CAD) software
- converting to a file type appropriate for 3D printer
- setting up and configuring a 3D printer (hardware and software)
- printing and conducting the finishing operation.

**Process/Skill Questions**

- What is stereolithography?
- What materials are commonly used by 3D printers?
- What are the differences between additive and subtractive manufacturing processes?

---

**Understanding the Welding Lab**
Task Number 80

Describe the use of equipment and tools in a welding lab.

Definition

Description should include identifying

- the welding equipment found in a welding lab
- the basic tools (e.g., grinder, hammer, plasma cutter, brush, and welding gauges)
- the required safety equipment (e.g., helmet, gloves, and leather jacket).

Description also includes describing the different uses of each machine and tool.

Process/Skill Questions

- What machine is specifically used to weld aluminum?
- What do TIG, MIG, SMAW, and GMAW stand for?
- What are two major safety hazards in a welding lab?

Task Number 81

Describe the phases of the welding process.

Definition

Description should include explanation of the phases (e.g., metal preparation, current settings of the machines, rod selection) of the welding process once these have been demonstrated.

Process/Skill Questions

- What are safety considerations in welding?
- What is puddling?
- What constitutes a sound weld?

Engineering Robotic Systems

Task Number 82

Maintain an engineering notebook.
Definition

Maintenance should include

- adhering to industry standards
- documenting class projects
- providing evidence to support the patent application process.

Process/Skill Questions

- Why is it important to label the front and back of each page of the engineering notebook?
- Why is it important to have the pages signed and dated by a peer?
- What is the appropriate procedure for revising data recorded in the notebook?

Task Number 83

**Design a robotic system to perform a specified task.**

Definition

Design should demonstrate a mastery of the course competencies. Design should be in the context of a competitive event. Competition may occur in the classroom or at another location and may be observed by industry partners and the public.

Process/Skill Questions

- What are the benefits of having industry representatives observe the competition?
- Why is it important to present the engineering notebook as part of the competition?
- How is the engineering design process used in the completion of the project?

**SOL Correlation by Task**

<table>
<thead>
<tr>
<th>Comply with federal, state, and local safety legal requirements.</th>
<th>English: 11.5, 12.5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15</td>
</tr>
<tr>
<td></td>
<td>Science: CH.1</td>
</tr>
<tr>
<td>Maintain a safe working environment.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td></td>
<td>History and Social Science: WHII.8</td>
</tr>
<tr>
<td>Explain safe working practices around electrical hazards.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td></td>
<td>History and Social Science: WHII.8</td>
</tr>
<tr>
<td>Task</td>
<td>Subject(s)</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------</td>
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<tr>
<td>Identify emergency first-aid procedures.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>Identify the types of fires and the methods used to extinguish them.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>Identify personal protective equipment (PPE) requirements.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>Inspect course-specific hand and power tools to visually identify defects.</td>
<td></td>
</tr>
<tr>
<td>Demonstrate lifting and carrying techniques.</td>
<td></td>
</tr>
<tr>
<td>Demonstrate safe laddering techniques.</td>
<td></td>
</tr>
<tr>
<td>Report personal injury and environmental and equipment safety violations.</td>
<td>English: 11.1, 11.6, 11.7, 12.1, 12.6, 12.7</td>
</tr>
<tr>
<td>Identify digital circuitry and signals.</td>
<td>English: 11.3, 11.5, 12.3, 12.5</td>
</tr>
<tr>
<td>Analyze digital integrated circuits.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>Convert numbers to digital numbering systems.</td>
<td>English: 11.3, 11.5, 12.3, 12.5</td>
</tr>
<tr>
<td>Mathematics: AII.3</td>
<td></td>
</tr>
<tr>
<td>Interpret logic gate symbols, Boolean expressions, and truth tables.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>Mathematics: COM.15</td>
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<tr>
<td>Construct logic circuit truth tables.</td>
<td>English: 11.3, 11.5, 11.6, 11.7, 12.3, 12.5, 12.6, 12.7</td>
</tr>
<tr>
<td>Mathematics: G.1, COM.8, COM.15</td>
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<tr>
<td>Construct encoder and decoder circuits.</td>
<td>English: 11.5, 12.5</td>
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<tr>
<td>Explain basic computer architecture.</td>
<td>English: 11.6, 11.7, 12.3, 12.5, 12.6, 12.7</td>
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<tr>
<td>Mathematics: COM.16</td>
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<tr>
<td>Use dedicated microcontrollers.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>Connect peripheral devices to robotics equipment.</td>
<td>English: 11.3, 11.5, 12.3, 12.5</td>
</tr>
<tr>
<td>Operate dip switches and interface controls.</td>
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<tr>
<td>Interpret schematics, technical drawings, and flowcharts.</td>
<td>English: 11.5, 12.5</td>
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<tr>
<td>Mathematics: COM.2</td>
<td></td>
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<tr>
<td>Create schematics, technical drawings, and flowcharts.</td>
<td></td>
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<tr>
<td>Write programs to control robots.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>Mathematics: COM.1, COM.2, COM.8, COM.9, COM.10, COM.11</td>
<td></td>
</tr>
<tr>
<td>Manipulate a robot, using a PC host computer.</td>
<td></td>
</tr>
<tr>
<td>Program a robot, using a teach pendant.</td>
<td></td>
</tr>
</tbody>
</table>

History and Social Science: WHII.8
<table>
<thead>
<tr>
<th>Task</th>
<th>English</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program a robot, using a PC host computer.</td>
<td></td>
<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.18</td>
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<tr>
<td>Describe how robots can be interfaced to communicate across a network to function in a workcell.</td>
<td></td>
<td></td>
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<tr>
<td>Write a computer program to solve a physics problem.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<tr>
<td>Design a mechanical system, using the principles of simple machines.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<tr>
<td>Differentiate between servo and non-servo electrical-drive systems.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<tr>
<td>Perform a lab activity, using electrical motor-control systems.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<tr>
<td>Describe motor-control systems.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<tr>
<td>Troubleshoot electrical motor-control systems.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Explain the principles of fluid power.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<tr>
<td>Describe the use of a fluid-power device in a robotic workcell.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Troubleshoot a fluid-power system.</td>
<td></td>
<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<tr>
<td>Describe the use of essential machines and basic measuring tools found in a machining lab.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
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<td>Use computer numerical control (CNC) to interface with a robot.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Produce a finished machine part.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Produce a part using a three-dimensional (3D) printer.</td>
<td></td>
<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Describe the use of equipment and tools in a welding lab.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Describe the phases of the welding process.</td>
<td></td>
<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Maintain an engineering notebook.</td>
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<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
<tr>
<td>Design a robotic system to perform a specified task.</td>
<td></td>
<td>COM.1, COM.2, COM.8, COM.9, COM.10, COM.11, COM.15</td>
</tr>
</tbody>
</table>
Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- College and Work Readiness Assessment (CWRA+)
- Customer Service Examination
- Customer Service Specialist (CSS) Examination
- Manufacturing Specialist Certification Examination
- Manufacturing Technician Level I Certification Examination
- Mechatronic Systems Certification Examinations
- Mechatronics Level 1 Assessment
- National Career Readiness Certificate Assessment
- Pre-Manufacturing Technician I (PreMT1) Examination
- Professional Communications Certification Examination
- Robotics and Automation Examination
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.

- Electronics/Industrial Robotics Technology (8547/36 weeks, 140 hours)

Career Cluster: Manufacturing

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance, Installation, and Repair</td>
<td>Millwright</td>
</tr>
<tr>
<td>Manufacturing Production Process Development</td>
<td>Electro-Mechanical Technician&lt;br&gt;Industrial Engineer&lt;br&gt;Industrial Engineering Technician&lt;br&gt;Manufacturing Systems Engineer&lt;br&gt;Millwright&lt;br&gt;Precision Inspector, Tester, or Grader&lt;br&gt;Production Manager&lt;br&gt;Programmer</td>
</tr>
<tr>
<td>Production</td>
<td>Assembler&lt;br&gt;Automated Manufacturing Technician&lt;br&gt;Welder</td>
</tr>
</tbody>
</table>
# Career Cluster: Science, Technology, Engineering and Mathematics

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
</table>
| Engineering and Technology | Aerospace Engineer  
|                     | Aerospace Engineering Technician  
|                     | Agricultural Engineer  
|                     | Assembler  
|                     | Biomedical Engineer  
|                     | Commercial and Industrial Designer  
|                     | Computer Hardware Engineer  
|                     | Computer Programmer  
|                     | Computer Software Engineer  
|                     | Electrical Engineer  
|                     | Electrical Engineering Technician  
|                     | Electro-Mechanical Technician  
|                     | Electronic Drafter  
|                     | Electronics Engineering Technician  
|                     | Engineer  
|                     | Engineering Manager  
|                     | Engineering Technician  
|                     | Human Factors Engineer  
|                     | Industrial Engineer  
|                     | Industrial Engineering Technician  
|                     | Manufacturing Systems Engineer |