Acknowledgments

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

- Brandon Barts, Instructor, Pittsylvania Career and Technical Center, Pittsylvania County Schools
- Stephanie Cruz, Instructor, Thomas Nelson Community College, Hampton
- Gary Daniels, Sales Consultant, Amteck Company, Inc., Arnold, Maryland
- Gavin Garner, PhD, Assistant Professor, University of Virginia, Charlottesville
- Vukica Jovanovic, PhD, Assistant Professor, Old Dominion University, Norfolk
- Victor Vince, Instructor, Colonial Heights High School, Colonial Heights Public Schools
- Clarence Wilcox, Instructor, Thomas Nelson Community College, Hampton

Correlations to the Virginia Standards of Learning were reviewed and updated by the following:

- Leslie R. Bowers, English Teacher (ret.), Newport News Public Schools
- Vickie L. Inge, Mathematics Committee Member, Virginia Mathematics and Science Coalition
- Anne F. Markwith, New Teacher Mentor (Science), Gloucester County Public Schools
- Michael L. Nagy, Social Studies Department Chair, Rustburg High School, Campbell County Public Schools

The framework was edited and produced by the CTE Resource Center:

- Leanne Forbes Tipton, Writer/Editor
- Kevin P. Reilly, Administrative Coordinator

Virginia Department of Education Staff

Lauren Sledzinski, Specialist, Trade and Industry Education and Related Clusters
Dr. J. Anthony Williams, Curriculum and Instruction Coordinator
Dr. David S. Eshelman, Director, Workforce Development and Initiatives
Course Description

Suggested Grade Level: 12

Students will build on their knowledge of mechatronic systems in this advanced course. Mechatronic systems are comprised of mechanical, electrical, and software systems, and form the foundation of robotics, automation, and advanced manufacturing (such as three dimensional [3D] printing). Students will apply principles related to pneumatic, electro-pneumatic, and hydraulic control circuits as well as basic digital logic and programmable logic controllers (PLCs) in a complex mechatronic system. Students will troubleshoot and resolve malfunctioning pneumatic and hydraulic components and circuits. Upon successful completion, students may qualify for industry certification.

Task Essentials Table

- Tasks/competencies designated by plus icons (⁺) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⁻) are omitted
- Tasks marked with an asterisk (*) are sensitive.

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8556</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying 4.0 Basic Safety Standards for Mechatronics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>☑️</td>
<td>Comply with federal, state, and local safety-related legal requirements.</td>
</tr>
<tr>
<td>40</td>
<td>☑️</td>
<td>Demonstrate lockout-tagout procedures.</td>
</tr>
<tr>
<td>41</td>
<td>☑️</td>
<td>Maintain a safe working environment.</td>
</tr>
<tr>
<td>42</td>
<td>☑️</td>
<td>Explain safe working practices around electrical hazards.</td>
</tr>
<tr>
<td>43</td>
<td>☑️</td>
<td>Identify emergency first-aid procedures.</td>
</tr>
<tr>
<td>44</td>
<td>☑️</td>
<td>Identify the types of fires and the methods used to extinguish them.</td>
</tr>
<tr>
<td>45</td>
<td>○</td>
<td>Demonstrate the use of a fire extinguisher.</td>
</tr>
<tr>
<td>46</td>
<td>☑️</td>
<td>Identify personal protective equipment (PPE) requirements.</td>
</tr>
<tr>
<td>47</td>
<td>☑️</td>
<td>Inspect hand and power tools to ensure safety and usability.</td>
</tr>
<tr>
<td>48</td>
<td>☑️</td>
<td>Demonstrate lifting and carrying techniques.</td>
</tr>
<tr>
<td>49</td>
<td>☑️</td>
<td>Report injuries.</td>
</tr>
<tr>
<td>50</td>
<td>☑️</td>
<td>Report personal, environmental, and equipment safety violations to the appropriate authority.</td>
</tr>
<tr>
<td>51</td>
<td>☑️</td>
<td>Pass the safety exam.</td>
</tr>
<tr>
<td>Exploring Programming Applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>☑️</td>
<td>Create sequential programs using flowcharts.</td>
</tr>
<tr>
<td>53</td>
<td>☑️</td>
<td>Describe the use of logic in programming machines used in industry.</td>
</tr>
<tr>
<td>54</td>
<td>☑️</td>
<td>Convert units in numeric systems.</td>
</tr>
<tr>
<td>Understanding Programmable Logic Controller Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>☑️</td>
<td>Explain the role of programmable logic controllers (PLCs) (or programmable automation controllers [PACs]) within mechatronic systems, modules, and subsystems.</td>
</tr>
<tr>
<td>56</td>
<td>☑️</td>
<td>Trace the flow of information in a control function for a mechatronic system or subsystem.</td>
</tr>
<tr>
<td>57</td>
<td>☑️</td>
<td>Define the term Industry 4.0 Industrial Internet of Things (IIoT).</td>
</tr>
<tr>
<td>58</td>
<td>☑️</td>
<td>Describe the basic functions and design of PLCS.</td>
</tr>
</tbody>
</table>
Describe numbering systems and data types used in computer programming.

Apply DeMorgan’s theorem.

Apply DeMorgan’s theorem in creating logic circuits.

Simplify logical equations.

Create Boolean logic equations to prescribe the use of logic gates in the implementation of a given scenario.

Explain hexadecimal, decimal, octal, binary, 2s complement, and binary coded decimal (BCD) values as used in a common PLC.

Explain ladder logic and function block diagram (FBD) programming.

Convert wiring and line or ladder diagrams for simple logic tasks into PLC programs.

Connect a PLC with electrical components.

Create PLC programs.

Execute PLC programs on a PLC.

Assess pneumatic and/or hydraulic components within a mechatronican system.

Perform adjustments on pneumatic and/or hydraulic components within a mechatronican system.

Document adjustments in an equipment log.

Troubleshoot malfunctioning pneumatic and/or hydraulic systems.

Document the cause and repair of the malfunction.

Describe the process and requirements for obtaining industry certifications related to the mechatronics course.

Identify testing skills and strategies for certification examination.

Demonstrate ability to successfully complete selected practice examinations (e.g., practice questions similar to those on certification examinations).

Complete an industry certification examination representative of skills learned in this course.

Applying 4.0 Basic Safety Standards for Mechatronics

Task Number 39

Comply with federal, state, and local safety requirements.

Definition

Compliance should include

- understanding the roles of the Occupational Safety and Health Administration (OSHA), Virginia Occupational Safety and Health (VOSH) program, and the U.S. Environmental Protection Agency (EPA)
- identifying the OSHA 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

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

Task Number 40
Demonstrate lockout-tagout procedures.

Definition
Demonstration should include

- identifying existing and potential energy sources
- using appropriate equipment
- following administrative procedures
- challenging and/or testing the equipment.

Process/Skill Questions

- Why are lockout-tagout procedures important?
- What administrative procedures are part of lockout-tagout? Why are those procedures in place?

Task Number 41
Maintain a safe working environment.

Definition
Maintaining safety should be an ongoing process and should result in identifying potential hazards on a job site or in the lab, such as unstable or improperly erected scaffolding, electrical hazards, job-site debris, improperly stored materials, and air-quality hazards. When present, hazards must be remedied by appropriate measures, in compliance with school and instructor guidelines.

Process/Skill Questions

- What are examples of job-site hazards?
- Why is it important to maintain safe work space standards on a job site?
- Why is it important to store materials and tools in their proper places?

Task Number 42
Explain safe working practices around electrical hazards.

Definition
Explanation should include

- identifying equipment used to test electrical circuits
- describing safe working conditions (e.g., grounding, using ground-fault circuit interrupters [GFCIs] and cords)
- demonstrating safe work habits.
- outlining lockout-tagout procedures.
Process/Skill Questions

- What is the definition of proximity work?
- What are safe working clearances, according to the National Electrical Code (NEC)?
- What are considered safe working conditions and safe work habits?
- What is the unseen hazard with electrical work?
- What are lockout-tagout procedures?

Task Number 43

Identify emergency first-aid procedures.

Definition

Identification should include procedures for accidents involving

- bodily fluids
- electrical injuries
- eye injuries
- hydraulic fluid injection injury
- falls
- burns.

Process/Skill Questions

- What steps should be followed in the event of an accident?
- Why is the knowledge of cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) use important in the electrical trades?
- Why is it important to be certified to administer first aid?
- What are the different degrees of electrical burns?
- What is CPR/AED?

Task Number 44

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

Definition

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

Process/Skill Questions

- Why do fires have different classifications, and what are they?
- What is 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 fire when trying to extinguish it?
- Why should extinguishers be inspected, and how often should they be inspected?
- What are the classifications of extinguishers?
Task Number 45
Demonstrate the use of a fire extinguisher.

Definition
Demonstration should include the use of the pull, aim, squeeze, sweep (PASS) method.

Process/Skill Questions
- Why is it important to know how to use a fire extinguisher?
- When might a fire extinguisher be used?

Task Number 46
Identify personal protective equipment (PPE) requirements.

Definition
Identification could include procedures for inspecting, wearing, and removing
- eye protection
- respirator
- hard hat
- gloves
- safety harness
- hearing protection
- safety shoes.

Identification should also include explaining when a particular PPE is required.

Process/Skill Questions
- What are some dangerous effects of exposure, and how can these risks be mitigated?
- Why is wearing jewelry prohibited while in the lab or on the job site?

Task Number 47
Inspect hand and power tools to ensure safety and usability.

Definition
Inspection should include
- verifying that components of machinery (e.g., guards, blades, moving parts, start/stop switches) are in good working condition
- identifying any defects in tools, parts, or functions
- adhering to standard safety procedures (i.e., shop practices and manufacturer's recommendations)
- demonstrating the safe operation and use of all equipment, tools, and machines.

Process/Skill Questions
- What are some of the basic power tools?
- What are the proper actions to take before using a band saw?
- Why must a power tool with a three-prong plug be grounded?
Task Number 48

Demonstrate lifting and carrying techniques.

Definition
Demonstration should include

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

Process/Skill Questions

- What are common injuries associated with improper lifting techniques?
- What can one do to prevent injury?
- How does proper positioning affect proper technique?

Task Number 49

Report injuries.

Definition
Report should consist of an immediate oral statement of the job-related or non-job-related injury to the instructor or supervisor, which may be followed by a written confirmation reporting the date, extent of the injury, and circumstances of the incident.

Process/Skill Questions

- Why is it important to report injuries?
- What are common reporting procedures?
- Why is it important to report an injury promptly, before leaving the job site?
- What is workers' compensation?
- What are the key components of a report?

Task Number 50

Report personal, environmental, and equipment safety violations to the appropriate authority.

Definition
Report should include

- providing a verbal or written statement
- identifying the violation
- documenting the date when the incident or behavior was observed
- following the protocol for submitting the report to the instructor, supervisor, or the local OSHA inspector.
Process/Skill Questions

• What ethical considerations might be involved when reporting coworkers?
• Why is it important to follow reporting procedures?
• What is liability?

Task Number 51
Pass the safety exam.

Definition
Passing the safety exam should allow the instructor to approve the student for working with course materials and equipment.

Process/Skill Questions

• How often should one participate in safety training programs? Why?
• How does insurance affect the requirement of continuous retraining for safety?
• What is workers' compensation?

Exploring Programming Applications

Task Number 52
Create sequential programs using flowcharts.

Definition
Creation should include

• understanding the types and meanings of flowchart symbols (e.g., start, input/output, internal process, decision, end)
• producing a flowchart using the symbols
• converting the flowchart into a computer program
• creating a program that includes a text box, labels, buttons, and picture boxes.

Process/Skill Questions

• How are flowcharts useful in creating sequential programs?
• What are some symbols used in a flowchart and what do they mean?

Task Number 53
Describe the use of logic in programming machines used in industry.

Definition
Description should include logic gates (i.e., AND/OR and NAND/NOR) and the use of coding in programming machines to do specific tasks at specific times.

Process/Skill Questions

• What are logic gates?
• How do computers use logic to make decisions?
Task Number 54

Convert units in numeric systems.

**Definition**
Conversion should include

- binary
- binary-coded decimal (BCD)
- hexadecimal.

**Process/Skill Questions**

- What is the *hexadecimal system*?
- What is the difference between BCD and binary?

Understanding Programmable Logic Controller Systems

Task Number 55

Explain the role of programmable logic controllers (PLCs) (or programmable automation controllers [PACs]) within mechatronic systems, modules, and subsystems.

**Definition**
Explanation should include the benefits of a PLC over standard relay control and/or solid-state control. Explanation should also address the components and operation of a PLC within a system.

**Process/Skill Questions**

- What is the *relay control*?
- What is *solid-state control*?
- What is the *programmable controller*?
- What is the difference between a PLC and a PAC?

Task Number 56

Trace the flow of information in a control function for a mechatronic system or subsystem.

**Definition**
Tracing should include standards in automation technology such as

- channel-to-channel
- fieldbus (fieldbus communication) process
- field net (industrial Ethernet)
- wireless.
Tracing may also include the creation of a schematic and/or narrative to describe the flow of information to/from an equipment operator.

Process/Skill Questions

- How does information get exchanged within the different components of a mechatronic system?
- How are standards related to communication technologies such as fieldbus and field net similar and different?
- What are the main advantages and disadvantages between wired and wireless information transfer methodologies in mechatronics?

---

Task Number 57

**Define the term Industry 4.0 Industrial Internet of Things (IIoT).**

**Definition**

Definition could include

- radio-frequency identification (RFID)
- vertical integration
- digital twin and/or digital shadow
- big data
- supervisory control and data acquisition (SCADA)
- manufacturing execution systems (MES)
- enterprise resource planning (ERP)
- automation pyramid
- cybersecurity
- distributed control system (DCS)
- cloud computing.

- What are the main technologies enabling the IIoT?
- What is the difference between digital twin and digital shadow?

---

Task Number 58

**Describe the basic functions and design of PLCs.**

**Definition**

Description should include

- central processing unit (CPU)
- digital input (DI) modules
- digital output (DO) modules
- analog input (AI) modules
- analog output (AO) modules
- extension modules
- power supply.

**Process/Skill Questions**

- How does the PLC store and process signals?
• How does the PLC receive and transmit information to transducers (e.g., sensors, actuators)?
• What is the main difference between analog and discrete signals?

Task Number 59
Describe numbering systems and data types used in computer programming.

Definition
Description should include

• integer
• string
• float
• double.

Process/Skill Questions

• What are the different numbering systems used in computer programming?
• What are the different data types used in computer programming?

Task Number 60
Describe DeMorgan’s theorem.

Definition
Description should state that the theorem says any logical binary expression remains unchanged if we

• change all variables to their complements
• change all AND operations to OR operations
• change all OR operations to AND operations
• take the complement of the entire expression.

Description also should state that the theorem is useful in basic gate operations, particularly NAND and NOR gates.

Process/Skill Questions

• How is DeMorgan’s theorem applied in basic gate operations?
• How are variables changed to their complements?

Task Number 61
Apply DeMorgan’s theorem in creating logic circuits.

Definition
Application should include converting

• AND operations to OR operations
• OR operations to AND operations.
Process/Skill Questions

- Why would an AND operation need to be converted to an OR operation?
- What happens if an AND operation is not converted to an OR operation?

Task Number 62

Simplify logical equations.

Definition

Simplification should include the application of

- the algebra of sets
  - identity law
  - complement law
  - associative law
  - distributive law
- DeMorgan’s theorem.

Process/Skill Questions

- What is the identity law?
- What is the associative law?

Task Number 63

Create Boolean logic equations to prescribe the use of logic gates in the implementation of a given scenario.

Definition

Creation should demonstrate application within a real-world mechatronic system. Scenario should be bound by several logical parameters.

Process/Skill Questions

- How does the Boolean equation compare to regular algebraic equations (e.g., 1+1)?
- Why are Boolean equations used?
- How does Boolean logic apply in a motor control circuit?

Task Number 64

Explain hexadecimal, decimal, octal, binary, 2s complement, and binary coded decimal (BCD) values as used in a common PLC.

Definition

Explanation should include how these codes are relevant to mechatronic systems.

Process/Skill Questions

- How are physical properties encoded in these numbering systems?
- How do different encoding systems affect the behavior of a mechatronic system?
• Why are there so many different values used and/or needed in PLCs?

Task Number 65

Explain ladder logic and function block diagram (FBD) programming.

Definition
Explanation should include a description of

• the rungs and their function
• the rails and their function
• symbols used.

Process/Skill Questions

• How are logical AND and OR represented in a ladder logic diagram?
• Which type of circuit does a ladder logic diagram symbolize (parallel or series)? Why?
• Where are ladder logic diagrams used most frequently?

Task Number 66

Convert wiring and line or ladder diagrams for simple logic tasks into PLC programs.

Definition
Conversion could include common instructions such as

• digital
• logical
• compare
• compute
• move
• file
• sequencer
• timer
• program control instruction sets.

Process/Skill Questions

• How does the ladder diagram simplify the logic tasks of a PLC program?
• How are the compare and compute conversions different?
• What are the differences in some common instructions related to normally open and normally closed contacts?

Task Number 67

Connect a PLC with electrical components.

Definition
Connection may include the use of components such as
• normally open (NO) momentary (start)
• normally closed (NC) momentary (stop)
• sensors
• contactor and solid state relay
• status lamps
• drives (e.g., variable frequency drive [VFD], microstepper, servo).

Process/Skill Questions

• What enables an emergency stop button to shut down a system immediately?
• What is the purpose of a status lamp?
• What happens if NO and NC switches are accidentally swapped in a hydraulic lift?

Task Number 68
Create PLC programs.

Definition
Creation should include

• single start/stop with counter
• sequential start/stop with timer
• forward/reverse motor controllers.

Process/Skill Questions

• How does the PLC understand the sequencing of a program?
• What happens if a timer is not reset?
• What are the advantages of PLC programs?

Task Number 69
Execute PLC programs on a PLC.

Definition
Execution should include downloading the written program to a PLC and performing the functions, according to the written assignment or instruction.

Process/Skill Questions

• How are PLCs made by different manufacturers similar and different?
• What would happen if the PLC does not have enough space for a program that is to be uploaded?
• Why must the PLC have an adequate version of the software?

Troubleshooting Fluid-Power Systems

Task Number 70
Assess pneumatic and/or hydraulic components within a mechatronic system.
Definition
Assessment should include referencing technical documents (e.g., data sheets, circuit diagrams, displacement step diagrams, timing diagrams, function charts, operations manuals, schematics) for pneumatic and hydraulic components within a mechatronic system.

Process/Skill Questions
- Why are the fluid-power systems important for mechatronic systems?
- What purpose do fluid-power systems serve in mechatronics? How is this helpful?

Task Number 71
Perform adjustments on pneumatic and/or hydraulic components within a mechatronic system.

Definition
Performance could include
- flow control
- pressure regulation
- current-to-pressure transducer
- voltage-to-pressure transducer.

Process/Skill Questions
- What tools are needed to perform adjustments on pneumatic and/or hydraulic components?
- How are necessary adjustments made apparent?
- What might cause a leakage in a pneumatic or hydraulic system?

Task Number 72
Document adjustments in an equipment log.

Definition
Documentation should include a justification of adjustments made and the date of each adjustment. Documentation should be accessible for technician and engineer reference.

- Why is documentation so important?
- What problems can be caused by not properly documenting adjustments?
- What are some methods of version control?

Task Number 73
Troubleshoot malfunctioning pneumatic and/or hydraulic systems.

Definition
Troubleshooting should include
- identifying the problem
• identifying the source of the problem(s)
• planning a multistep procedure to correct the malfunction
• implementing the plan
• verifying the corrective action.

Process/Skill Questions

• What fault would be seen if a wire were to become disconnected in a NC motor control circuit?
• Why is it important to test the result of attempting to repair a fault at each step of the multistep procedure?
• What could happen if the source of the problem were not identified and the system continues to operate?

Task Number 74

Document the cause and repair of the malfunction.

Definition

Documentation should include using appropriate technical language and terminology, and it should justify the procedure used to correct the malfunction.

Process/Skill Questions

• Why is documentation so important?
• How does documenting cause and repair improve future prediction and/or avoidance of equipment failure?
• How would the loss of an employee by retirement affect the need for documentation?

Preparing for Industry Certification

Task Number 75

Describe the process and requirements for obtaining industry certifications related to the mechatronics course.

Definition

Description should include a list of industry certifications related to the mechatronics course and the process/requirements for obtaining the certifications from

• official websites of the testing organizations and vendors
• materials from publishers that have developed practice materials and tests based on information from the testing organizations and vendors
• information from certified instructors or industry-certified professionals
• information in the “Course Description” section of this document.

Description should also include the benefit and/or value of the certification.

Process/Skill Questions

• How do various certifications differ?
• What is the value of an industry certification?
• How long does it take to obtain an industry certification?
• What is the cost of the industry certification?
Task Number 76
Identify testing skills and strategies for certification examination.

Definition
Identification of testing skills and strategies could be undertaken by

- conducting an Internet research project
- reviewing materials from examination and practice-examination publishers
- interviewing certified instructors and/or industry-certified professionals.

Process/Skill Questions

- Has this course covered all the anticipated material on the test?
- How does this test compare to other tests taken?
- What is the format of the questions expected on this test?

Task Number 77
Demonstrate ability to successfully complete selected practice examinations (e.g., practice questions similar to those on certification examinations).

Definition
Demonstration should include obtaining and successfully completing practice examinations for selected certifications related to the course obtained from vendor sites and/or materials from publishers. The level of performance on a practice examination serves as a gauge of the applicant's readiness for formal industry testing.

Process/Skill Questions

- How was taking a practice examination helpful?
- What causes poor performance on multiple-choice tests?
- How did taking the practice examination provide a better sense of what will be covered/expected on the real exam?
- How can a proper pace be maintained?

Task Number 78
Complete an industry certification examination representative of skills learned in this course.

Definition
Completion of an industry certification examination will be achieved when the student applicant earns an examination score deemed “passing” by the testing organization. Qualifying examinations are those currently approved at the state level as representative of mechatronics skills. Students should be encouraged to attain industry certification as evidence of their mechatronics skill level and general employability.
Process/Skill Questions

- What happens if the first attempt at this certification test is unsuccessful?
- Why is good time management important for the industry?
- Why is working under pressure important for industry?

SOL Correlations by Task

<table>
<thead>
<tr>
<th>Task</th>
<th>Language</th>
<th>Subject(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comply with federal, state, and local safety requirements.</td>
<td>English: 12.5</td>
<td>Science: CH.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Demonstrate lockout-tagout procedures.</td>
<td>English: 12.5</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Maintain a safe working environment.</td>
<td>English: 12.5</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Explain safe working practices around electrical hazards.</td>
<td>English: 12.5, 12.6, 12.7</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Identify emergency first-aid procedures.</td>
<td>English: 12.5</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Identify the types of fires and the methods used to extinguish them.</td>
<td>English: 12.5</td>
<td>Science: CH.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Demonstrate the use of a fire extinguisher.</td>
<td>Science: CH.1</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Identify personal protective equipment (PPE) requirements.</td>
<td>English: 12.5</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Inspect hand and power tools to ensure safety and usability.</td>
<td>English: 12.5</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Demonstrate lifting and carrying techniques.</td>
<td>English: 12.5</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Report injuries.</td>
<td>English: 12.5</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
</tr>
<tr>
<td>Report personal, environmental, and equipment safety violations to the appropriate authority.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>Required Knowledge</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Pass the safety exam.</td>
<td>History and Social Sciences: WHII 8, 14; VUS 8, 14; Govt 7, 8, 9</td>
<td></td>
</tr>
<tr>
<td>Create sequential programs using flowcharts.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Describe the use of logic in programming machines used in industry.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Convert units in numeric systems.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Explain the role of programmable logic controllers (PLCs) (or programmable automation controllers [PACs]) within mechatronic systems, modules, and subsystems.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Trace the flow of information in a control function for a mechatronic system or subsystem.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Define the term Industry 4.0 Industrial Internet of Things (IIoT).</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Describe the basic functions and design of PLCs.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Describe numbering systems and data types used in computer programming.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Describe DeMorgan’s theorem.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Apply DeMorgan’s theorem in creating logic circuits.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Simplify logical equations.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Create Boolean logic equations to prescribe the use of logic gates in the implementation of a given scenario.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Explain hexadecimal, decimal, octal, binary, 2s complement, and binary coded decimal (BCD) values as used in a common PLC.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Explain ladder logic and function block diagram (FBD) programming.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Convert wiring and line or ladder diagrams for simple logic tasks into PLC programs.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Connect a PLC with electrical components.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Create PLC programs.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Execute PLC programs on a PLC.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Assess pneumatic and/or hydraulic components within a mechatronic system.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Perform adjustments on pneumatic and/or hydraulic components within a mechatronic system.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Document adjustments in an equipment log.</td>
<td>English: 12.5, 12.6, 12.7</td>
<td></td>
</tr>
<tr>
<td>Troubleshoot malfunctioning pneumatic and/or hydraulic systems.</td>
<td>English: 12.5</td>
<td></td>
</tr>
<tr>
<td>Document the cause and repair of the malfunction.</td>
<td>English: 12.5, 12.6, 12.7</td>
<td></td>
</tr>
</tbody>
</table>
Describe the process and requirements for obtaining industry certifications related to the mechatronics course.

Identify testing skills and strategies for certification examination.

Demonstrate ability to successfully complete selected practice examinations (e.g., practice questions similar to those on certification examinations).

Complete an industry certification examination representative of skills learned in this course.

<table>
<thead>
<tr>
<th>Task</th>
<th>English:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the process and requirements for obtaining industry certifications related to the mechatronics course.</td>
<td>12.5</td>
</tr>
<tr>
<td>Identify testing skills and strategies for certification examination.</td>
<td>12.1, 12.5</td>
</tr>
<tr>
<td>Demonstrate ability to successfully complete selected practice examinations (e.g., practice questions similar to those on certification examinations).</td>
<td>12.5</td>
</tr>
<tr>
<td>Complete an industry certification examination representative of skills learned in this course.</td>
<td>12.5</td>
</tr>
</tbody>
</table>

**Teacher Resources**

**Mechatronics I/II/III Teacher Resources**

All About Circuits: Educational Resources

Amatrol curriculum

ASME Resources: Mechatronics and the role of engineers

ASTM Fastener Standards

Hand Tools and Safety

Hydraulic Injection Injuries

IEEE Educational Resources

NOCTI Job Ready Assessment Blueprint: Mechatronics Level I

Penn State University Lockout/Tagout Policy:

- Overview
- Resources

SkillsUSA Resources:

- Mechatronics Contest Standard
- Mechatronics Contest Rules

Try Engineering: Differentiating between Mechatronics and Robotics
## Appendix: Credentials and Career Cluster Information

**Industry Credentials: Only apply to 36-week courses**

- Automated Manufacturing Technology Examination
- College and Work Readiness Assessment (CWRA+)
- Festo NC3 Introduction to Mechatronics STEM Lab Certification
- Festo NC3 Level 1 Fundamentals Certifications
- Manufacturing Specialist Certification Examination
- Manufacturing Technician Level I Certification Examination
- Manufacturing Technology Assessment
- Mechatronic Systems Certification Examinations
- Mechatronics Level 1 Assessment
- National Career Readiness Certificate Assessment
- Pre-Manufacturing Technician I (PreMT1) Examination
- Robotics Certification Examinations
- Workplace Readiness Skills for the Commonwealth Examination

### Career Cluster: Manufacturing

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Production Process Development</td>
<td>Electro-Mechanical Technician</td>
</tr>
<tr>
<td></td>
<td>Industrial Engineer</td>
</tr>
<tr>
<td></td>
<td>Industrial Engineering Technician</td>
</tr>
<tr>
<td></td>
<td>Manufacturing Systems Engineer</td>
</tr>
<tr>
<td>Production</td>
<td>Automated Manufacturing Technician</td>
</tr>
</tbody>
</table>

### Career Cluster: Science, Technology, Engineering and Mathematics

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering and Technology</td>
<td>Electrical Engineering Technician</td>
</tr>
<tr>
<td></td>
<td>Electro-Mechanical Technician</td>
</tr>
<tr>
<td></td>
<td>Mechanical Engineer</td>
</tr>
<tr>
<td></td>
<td>Mechanical Engineering Technician</td>
</tr>
</tbody>
</table>