TENNESSEE DEPARTMENT OF EDUCATION
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Introduction to Electromechanical

Primary Career Cluster:	Manufacturing
Consultant:	Bethany King Wilkes, (615) 532-2844, Bethany.Wilkes@tn.gov
Course Code(s):	6091
Prerequisite(s):	Principles of Manufacturing (5922), Algebra I (6109/3102), and Physical Science (3202). *Note: Algebra I (6109/3102) and Physical Science (3202) can be taken as co-requisites.*
Credit:	1
Grade Level:	10
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Manufacturing courses.
Programs of Study and Sequence:	This is the second course in the *Electromechanical Technology* program of study.
Necessary Equipment:	Hand tools, power tools, electronic test equipment, personal protective equipment, lifting equipment, rigging equipment, computer-aided drafting software.
Aligned Student Organization(s):	Skills USA: www.tnskillsusa.com Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, he or she can offer appropriate student placements. To learn more, visit http://tennessee.gov/education/cte/wb/.
Available Student Industry Certifications:	None
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	531, 584, 596
Required Teacher Certifications/Training:	None
Teacher Resources:	http://www.state.tn.us/education/cte/Manufacturing.shtml

Course Description

Introduction to Electromechanical is a foundational course that introduces students to basic electromechanical skills necessary in a manufacturing facility. Topics covered include safety, construction drawings, site layout, hand and power tools, linear and angular measurements, and application of algebraic and geometric principles to construction problems. Standards in this course are aligned with Tennessee Common Core State Standards in English Language Arts & Literacy in Technical Subjects and Tennessee Common Core State Standards in Mathematics.*

Program of Study Application

This course is the second course in the *Electromechanical Technology* program of study. For more information on the benefits and requirements of implementing this program in full, please see the program of study description documents found on the Manufacturing website at http://www.state.tn.us/education/cte/Manufacturing.shtml.

Course Standards

Safety

1) Assess a given situation requiring the use of tools, equipment, and materials. Explain the applicability of various safety standards and procedures, and then safely demonstrate the use of the tools, equipment, and materials. For example, the hoisting of material requires lifting equipment of sufficient strength and applicability to the task, physical clearance from personnel, necessary alerting to others, and authorization to use the required equipment, as well as conformance to Occupational Safety and Health Administration (OSHA) policies for avoiding and reporting accidents associated with this type of activity. (TN CCSS Reading 2, 3)

2) Assess a given situation requiring the use of hand and/or power tools. Select the proper tool and accessories, critique the readiness of the tool, use the tool to accomplish the desired task, and then return the tool and accessories to its proper storage. For example, creating a hole in aluminum requires the choice of the proper drill, drill bit, mounting hardware, lubricant, and safety procedures and precautions. The suitability of the drill bit is just one of many aspects that must be assessed and analyzed. (TN CCSS Reading 3)

3) Analyze situations, create plans, and implement plans requiring the use of rigging to install and/or remove equipment and machinery. Perceive and critique the safety risks involved in the job. For example, contrast the implications of lifting and positioning heavy objects of small compact shape versus those of large rotational moment. (TN CCSS Reading 3, 4; TN CCSS Writing 4)

4) Identify and evaluate situations that require electrical circuits and electromechanical principles. Develop and safely implement a plan to achieve the desired electromechanical objective. For example, recognize the power requirements for operating a 35 hp lathe, develop a wiring plan, and draft the details for a work order. (TN CCSS Reading 4)

Problem Solving & Critical Thinking

5) Create linear and angular drawings to represent real-world physical scenarios in two and three dimensions. For example, based on physical requirements for a bracket, develop a plan, and create a drawing based on the required geometry for accurately fabricating the bracket, including precise linear and angular measures. (TN CCSS Reading 7; TN CCSS Math: N-Q, A-CED, G-GMD, G-MG)

6) Apply mathematics concepts to solve electronics and manufacturing industry problems. For example, calculate the impact of the addition of random variables representing material dimensions that include several tolerances and dimensional allowances on the final combined work product. (TN CCSS Reading 4, 7; TN CCSS Math: N-Q, A-SSE, A-REI)

7) Create two- and three-dimensional scale drawings using accepted dimensioning rules and measurement systems. For example, as part of a project to fabricate a custom-shaped metal block, develop the complete drawings that specify the dimensional details for each step of the construction process. (TN CCSS Reading 3, 7; TN CCSS Math: A-REI, G-CO, G-C, G-GMD, G-MG)

8) Identify and demonstrate basic troubleshooting strategies appropriate for evaluating electronic circuits/systems and electromechanical devices. For example, in a relay-logic circuit with four display bulbs, develop and implement a troubleshooting strategy to remedy a bulb that fails to light. (TN CCSS Reading 3; TN CCSS Math N-Q, S-IC)

Computers & Electronics

9) Demonstrate understanding of the operation of electrical circuits and devices and relate it to the physical laws (such as Ohm's Law, Kirchhoff's Law, and power laws) that govern the behavior of electrical circuits and devices. Accurately apply these physical laws to solve problems. For example, calculate and support the consequence of the maximum volume of air that can be moved by an AC-powered 50 hp electric motor. (TN CCSS Reading 3, 4; TN CCSS Math N-Q, A-CED, A-REI, F-BF)

10) Explain the interrelationships among sources of current, voltage, resistance, and power in electric circuits, both theoretical (illustrated) and actual by designing a direct current (DC) circuit of resistors and LEDs, and predicting the likely current and power requirement. Discriminate among used resistors in a junk box, using the color codes to identify resistors of suitable value. (TN CCSS Reading 1, 5; TN CCSS Writing 4; TN CCSS Math N-Q, A-REI)

11) Assemble the required connections of electronic test equipment to properly test the operation of basic electronic circuit behavior and performance, using equipment such as a digital multimeter, oscilloscope, and resistance bridge. For example, design, assemble, and verify a passive analog filter able to block at least 6 dB of audio-level signals of frequency greater than 500 Hz. (TN CCSS Reading 3; TN CCSS Math N-Q)

Production & Processing

12) Investigate an assortment of occupations and manufacturing processes that rely on electromechanical principles and technologies, such as shipyard rigging, metalworking,

agricultural mechanics, construction, and medical prosthetics. Write an informative text that summarizes the typical educational and certification requirements, working environments, and career opportunities for these occupations. (TN CCSS Reading 2; TN CCSS Writing 2)

13) Analyze and describe a variety of quality control constraints on manufacturing materials, parts, and processes that impact the suitability of a given electromechanical production process. Collect and interpret data that includes, but is not limited to, physical and electrochemical properties such as size, mass, hardness, pH, temperature, conductivity, rate, and so forth, and synthesize the results to yield a clear, written documentation of the findings. For example, assist a quality assurance inspector who must carefully complete the steps of a standard inspection order to certify an incoming shipment of raw material by making several measurements and tests for conformance to specification. (TN CCSS Reading 1, 5; TN CCSS Writing 7)

14) Inspect and interpret blueprints, schematic diagrams, or written specifications for electromechanical devices and systems. Explain how pictorial representations relate to an actual project layout, verifying sufficient agreement as prescribed by specified tolerances. For example, create a proposed parts list for wiring a room addition based on electrical construction drawings, conforming to generally accepted building codes. (TN CCSS Reading 1, 5; TN CCSS Writing 7; TN CCSS Math N-Q, G-CO, G-GMD)

15) Given a malfunctioning electromechanical system, use resources such as blueprints, diagrams, and equipment manuals to troubleshoot the machinery. Develop and graphically illustrate at least three possible solutions to the problem. Select the optimal solution and justify the selection with evidence drawn from the resources listed above. (TN CCSS Reading 1, 4; TN CCSS Writing 1, 4)

Standards Alignment Notes

*References to other standards include:

- TN CCSS Reading: Tennessee Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).
    - Note: While not directly aligned to one specific standard, students that are engaging in activities outlined above should be able to also demonstrate fluency in Standards 6, 8, 9, and 10 at the conclusion of the course.
- TN CCSS Writing: Tennessee Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
    - Note: While not directly aligned to one specific standard, students that are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 5, 6, 8, 9, and 10 at the conclusion of the course.
- TN CCSS Math: Tennessee Common Core State Standards for Mathematics; Math Standards for High School: Number and Quantity, Algebra, Functions, Geometry, Statistics and Probability (pages 58-83).

- Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students that are engaging in activities listed above should be able to demonstrate quantitative, algebraic, functional, geometric, and statistical reasoning as applied to specific technical concepts. In addition, upon completion of this course, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.

- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
  - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.

Mechatronics I

Primary Career Cluster:	Manufacturing
Consultant:	Bethany King Wilkes, (615) 532-2844, Bethany.Wilkes@tn.gov
Course Code(s):	TBD
Prerequisite(s):	Algebra I (6109/3102), Geometry (6111/3108), Physical Science (3202), Principles of Manufacturing (5922), and Digital Electronics (5925)
Credit:	1
Grade Level:	11
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Manufacturing courses.
Programs of Study and Sequence:	This is the third course in the *Mechatronics* program of study.
Necessary Equipment:	Refer to the Teacher Resources page below.
Aligned Student Organization(s):	Skills USA: www.tnskillsusa.com Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, he or she can offer appropriate student placement. To learn more, visit http://tennessee.gov/education/cte/wb/.
Available Student Industry Certifications:	If a student continues successfully through both Mechatronics I and II, he or she is eligible to sit for Level 1 Siemens Certified Mechatronic Systems Assistant certification.
Dual Credit or Dual Enrollment Opportunities:	There are currently dual enrollment opportunities with specific community colleges, such as Motlow Community College.
Teacher Endorsement(s):	TBD
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.state.tn.us/education/cte/Manufacturing.shtml

Course Description

Mechatronics I is an applied course in the manufacturing cluster for students interested in learning more about careers as a mechatronics technician, maintenance technician, electromechanical technician, and manufacturing engineer. This first of two courses covers basic electrical and mechanical components of mechatronics systems as well as their combined uses with instrument controls and embedded software

designs. Upon completion of this course, proficient students are able to describe and explain basic functions of physical properties and electrical components within a mechatronic system. They can logically trace the flow of energy through a mechatronic system and can communicate this process to others. They know how to effectively use technical documentation such as data sheets, schematics, timing diagrams, and system specifications to troubleshoot basic problems with equipment. Finally, they develop strategies to identify, localize, and correct malfunctioning components and equipment. Standards in this course are aligned with Tennessee Common Core State Standards in English Language Arts & Literacy in Technical Subjects and Tennessee Common Core State Standards in Mathematics.*

Program of Study Application

This course is the third course in the *Mechatronics* program of study. For more information on the benefits and requirements of implementing this program in full, please see the program of study description documents found on the Manufacturing website at http://www.state.tn.us/education/cte/Manufacturing.shtml.

Course Standards

Mechatronics Overview

1) Drawing on various media, including visual, quantitative, and written resources, trace the historical development of the four facets (mechanical systems, electronic systems, computers, and control systems) of a mechatronic system and explain their chief applications in modern society, citing specific textual evidence. (TN CCSS Reading 1, 2)

2) Citing specific evidence from a textual description or actual observation of a mechatronic system, describe the flow of electrical and mechanical energy in the system. Create a computational model to represent the transfer of energy from one component to others in a system. (TN CCSS Reading 1, 7)

Safety

3) Accurately read and interpret safety rules, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA), state and national code requirements. Apply them accordingly while working on electrical and mechanical components and explain why certain rules apply. (TN CCSS Reading 3)

Electronics

4) Demonstrate understanding of the specific roles of various electrical components discerned in a circuit schematic by correctly predicting the effects of changing selected parameter values. For example, predict the effect of halving a resistor's value. Compare and contrast these roles and explain how electronic designs vary within a given system or module. (TN CCSS Reading 3, 9)

5) Create, measure, and analyze basic director current (DC) circuits prescribed by schematics using Ohm's law, Kirchhoff's law, and Watt's law to predict and verify circuit behavior. Apply understanding of these laws to troubleshoot simple circuits, and document the steps required to

remedy the trouble. (TN CCSS Reading 3, 4; TN CCSS Writing 4; TN CCSS Math N-Q, A-REI, A-SSE, F-IF)

6) Create, measure, and analyze circuits prescribed by schematics to predict and verify the behavior of series versus parallel DC circuits or resistances. Where unexpected behavior is observed, cite specific evidence to explain the observations. (TN CCSS Reading 1)

7) Using technical documentation, such as manuals and schematics, craft an informative narrative to explain the physical operation of electromagnetic and electrostatic components (such as coils, solenoids, relays, and various sensors) in a mechatronic system. Interpret resolved work orders by analyzing underlying issues and explaining the correct physical operation of the included components. (TN CCSS Reading 6, 8; TN CCSS Writing 2)

8) Create, measure, and analyze circuits prescribed by schematics to predict and verify the behavior of the electrical and physical properties of components (such as resistors, capacitors, diodes, transformers, relays, and power supplies). Report findings explaining the typical application and operation in circuits of the previously listed components, citing measurement and/or observed evidence supporting the explanation. (TN CCSS Reading 8; TN CCSS Writing 4)

Mechanical

9) Demonstrate understanding of the specific role of various mechanical components in mechatronic systems, discerning in a system schematic the effects of various design parameters on the system behavior. For example, predict the effect of a larger gear size. Compare and contrast these roles in the context of mechatronic systems, modules, and subsystems, explaining how designs vary within a given system or module. (TN CCSS Reading 3, 9)

10) Create, measure, and analyze mechanical systems prescribed by drawings to predict and verify the behavior of the physical operation of components in a mechatronic system, including but not limited to:
    a. Springs, and spring-like effects
    b. Dampers and energy dissipation
    c. Masses (weights)

    Craft an explanatory narrative to report findings and outline the typical application in systems of the components listed above, citing the observed behavior to support explanations. (TN CCSS Reading 3, 9; TN CCSS Writing 2)

11) Interpret technical information in design problems to analyze forces, speeds, torque, and power, for mechanical drives including:
    a. Gears, cams, screws, and levers
    b. Belt and chain drives
    c. Flywheels
    d. Motors and generators

    Explain the typical application and operation in systems of the components listed above, citing measurement and/or observed evidence to support explanations. Create equations that describe relationships to solve the design problems and justify the solutions. (TN CCSS Reading 4; TN CCSS Math A-CED)

12) Research and measure the behavior of different types of alternating current (AC) motors and direct current (DC) motors, comparing and contrasting behaviors and drawing inferences from the observations to create a checklist for use by a technician to ensure proper functioning of equipment. (TN CCSS Reading 1, 9; TN CCSS Writing 4)

13) Referencing appropriate technical documents (such as data sheets, timing diagrams, operating manuals, and schematics), design an experiment to observe and measure the mechanical properties and behavior of shafts, couplings, and sealing devices with and without proper lubrication. Document research and measurement results in a technical report to be used by other technicians. (TN CCSS Reading 1, 3; TN CCSS Writing 2, 7, 9)

14) Demonstrate understanding of power transmission components, such as clutches and brakes, by measuring the operation of working automotive equipment. Create a graphic illustration showing the roles of each component and how they work together in a system. (TN CCSS Reading 7)

15) Assess the required maintenance for a variety of mechatronic system components in a mechatronic device, and carry out the necessary adjustments to the system. Document and justify the adjustments in an equipment log that can be easily referenced by technicians and engineers. (TN CCSS Reading 3; Writing 2)

Technical Documentation and Troubleshooting

16) Consult technical documents (such as data sheets, timing diagrams, operating manuals, and schematics) to assess a mechatronic system and effectively troubleshoot the malfunctions in electrical components. Record and analyze test results and prepare written testing documentation to justify a solution. (TN CCSS Reading 5, 9; Writing 1, 2)

17) Verify by observation and measurement the parts, relationships, and behavior depicted by the technical data sheets for the mechanical and electrical components within a mechatronic system. Use these data sheets to create a training document to instruct a new technician on maintaining and operating these components and drives. (TN CCSS Reading 4, 5; Writing 2)

Standards Alignment Notes

*References to other standards include:

- TN CCSS Reading: Tennessee Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
    - Note: While not directly aligned to one specific standard, students that are engaging in activities outlined above should be able to also demonstrate fluency in standard 10 at the conclusion of the course.
- TN CCSS Writing: Tennessee Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).

    - Note: While not directly aligned to one specific standard, students that are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 5, 6, 8, and 10 at the conclusion of the course.
- TN CCSS Math: Tennessee Common Core State Standards for Mathematics; Math Standards for High School: Number and Quantity, Algebra, Functions (pages 58-83).
    - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students that are engaging in activities listed above should be able to demonstrate quantitative, algebraic, and functional reasoning as applied to specific technical concepts. In addition students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.

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Mechatronics II

Primary Career Cluster:	Manufacturing
Consultant:	Bethany King Wilkes, (615) 532-2844, Bethany.Wilkes@tn.gov
Course Code(s):	TBD
Prerequisite(s):	Mechatronics I (TBD), Physics (3231). *Note: Physics (3231) may be taken as a co-requisite.*
Credit:	1
Grade Level:	12
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Manufacturing courses.
Programs of Study and Sequence:	This is the fourth, and final, course in the *Mechatronics* program of study.
Necessary Equipment:	Refer to the Teacher Resources page below.
Aligned Student Organization(s):	Skills USA: www.tnskillsusa.com Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, he or she can offer appropriate student placement. To learn more, visit http://tennessee.gov/education/cte/wb/.
Available Student Industry Certifications:	If a student continues successfully through both Mechatronics I and II, he or she is eligible to sit for Level 1 Siemens Certified Mechatronic Systems Assistant certification.
Dual Credit or Dual Enrollment Opportunities:	There are currently dual enrollment opportunities with specific community colleges, including Motlow Community College.
Teacher Endorsement(s):	TBD
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.state.tn.us/education/cte/Manufacturing.shtml

Course Description

Mechatronics II is an advanced course in the Manufacturing cluster for students interested in learning more about such careers as mechatronics technician, maintenance technician, or electromechanical technician. Following the groundwork of mechanics and electronics laid in Mechatronics I, this course covers basics of pneumatic, electro pneumatic, and hydraulic control circuits in a complex mechatronic

system. In addition, the course addresses basic digital logic and programmable logic controllers (PLCs) employed in the mechanical, electronic, and control systems in a mechatronics system.
Students proficient in Mechatronics II are able to explain the inter-relationships of components and modules within a complex mechatronic system. They understand the differences between hydraulic and pneumatic fluid power and can explain the scientific principles that apply. They also use technical documentation (such as datasheets, circuit diagrams, displacement step diagrams, timing diagrams, and function charts) to troubleshoot and resolve malfunctioning pneumatic and hydraulic components and circuits. They demonstrate understanding of the role of programmable logic controllers (PLC) in mechatronic systems and the ability to write, debug, and run basic ladder logic. Standards in this course are aligned with Tennessee Common Core State Standards for English Language Arts & Literacy in Technical Subjects and Tennessee Common Core State Standards in Mathematics.*

Program of Study Application

This course is the fourth course in the *Mechatronics* program of study. For more information on the benefits and requirements of implementing this program in full, please see the program of study description documents found on the Manufacturing website, at http://www.state.tn.us/education/cte/Manufacturing.shtml.

Course Standards

Safety

1) Accurately read and interpret safety rules, including but not limited to the rules of handling high-pressure pneumatics and hydraulics. Analyze the implications of the various rules and employ them accordingly while working on mechatronic systems with control system components, explaining why certain rules apply. (TN CCSS Reading 1, 3)

Fluid Power Systems

2) Demonstrate understanding of the interrelationships and specific roles of (electro) pneumatic and hydraulic components and modules within a complex mechatronic system. For example, provide a written technical description of the expected changes in one or more systems on other components and modules in the total mechatronic system. (TN CCSS Reading 9; TN CCSS Writing 2)

3) Identify the differences between hydraulic and pneumatic fluid power and justify decisions surrounding when to use control systems based on one component as opposed to the other by crafting and defending an argument with specific claim(s), reasoning and supporting evidence. (TN CCSS Reading 9; TN CCSS Writing 1)

4) Create laboratory setups or simple control systems that apply hydraulic and pneumatic principles such as Boyle's Law and Pascal's Law. Apply these principles to solving problems and troubleshooting mechatronic systems, explaining the reasoning behind each step. (TN CCSS Reading 5; TN CCSS Math A-REI)

5) Using real-world examples of hydraulic/pneumatic systems, and citing reputable print and visual sources of such systems, conduct research to identify the basic components and functions in a

fluid power system. Create a visual aid to summarize and explain this information to technicians or upper management. (TN CCSS Reading 7; TN CCSS Writing 6)

1) Measure and analyze basic physical properties of (electro) pneumatic and hydraulic components (such as cylinders, directional control valves, regulators, flow control valves, pumps, and motors) within a given system. Interpret resolved work orders by analyzing underlying issues and explaining the correct physical operation of the included components. (TN CCSS Reading 6, 8; TN CCSS Writing 2)

6) Citing evidence from a technical description or actual observation of a mechatronic system, describe the flow of fluid energy in a given mechatronic system or subsystem. Create a graphic illustration to represent the transfer of energy from one component to others in the system. (TN CCSS Reading 1; TN CCSS Writing 4)

Computers and Control Systems

7) Research the different roles of programmable logical controllers (PLCs) in complex mechatronic systems, modules, and subsystems, and be able to verbally describe their components and operation to others. Collaboratively create a technical document for a new technician that explains the basic components of a PLC, addressing how the role of a PLC varies in different systems (such as mechatronic systems, modules, and subsystems). (TN CCSS Reading 6, 9; TN CCSS Writing 2, 6)

8) Demonstrate understanding of the flow of information in a given mechatronic system or subsystem, focusing on the control function of PLCs in the system. Create both a schematic and explanatory narrative to describe the flow of information to/from an equipment operator. (TN CCSS Reading 4, 7; TN CCSS Writing 2, 4)

9) Given a control scenario, bound by several logical parameters, create Boolean logic equations to prescribe the use of logic gates in the implementation of the scenario. Show how they apply to the functioning of a real-world mechatronics system, explaining the reasoning involved. (TN CCSS Reading 4; TN CCSS Writing 4; TN CCSS Math A-CED; A-REI)

10) Demonstrate understanding of hexadecimal, decimal, octal, binary, 2s complement, and binary coded decimal (BCD) values as used in a common PLC. Write an explanation or develop and deliver a brief presentation of how these codes are relevant to mechatronic systems. (TN CCSS Reading 4, 7; TN CCSS Writing 2)

11) Convert wiring and ladder diagrams for simple logic chores into PLC programs that use common instructions such as digital, logical, compare, compute, move, file, sequencer, and program control instruction sets. (TN CCSS Reading 3; TN CCSS Writing 4, 9; TN CCSS Math A-REI)

Technical Documentation and Troubleshooting

12) Referencing technical documents (such as data sheets, circuit diagrams, displacement step diagrams, timing diagrams, function charts, operations manuals, and schematics) for pneumatic and hydraulic components within a mechatronic system, assess the required maintenance for

such systems, taking appropriate measurements where needed, and perform the necessary adjustments on these systems. Document and justify adjustments in an equipment log that can be referenced by technicians and engineers. (TN CCSS Reading 3, TN CCSS Writing 2, 8)

13) Troubleshoot malfunctioning pneumatic and hydraulic systems: identify the source of the problem(s), plan a multistep procedure to correct the malfunction, implement the plan, and verify the corrective action. Using appropriate technical language and terminology, document the cause of the malfunction and justify the procedure used to correct it. (TN CCSS Reading 3, 4, 9; TN CCSS Writing 1, 9)

Standards Alignment Notes

*References to other standards include:

- TN CCSS Reading: Tennessee Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
    - Note: While not directly aligned to one specific standard, students that are engaging in activities outlined above should be able to also demonstrate fluency in Standards 2 and 10 at the conclusion of the course.
- TN CCSS Writing: Tennessee Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
    - Note: While not directly aligned to one specific standard, students that are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 5, 7, and 10 at the conclusion of the course.
- TN CCSS Math: Tennessee Common Core State Standards for Mathematics; Math Standards for High School: Algebra.
    - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students that are engaging in activities listed above should be able to demonstrate algebraic reasoning as applied to specific technical concepts. In addition students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.