

**Arkansas Department of Career Education
Model Framework**

Course Title: Pre-Mechatronics Intermediate

Secondary – Skilled and Technical Sciences	
Course Number	494820
Cluster	Manufacturing
CIP Number	47.0303, 14.4201
Grade Level	10-12
Prerequisite	Introductory Craft Skills and Pre-Mechatronics
Course Type	Elective
Teacher Certification	577/583/585/586/587/593/616/621
CTSO	SKILLS USA
Facility Requirements	http://arkansasfacilities.arkansas.gov/facilities/academic-facilities-manual
Industry Certifications	http://nccer.org

Course Description

A program that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of computer controlled electro-mechanical systems and products with embedded electronics, sensors, and actuators; and which includes, but is not limited to, automata, robots and automation systems.

Mechatronics 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 course covers basic electrical and mechanical components of mechatronics systems with instrument controls and embedded software designs. Manufacturing Technology (Mechatronics) teaches the design, building, and maintaining of equipment that combines electronics, mechanics, pneumatics, hydraulics, and computer control systems. 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.

Mechatronics is a multi-disciplinary study to develop specialized and highly trained technicians dealing with the integration of mechanical devices, actuators, sensors, electronics, intelligent controllers and computers. Many new generations of consumer or commercial products can be classified as mechatronic products as they involve mechanical as well as electronic components. The need for mechatronic education has grown due to the increase in the number and importance of such systems and devices. Manufacturing Technology (Mechatronics) is the combination of many disciplines. Computer Programming, Electronics, Programmable Logic Controllers, and Robotics are key fields, with specific skills including: panel wiring, machine set-up/trouble shooting, and quality control.

This is an intermediate level course to prepare students for postsecondary programs in electronics, manufacturing, and technical programs designed to develop skilled installation, maintenance and repair technicians in cross disciplinary systems.

Standard 1.0 Demonstrate an understanding of Basic Electrical and Electronic Systems			
Performance Indicator 1.1 Identify and demonstrate an understanding of basic electronic systems.	Recommended Application/Activity 26404-14	CCSS Standards	CCTC Standards
1.1.1 Describe the purposes and fundamental processes of electrical and electronic systems.	•		
1.1.1 Identify electronic system components.	•		
1.1.2 Describe the electrical characteristics of solid-state devices.	•		
1.1.3 Describe the basic materials that make up solid-state devices.	•		
1.1.4 Describe and identify the various types of transistors and explain how they operate.	•		
1.1.5 Interpret electronic schematic diagrams.	•		
1.1.6 Describe and explain the use and purpose of electronic diodes and light-emitting diodes (LEDs).	• Connect diodes and light-emitting diodes (LEDs).		
1.1.7 Describe how to connect silicon-controlled rectifiers (SCRs).	• Test a transistor to determine whether it is an NPN or PNP.		
1.1.8 Identify the leads of various solid-state devices.	• Identify the cathode on three different styles of SCRs, using the shape or markings for identification.		
Performance Indicator 1.2 Identify and demonstrate an understanding of basic electrical charge.	Recommended Application/Activity	CCSS Standards	CCTC Standards
1.2.1 Set up an oscilloscope to observe waveforms and determine voltage.	•		
1.2.2 Explain the properties of resistance.			
1.2.3 Identify ohmic value using an ohmmeter.	•		
1.2.4 Measure voltage using a voltmeter.	•		
1.2.5 Measure current using an ammeter.	•		
1.2.6 Explain how a capacitor stores electrical	•		

charge.			
1.2.7 Explain the difference between digital and analog signals.	•		
Performance Indicator 1.3 Identify and demonstrate an understanding of circuit protective devices.	Recommended Application/Activity 26210-14	CCSS Standards	CCTC Standards
1.3.1 Explain the necessity of overcurrent protection devices in electrical circuits.	•		
1.3.2 Demonstrate proper usage of testing devices to determine condition of a circuit breaker.	•		
1.3.3 Describe the purpose and operation of a circuit breaker, fuse, resistor, and thermistor.	• Define the terms associated with fuses and circuit breakers.		
1.3.4 Apply the National Electrical Code® (NEC®) requirements for overcurrent devices.	• Identify the following on one or more circuit breaker(s) and fuse(s); Poles, Load rating, Voltage rating, Amperage		
1.3.5 Describe the operation of single-element and time-delay fuses.	• Identify properties of conductors and insulators.		
Standard 2.0 Demonstrate an understanding of mechanical control systems			
Performance Indicator 2.1 Analyze components of power, force, friction and acceleration in a mechanical system.	Recommended Application/Activity	CCSS Standards	CCTC Standards
2.1.1 Describe practical application of mechanical advantage.	•		
2.1.2 Explain how mechanical systems require the increase or decrease in force.	•		
2.1.3 Demonstrate the use of torque in a mechanical device.	•		
2.1.4 Demonstrate methods by which friction can be decreased or increased.	•		
2.1.5 Demonstrate the use of bearings in mechanical systems.	•		
2.1.6 Explain why processing time is critical in			

industrial manufacturing.			
2.1.7 Explain how energy cannot be created, however it can be converted from one form to another.	<ul style="list-style-type: none"> • 		
2.1.8 Explain potential and kinetic energy and demonstrate its practical application.	<ul style="list-style-type: none"> • 		
Performance Indicator 2.2 Identify and demonstrate an understanding of the application of industrial motors controls.	Recommended Application/Activity 26202-14	CCSS Standards	CCTC Standards
2.2.1 Explain how RPM, torque and horsepower effect mechanical output.	Define the following terms: <ul style="list-style-type: none"> • Controller • Duty cycle • Full-load amps • Interrupting rating • Thermal protection • NEMA design letter • Overcurrent • Overload • Power factor • Rated full-load speed • Rated horsepower • Service factor 		
2.2.2 Describe the various types of motor enclosures.	<ul style="list-style-type: none"> • Collect data from a motor nameplate. 		
2.2.3 Explain the relationships among speed, frequency, and the number of poles in a three-phase induction motor.	<ul style="list-style-type: none"> • Identify various types of motors and their application(s). 		
2.2.4 Define percent slip and speed regulation.	<ul style="list-style-type: none"> • 		
2.2.5 Explain how the direction of a three-phase motor is changed.	<ul style="list-style-type: none"> • 		
2.2.6 Describe the component parts and operating characteristics of a three-phase wound-rotor induction motor.	<ul style="list-style-type: none"> • Connect the terminals for a dual-voltage motor. 		
2.2.7 Describe the component parts and operating	<ul style="list-style-type: none"> • 		

characteristics of a three-phase synchronous motor.			
2.2.8 Describe the design and operating characteristics of various DC motors.	•		
2.2.9 Describe the methods for determining various motor connections.	•		
2.2.10 Describe general motor protection requirements as delineated in the National Electrical Code® (NEC®).	•		
2.2.11 Define the braking requirements for AC and DC motors.	• Demonstrate how gears can be used to change torque and speed.		
Performance Indicator 2.3 Identify and demonstrate an understanding of motor controls.	Recommended Application/Activity 26311-14	CCSS Standards	CCTC Standards
2.3.1 Identify contactors and relays both physically and schematically and describe their operating principles.	•		
2.3.2 Identify pilot devices both physically and schematically and describe their operating principles.	•		
2.3.3 Interpret motor control wiring, connection, and ladder diagrams.	<ul style="list-style-type: none"> • Select and size contactors and relays for use in specific electrical motor control systems • Select and size pilot devices for use in specific electrical motor control systems. 		
2.3.4 Connect motor controllers for specific applications according to National Electrical Code (NEC®) requirements.	• Make all connections for a magnetic motor controller, controlled by two pushbutton stations, including the connections for holding the circuit interlock.		

Standard 3.0 Demonstrate an understanding of the fundamental concepts of control systems			
Performance Indicator 3.1 Identify and demonstrate an understanding of control systems.	Recommended Application/Activity 26211-14	CCSS Standards	CCTC Standards
3.1.1 Describe the operating principles of contactors and relays.	<ul style="list-style-type: none"> Select contactors and relays for use in specific electrical systems. 		
3.1.2 Explain how mechanical contactors operate.	<ul style="list-style-type: none"> 		
3.1.3 Explain how solid-state contactors operate.	<ul style="list-style-type: none"> 		
3.1.4 Install contactors and relays according to the NEC® requirements.	<ul style="list-style-type: none"> Mount and connect a 120V lighting contactor with a three-wire pushbutton control. Select and install contactors and relays for lighting control. 		
3.1.5 Read wiring diagrams involving contactors and relays.	<ul style="list-style-type: none"> 		
3.1.6 Describe how overload relays operate.	<ul style="list-style-type: none"> Connect and test a simple control circuit. 		
Performance Indicator 3.2 Identify and demonstrate an understanding of programmable logic controllers.	Recommended Application/Activity 12406-03	CCSS Standards	CCTC Standards
3.2.1 Describe the function and purpose of a programmable logic controller (PLC).	<ul style="list-style-type: none"> Compare hardwired and PLC systems. 		
3.2.2 Explain the purpose of binary codes.	<ul style="list-style-type: none"> Count and convert between number systems. 		
3.2.3 Describe the purpose of the various power supplies used within a PLC.	<ul style="list-style-type: none"> 		
3.2.4 Explain the general function of an input/output (I/O) module, including the following types: <ul style="list-style-type: none"> Discrete Numerical data Special Remote 	<ul style="list-style-type: none"> 		
3.2.5 Explain the power supply and ground connections to I/O modules.	<ul style="list-style-type: none"> State the function of the PLC processor module. 		
3.2.6 Explain the interrelations between the various	<ul style="list-style-type: none"> State the characteristics of various types of memory. 		

microprocessor components.			
3.2.7 Describe the characteristics and features of a PLC processor module.	•		
3.2.8 Explain the purpose of PLC software and firmware.	•		
3.2.9 Describe the features and the differences between PLC programming languages.	•		
3.2.10 Describe the features of relay ladder logic instruction categories.	•		
3.2.11 Explain the principles used to correlate PLC hardware components to software instructions.	• Program and install a PLC.		
Performance Indicator 3.3 Identify and demonstrate an understanding of conductor terminations and splices.	Recommended Application/Activity 26208-14	CCSS Standards	CCTC Standards
3.3.1 Describe how to make a good conductor termination.	<ul style="list-style-type: none"> • Prepare cable ends for terminations and splices. • Install lugs and connectors onto conductors. • Train cable at termination points. 		
3.3.2 Explain the role of the NEC® in making cable terminations and splices.	•		
3.3.3 Explain why mechanical stress should be avoided at cable termination points.	•		
3.3.4 Describe the importance of using proper bolt torque when bolting lugs onto busbars.	•		
3.3.5 Describe crimping and splicing techniques.	• Select the proper lug or connector for the job.		
3.3.6 Describe the installation rules for parallel conductors.	• Explain how to use hand and power crimping tools.		

Standard 4.0 Demonstrate an understanding of basic hydraulic pneumatic systems			
Performance Indicator 4.1 Identify and demonstrate an understanding of basic pneumatic systems.	Recommended Application/Activity 15407-08/15408-08	CCSS Standards	CCTC Standards
4.1.1 Explain compressed-air treatment.	•		
4.1.2 Identify and explain pneumatic system components and symbols.	• Identify at least four components of basic pneumatic equipment.		
4.1.3 Explain the properties of pneumatic solids, liquids and gases.	•		
4.1.4 Explain the differences between hydraulic and pneumatic power.	•		
Performance Indicator 4.2 Identify and demonstrate an understanding of basic hydraulic systems.	Recommended Application/Activity 15409-08	CCSS Standards	CCTC Standards
4.2.1 Explain hydraulic system safety.	•		
4.2.2 Explain the principles of hydraulics and power transmission.	•		
4.2.3 Identify and explain hydraulic fluids and lubricants.	• Identify at least four hydraulic system components.		
4.2.4 Explain the purpose of packing and seals.	•		
4.2.5 Identify and explain system parts, pumps and motors.	•		
4.2.6 Demonstrate understanding of pressure and force in a fluid power cylinder.	•		

Common Core State Standards Grades 11-12

ELA Speaking and Listening Standards Grades 11-12

1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL11-12.1**
 - a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. **SL11-12.1a**
 - b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. **SL11-12.1b**
 - c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. **SL11-12.1c**
 - d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. **SL11-12.1d**
2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. **SL11-12.2**
3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. **SL11-12.3**
4. Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. **SL11-12.4**
5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. **SL11-12.5**

ELA Language Grades 9-10

ELA Language Grades 11-12

4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 11–12 reading and content, choosing flexibly from a range of strategies. **L11-12.4**
 - a. Use context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence) as a clue to the meaning of a word or phrase. **L11-12.4a**

- b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., conceive, conception, conceivable). **L11-12.4b**
 - c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, its etymology, or its standard usage. **L11-12.4c**
 - d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary) **L11-12.4d**
6. Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. **L11-12.6**

Reading Standards for Literacy in Science and Technical Subjects Grades 11-12

1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **R11-12.1**
2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. **R11-12.2**
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. **R11-12.3**
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. **R11-12.4**
5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. **R11-12.5**
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. **R11-12.6**
7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. **R11-12.7**
8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **R11-12.8**
9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **R11-12.9**
10. By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently. **R11-12.10**

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects Grades 11-12

1. Write arguments focused on discipline-specific content. **W11-12.1**

- a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. **W11-12.1a**
 - b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. **W11-12.1b**
 - c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. **W11-12.1c**
 - d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. **W11-12.1d**
 - e. Provide a concluding statement or section that follows from or supports the argument presented. **W11-12.1e**
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. **W11-12.2**
 - a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. **W11-12.2a**
 - b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. **W11-12.2b**
 - c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. **W11-12.2c**
 - d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. **W11-12.2d**
 - e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic). **W11-12.2e**
 3. Write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work that others can replicate them and (possibly) reach the same results. **W11-12.3**
 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. **W11-12.4**
 5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **W11-12.5**
 6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information. **W11-12.6**

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **W11-12.7**
8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **W11-12.8**
9. Draw evidence from informational texts to support analysis, reflection, and research. **W11-12.9**
10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. **W11-12.10**

Common Career and Technical Core Standards

Manufacturing Career Cluster

Manufacturing Career Cluster Standards (MN)

1. Evaluate the nature and scope of the Manufacturing Career Cluster and the role of manufacturing in society and in the economy. **MN1**
2. Analyze and summarize how manufacturing businesses improve performance. **MN2**
3. Comply with federal, state, and local regulations to ensure worker safety and health and environmental work practices. **MN3**
4. Describe career opportunities and the means to achieve those opportunities in each Manufacturing Career Pathways. **MN4**
5. Describe government policies and industry standards that apply to manufacturing. **MN5**
6. Demonstrate workplace knowledge and skills common to manufacturing. **MN6**

Maintenance, Installation and Repair Career Pathway (MN-MIR)

1. Demonstrate maintenance skills and proficient operation of equipment to maximize manufacturing performance. **MN-MIR1**
2. Demonstrate the safe use of manufacturing equipment to ensure a safe and healthy environment. **MN-MIR2**
3. Diagnose equipment problems and effectively repair manufacturing equipment. **MN-MIR3**
4. Investigate and employ techniques to maximize equipment performance. **MN-MIR4**
5. Implement a preventative maintenance schedule to maintain manufacturing equipment, tools, and workstations. **MN-MIR5**
6. Implement an effective, predictive, and preventive manufacturing equipment maintenance program. **MN-MIR6**

Production Career Pathway (MN-PRO)

1. Diagnose production process problems and take corrective action to meet production quality standards. **MN-PRO1**
2. Manage safe and healthy production working conditions and environmental risks. **MN-PRO2**

3. Make continuous improvement recommendations based on results of production process audits and inspections. **MN-PRO3**
4. Coordinate work teams when producing products to enhance production process and performance. **MN-PRO4**
5. Demonstrate the safe use of manufacturing equipment. **MN-PRO5**

Career Ready Practices

1. Act as a responsible citizen in the workplace and the community. (CRP1)
2. Apply appropriate technical skills and academic knowledge. (CRP2)
3. Practice personal health and understand financial literacy. (CRP3)
4. Communicate clearly, effectively, and with reason. (CRP4)
5. Understand the environmental, social, and economic impacts of decisions. (CRP5)
6. Demonstrate creativity and innovation. (CRP6)
7. Employ valid and reliable research strategies. (CRP7)
8. Utilize critical thinking to make sense of problems and persevere in solving them. (CRP8)
9. Model integrity, ethical leadership, and effective management. (CRP9)
10. Develop an education and career plan aligned to personal goals. (CRP10)
11. Apply technology to enhance productivity. (CRP11)
12. Work productively in teams while integrating cultural/global competence. (CRP12)