Robotics and Mechatronics II - AES

Level: 4
Career Cluster: Advanced Manufacturing
Program: Engineering
Pathway(s): Aerospace Engineering Technician

Course Catalog Description

Students design, build, program, and troubleshoot robotic systems with a focus on aerospace applications such as unmanned aerial systems, inspection robotics, autonomous vehicles, satellite subsystems, and aerospace automation. Students apply safety practices, engineering design, and technical skills while exploring careers in aerospace engineering technology.

Summary

Aerospace Robotics and Mechatronics II is an advanced engineering course in which students explore career pathways in aerospace engineering technology while developing professional, technical, and problem-solving skills. Students apply advanced safety practices as they analyze, design, build, and test integrated robotic and mechatronic systems that combine mechanical, electrical, pneumatic, hydraulic, sensing, and control components. Through hands-on projects, students investigate system architecture, motion systems, circuits, sensors, actuators, avionics-inspired controls, and fluid power applications to understand how complex aerospace and automated systems function. Students develop and refine programming and control logic to operate robotic systems used in aerospace contexts such as drones, autonomous inspection platforms, and robotic manipulators; collect and analyze performance data; and optimize system efficiency, reliability, and precision. Using structured troubleshooting methods, students diagnose faults, implement corrective actions, and improve overall system performance. The course culminates in an engineering design project in which students design, construct, evaluate, and present a robotic or mechatronic solution for an aerospace-related challenge using technical evidence and effective communication.

Notes

The updated course reflects a shift from a primarily technical, component-focused curriculum to a more comprehensive, systems-based and industry-aligned engineering program. The original course emphasized foundational skills such as basic robotics components, circuits, programming, and mechanical systems, with a focus on individual subsystems and technical operation. In contrast, the revised course expands these concepts into a cohesive framework that emphasizes integrated system design, data-driven analysis, advanced troubleshooting, and optimization of complex robotic and mechatronic systems. Additionally, the new version incorporates aerospace applications, structured engineering design projects, leadership, and work-based learning, along with a stronger focus on technical communication and real-world problem solving. These updates improve alignment with current CTE expectations by emphasizing system integration, career readiness, and applied engineering practices while maintaining core robotics competencies.

Student Learning Outcomes

1. Career Exploration and Postsecondary Opportunities

Objective: *Students will analyze career pathways in aerospace engineering technician by exploring industry roles, workplace expectations, required education, certifications, professional organizations, and postsecondary opportunities available in Colorado in order to make informed academic and career decisions.*

1) Identify employment opportunities in various fields with a focus in the area of aerospace engineering technician
    a. Recognize the work typically performed, tools and technology used, and nature of work environments
    b. Identify potential certifications within the careers
    c. Find membership organizations associated with the careers
    d. Understand the necessary education associated within the careers
2) Define professionalism within the context of aerospace engineering technician
    a. Criticism and evaluation
    b. Presentation
    c. Assessment
3) Recognize laws, regulations, and ethics significant to the fields of aerospace engineering technician
4) Identify postsecondary opportunities offered in the state of Colorado
    a. Technical college, community college, 4-year institutions
    b. Certificates, associates, bachelor, and advanced degree opportunities

2. Safety and Advanced Lab Practices

Objective: *Students will apply advanced safety procedures in order to ensure safe operation when working with robotic, mechatronic, and aerospace-related systems.*

5) Interpret safety standards for electrical, pneumatic, hydraulic, and aerospace laboratory systems
6) Apply proper tool usage, PPE, and safe lab procedures for fabrication, assembly, and testing
7) Analyze risks associated with high-pressure systems, moving components, propellers, and powered aerospace platforms
8) Evaluate lab and test environments for compliance with safety standards and mission requirements

3. Mechatronic System Architecture and Integration

Objective: *Students will analyze the structure of mechatronic systems in order to explain interactions among mechanical, electrical, control, and aerospace subsystems.*

9) Identify subsystems (input, processing, output, feedback) in robotic and aerospace systems
10) Explain system interactions, signal flow, and energy flow across integrated platforms
11) Analyze system performance based on inputs, outputs, and mission constraints
12) Evaluate advantages and limitations of integrated systems used in aerospace applications

4. Mechanical Design and Motion Systems

Objective: *Students will apply mechanical principles to design and analyze motion systems used in robotic and aerospace applications.*

13) Identify mechanical components such as gears, linkages, frames, and structures used in robotic and aerospace systems
14) Analyze force, motion, torque, balance, and load relationships
15) Construct mechanical systems for defined motion or positioning tasks
16) Evaluate system efficiency, performance, and structural reliability

5. Electrical Systems and Circuit Integration

Objective: *Students will construct and analyze electrical systems in order to support robotic control, avionics-inspired functions, and system operation.*

17) Design circuits for robotic and aerospace-related applications
18) Analyze circuit behavior using measurements, calculations, and test data
19) Integrate electrical components into robotic, sensing, and control systems
20) Evaluate circuit performance, reliability, and signal integrity

6. Sensors, Data Acquisition, and Feedback Systems

Objective: *Students will analyze sensor systems to interpret data and improve robotic and aerospace system performance.*

21) Identify various sensors and their functions in robotics and aerospace platforms
22) Analyze how sensors convert physical inputs into usable data
23) Integrate sensors into robotic, autonomous, or monitoring systems
24) Evaluate sensor accuracy, reliability, responsiveness, and effectiveness

7. Actuators, Motion Control, and Output Systems

Objective: *Students will apply actuator principles to control system outputs and motion in robotic and aerospace systems.*

25) Compare different actuator types and applications across robotic and aerospace systems
26) Explain how actuators convert energy into controlled motion
27) Integrate actuators into robotic control systems and automated mechanisms
28) Evaluate actuator performance based on precision, efficiency, and response

8. Fluid Power Systems, Pneumatics, and Hydraulics

Objective: *Students will analyze fluid power systems in order to design and evaluate pneumatic and hydraulic control applications.*

29) Identify components such as valves, cylinders, and regulators
30) Explain fluid power principles and energy transfer
31) Construct simple pneumatic or hydraulic systems
32) Evaluate system performance and efficiency

9. Programming and Automated Control Systems

Objective: *Students will develop and implement control logic to operate robotic systems effectively in aerospace and automated environments.*

33) Design control algorithms using logical structures and mission requirements
34) Program robotic systems using appropriate platforms and interfaces
35) Analyze system response to programmed inputs and environmental conditions
36) Modify code to optimize performance, stability, and accuracy

10. Robotics Systems Integration and Automation

Objective: *Students will synthesize system components to design fully integrated robotic systems for aerospace-related applications.*

37) Combine mechanical, electrical, sensing, and control components into integrated systems
38) Design automated systems to perform complex aerospace-related tasks
39) Construct functional robotic systems based on requirements and mission criteria
40) Evaluate system functionality, efficiency, and operational readiness

11. System Testing, Data Analysis, and Optimization

Objective: *Students will analyze system performance data in order to optimize robotic and aerospace system functionality.*

41) Collect and interpret system performance data
42) Analyze system behavior under different operating conditions and constraints
43) Identify inefficiencies, instability, and errors
44) Evaluate improvements to system performance, reliability, and precision

12. Troubleshooting, Diagnostics, and System Improvement

Objective: *Students will diagnose system faults and implement solutions using structured troubleshooting methods in robotic and aerospace contexts.*

45) Identify mechanical, electrical, sensor, and programming faults
46) Apply troubleshooting procedures to isolate problems systematically
47) Analyze root causes of system failure in test and mission scenarios
48) Implement corrective actions and validate solutions through retesting

13. Engineering Design Project and Technical Communication

Objective: *Students will design, build, and present a robotic or mechatronic system to demonstrate mastery of concepts through an aerospace-related engineering challenge.*

49) Design a robotic or mechatronic system to solve a defined aerospace-related problem
50) Construct and integrate system components
51) Test and refine system performance against design criteria
52) Present design decisions using technical evidence and aerospace context
53) Evaluate system effectiveness and reflect on learning

14. Leadership

Objective: *Students will demonstrate leadership skills in order to collaborate effectively, take initiative, and contribute to successful team performance in classroom, CTSO, and project-based settings.*

54) Demonstrate leadership skills through initiative, accountability, and ethical decision-making in technical and collaborative settings
55) Collaborate effectively in teams by contributing ideas, listening actively, and supporting shared goals
56) Apply communication, organization, and problem-solving skills during classroom, laboratory, and CTSO experiences
57) Evaluate personal leadership growth and team contributions through reflection and feedback

15. Work-Based Learning

Objective: *Students will participate in work-based learning experiences in order to apply technical and professional skills in authentic industry and career-connected contexts.*

58) Participate in work-based learning experiences such as industry engagement, job shadows, mentorships, internships, or workplace tasks
59) Apply technical knowledge, safety practices, and professional behaviors in authentic workplace or career-connected environments
60) Analyze workplace expectations including communication, teamwork, time management, and adaptability
61) Evaluate the relationship between classroom learning, technical skill development, and career readiness

16. Final Assessment Project

Objective: *Students will complete a final assessment project in order to demonstrate cumulative understanding of course concepts, technical skills, problem solving, and communication.*

62) Plan and complete a final assessment project that demonstrates mastery of course knowledge and technical skills
63) Apply the engineering design process, troubleshooting strategies, and data-informed decision-making throughout project development
64) Present project goals, processes, outcomes, and evidence of learning using clear technical communication
65) Evaluate project effectiveness, reflect on performance, and identify areas for future improvement

17. Career and Technical Student Organizations

Objective: *Using the CTSO Resource Document, chapter activities will provide some of the best opportunities CTSO members will have to learn by doing. A successful program of work creates a positive learning atmosphere in the classroom. CTSO members learn how to accept responsibility, work as a team, manage a budget, and handle success and failure. Per the CTE Admin Handbook, CTSOs are embedded into curriculum.*

Professional Development

Prepare each member for entry into the workforce and provide a foundation for success in a career. Becoming a professional does not stop with acquiring a skill, but involves an increased awareness of the meaning of good citizenship and the importance of labor and management in the world of work.

Community Service

Promote and improve goodwill and understanding among all segments of the community through services donated by CTSO chapters, and to instill in its members a lifetime commitment to community service.

Business and Industry Connections

Increase awareness of quality job practices and attitudes, and increase the opportunities for employer engagement and eventual employment.

Financial Leadership

Plan and participate in activities to allow all members to carry out the chapter's projects. Educate members on their own personal finance for current and future success.

Public Relations

Make the general public aware of the good work that students in career and technical education are doing to better themselves and their community, state, nation, and world.

Social Activities

To increase cooperation in the school and community through activities that allow CTSO members to get to know each other in something other than a business or classroom setting.

Academic Standards Alignment

Colorado CTE courses are required to integrate academic and essential skills into course content. The following academic standards have been identified as aligned to this course and should be integrated throughout instruction.

CO CTE Academic Standards Resources (Rubrics, integration strategies, etc)
CDE Colorado Academic Standards Online (Online standards lookup tool)

Note: Mathematics and Science standards will be added in the future. Visit the Colorado Academic Standards page for the most current version.

Reading, Writing and Communicating Crosswalk

Course: Aerospace Robotics and Mechatronics II
Colorado Academic Standards – Reading, Writing, and Communicating

Standard	Prepared Graduate Competency	Description	Course Evidence / Alignment
Standard 1: Oral Expression and Listening	Prepared Graduate 1 – Collaboration	Collaborate effectively as group members or leaders.	Students work collaboratively on advanced robotic and mechatronic system integration projects by coordinating roles, timelines, and responsibilities within engineering teams and by listening to, evaluating, and incorporating peer feedback during the design, testing, and refinement of aerospace-related systems.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences and varied purposes.	Students present system designs, control strategies, and performance outcomes while explaining troubleshooting decisions and optimization choices

			and communicating technical concepts related to aerospace robotics, automation, and mechatronic systems to peers, instructors, and industry-style audiences.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts to build knowledge.	Students read and interpret advanced technical manuals, schematics, control documentation, and robotics guides; analyze informational texts related to sensors, actuators, avionics-inspired systems, and system integration; and apply safety standards and industry documentation relevant to advanced mechatronics and aerospace labs.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts.	Students use domain-specific language from electronics, robotics, controls, and aerospace systems precisely, interpret symbolic, numeric, procedural, and coded technical language, and adapt language for documentation, safety, presentations, and debugging contexts.
Standard 3: Writing and Composition	Prepared Graduate 6 – Craft arguments	Craft arguments using techniques specific to the genre.	Students justify system architecture, control logic, and component choices;

			defend troubleshooting and optimization decisions using data and constraints; and support conclusions with evidence from tests, diagnostics, and system performance in robotic and aerospace-related applications.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- O NET Online (careers robotics automation engineering technician pathways) https://www.onetonline.org/
- My Next Move (career exploration robotics engineering and manufacturing) https://www.mynextmove.org/
- CareerOneStop (training certifications advanced manufacturing careers) https://www.careeronestop.org/
- CCCS Career Advising (Colorado postsecondary engineering pathways planning) https://cccs.edu/career-advising/

2. Safety and Advanced Lab Practices

- OSHA (robotics lab safety electrical pneumatic hydraulic hazards) https://www.osha.gov/
- CDC NIOSH (workplace safety engineering hazard prevention) https://www.cdc.gov/niosh/
- Tool Box Talks (industrial lab safety procedures training) https://www.toolbox-talks.com/
- Robotics Industry Association (robot safety standards industrial automation) https://www.robotics.org/

3. Mechatronic System Architecture and Integration

- Teach Engineering (mechatronics systems integration engineering concepts) https://www.teachengineering.org/
- MIT OpenCourseWare Systems (systems engineering integration robotics concepts) https://ocw.mit.edu/
- Carnegie Mellon Robotics Academy (robotic systems components integration) https://www.cmu.edu/roboticsacademy/
- FIRST Robotics Resources (systems integration robotics design applications) https://www.firstinspires.org/

4. Mechanical Design and Motion Systems

- Learn Engineering YouTube (mechanical systems gears motion robotics explanation) https://www.youtube.com/@LearnEngineering
- Khan Academy Mechanics (forces motion torque fundamentals engineering) https://www.khanacademy.org/science/physics
- Teach Engineering Mechanical Systems (mechanisms robotics structures motion) https://www.teachengineering.org/
- BBC Bitesize Forces (mechanical motion systems engineering basics) https://www.bbc.co.uk/bitesize

5. Electrical Systems and Circuit Integration

- All About Circuits (electrical circuits robotics integration electronics fundamentals) https://www.allaboutcircuits.com/

- SparkFun Learn (electronics circuits robotics system applications)
  https://learn.sparkfun.com/
- Arduino Education (electronics robotics control systems integration)
  https://www.arduino.cc/education
- Khan Academy Circuits (voltage current circuit analysis basics)
  https://www.khanacademy.org/science/electrical-engineering

6. Sensors, Data Acquisition, and Feedback Systems

- SparkFun Sensors Guide (sensors robotics data acquisition feedback systems)
  https://learn.sparkfun.com/
- Adafruit Learning System (sensor integration robotics data collection projects)
  https://learn.adafruit.com/
- Arduino Sensor Tutorials (sensor data input robotics control systems)
  https://www.arduino.cc/
- Carnegie Mellon Robotics Academy Sensors (sensor feedback robotics systems)
  https://www.cmu.edu/roboticsacademy/

7. Actuators, Motion Control, and Output Systems

- Arduino Motors and Actuators (motor control robotics actuator systems)
  https://www.arduino.cc/
- Learn Engineering Motors (actuators motor control system explanation)
  https://www.youtube.com/@LearnEngineering
- Electronics Tutorials Motors (electromechanical actuators components basics)
  https://www.electronics-tutorials.ws/
- Robotics Academy Actuators (actuators robotics motion control applications)
  https://www.cmu.edu/roboticsacademy/

8. Fluid Power Systems, Pneumatics, and Hydraulics

- Festo Learning (pneumatics hydraulics industrial automation systems)
  https://www.festo.com/
- Hydraulic Supermarket (hydraulic systems components fluid power basics)
  https://www.hydraulicsupermarket.com/
- Engineering Toolbox Fluids (fluid power hydraulics engineering principles)
  https://www.engineeringtoolbox.com/
- Parker Hannifin Resources (pneumatics hydraulics motion control systems)
  https://www.parker.com/

9. Programming and Automated Control Systems

- Arduino Programming (robotics programming control systems coding)
  https://www.arduino.cc/
- Khan Academy Programming (coding logic loops conditionals robotics control)
  https://www.khanacademy.org/computing
- Scratch Robotics (intro robotics programming control logic systems)
  https://scratch.mit.edu/

- Carnegie Mellon Robotics Coding (robot programming control systems basics) https://www.cmu.edu/roboticsacademy/

10. Robotics Systems Integration and Automation

- FIRST Robotics Resources (robotics automation system integration design) https://www.firstinspires.org/
- MIT OpenCourseWare Robotics (robotics systems integration automation concepts) https://ocw.mit.edu/
- Siemens Automation (industrial automation system integration robotics) https://www.siemens.com/
- ABB Robotics Education (industrial robotics automation systems training) https://new.abb.com/products/robotics

11. System Testing, Data Analysis, and Optimization

- National Instruments LabVIEW (data acquisition system testing analysis tools) https://www.ni.com/
- Tektronix Education (measurement systems testing signal analysis) https://www.tek.com/en/education
- Keysight Learn (electronic testing data analysis systems) https://www.keysight.com/us/en/learn.html
- Engineering Toolbox Data (engineering data analysis and measurement tools) https://www.engineeringtoolbox.com/

12. Troubleshooting, Diagnostics, and System Improvement

- iFixit (troubleshooting diagnostics repair methodology systems) https://www.ifixit.com/
- Fluke Learn (electrical troubleshooting measurement diagnostics tools) https://www.fluke.com/en-us/learn
- All About Circuits Troubleshooting (circuit diagnostics fault analysis robotics systems) https://www.allaboutcircuits.com/
- Engineering Toolbox Troubleshooting (engineering problem solving systems analysis) https://www.engineeringtoolbox.com/

13. Engineering Design Project and Technical Communication

- Instructables Projects (robotics design build engineering projects ideas) https://www.instructables.com/
- Maker Ed (project based learning robotics engineering design) https://makered.org/
- MIT OpenCourseWare Projects (engineering design applications robotics systems) https://ocw.mit.edu/
- Purdue OWL Technical Writing (technical communication engineering documentation) https://owl.purdue.edu/

14. Leadership

- PBLWorks Projects and Resources (project based learning teamwork collaboration reflection) https://www.pblworks.org/resources-overview
- Northeastern Center for Advancing Teaching and Learning Through Research (student team projects teamwork communication collaboration) https://learning.northeastern.edu/successful-student-team-projects/
- American University EdSpace (supporting effective group projects teamwork leadership) https://edspace.american.edu/cfe/supporting-effective-group-projects-and-teamwork/
- MIT Open Learning (design thinking leading and learning classroom leadership) https://openlearning.mit.edu/news/free-mit-courses-and-resources-help-k-12-teachers-make-school-year-success

15. Work-Based Learning

- CareerOneStop GetMyFuture (career readiness work experience job search training) https://www.careeronestop.org/GetMyFuture/default.aspx
- Chicago Public Schools Work-Based Learning Toolkit (job shadow internship mentorship career day resources) https://www.cps.edu/academics/work-based-learning/toolkit/
- Forage Virtual Internship Simulations (career exploration virtual internships employability skills) https://career.berkeley.edu/resources-on-demand/forage-virtual-internship-simulations/
- Apprenticeships.org (youth apprenticeship work based learning career pathways) https://apprenticeships.org/

16. Final Assessment Project

- University of Colorado Boulder Center for Teaching and Learning Rubrics (assessment rubrics project evaluation feedback) https://www.colorado.edu/center/teaching-learning/teaching-resources/assessment/assessing-student-learning/rubrics
- PBLWorks Projects and Resources (project based learning rubrics project planning presentation) https://www.pblworks.org/resources-overview
- University of Delaware CTAL Rubrics (oral communication teamwork written communication rubric templates) https://ctal.udel.edu/resources-2/rubrics/
- Engineering Design Process Portfolio Scoring Rubric (engineering design project reflection presentation evaluation) https://academic.cpp.edu/senate/docs/GE009167ref_7.pdf

Technology Student Association – National Competitive Events

Robotics

Objective: *Students will design, build, test, operate, document, and explain a robot that completes the annual TSA Robotics challenge within competition requirements.*

- Analyze the annual TSA Robotics challenge and identify required tasks, constraints, safety considerations, and scoring criteria.
- Design and construct a robot that integrates mechanical, electrical, control, and structural systems.
- Program or configure the robot to complete required challenge tasks.
- Test robot performance before competition and make adjustments to improve reliability, control, and task completion.
- Operate the robot during the timed challenge while following TSA event procedures.
- Document the robot's design, construction, testing, revisions, and team problem-solving process.
- Participate in a team interview explaining robot systems, design decisions, programming or control strategies, and performance results.

Resources

- Technology Student Association – Robotics competition guidelines
  https://tsaweb.org/competitions-programs/tsa/themes-problems
- VEX Robotics STEM Labs
  https://education.vex.com/
- Arduino Education – Robotics and electronics resources
  https://www.arduino.cc/education
- FIRST Robotics Resource Library
  https://www.firstinspires.org/resource-library

Technology Student Association – National Competitive Events

System Control Technology

Objective: *Students will design, construct, program, troubleshoot, document, and demonstrate a working control-system solution that responds to a TSA-provided problem.*

- Interpret the TSA-provided control-system problem and identify the required functions, constraints, and performance goals.
- Design a system that uses inputs, outputs, circuits, sensors, motors, controls, feedback, or programmable components.
- Create a program or control sequence that allows the system to operate as intended.
- Construct and test the system using approved materials, tools, electronics, and safety procedures.
- Troubleshoot mechanical, electrical, sensor, programming, pneumatic, hydraulic, or feedback-loop issues to improve system performance.
- Maintain an inventor's log documenting design decisions, testing, revisions, and final system operation.
- Demonstrate the completed system and explain how the design meets the problem criteria during judge evaluation.

Resources

- Technology Student Association – System Control Technology competition guidelines
  https://tsaweb.org/competitions-programs/tsa/themes-problems
- Arduino Education – Electronics and control systems
  https://www.arduino.cc/education
- VEX Robotics STEM Labs – Mechanisms, sensors, and programming
  https://education.vex.com/
- Tinkercad Circuits – Circuit simulation and prototyping
  https://www.tinkercad.com/circuits

Technology Student Association – National Competitive Events

Animatronics

Objective: *Students will design, construct, control, document, and present an animatronic device that meets TSA requirements for movement, control technology, lights, sound, sensors, and mechanical systems.*

- Research the annual TSA Animatronics theme and develop an original animatronic concept.
- Design an animatronic device that integrates structure, motion, control, and presentation elements.
- Construct an exterior shell or skin that can be removed to show internal components to judges.
- Incorporate multiple movements using mechanisms such as linkages, gearing, cabling, fluid power, or related systems.
- Integrate control technology, sensors, lights, sound, motors, or electronic components into the animatronic model.
- Test and troubleshoot the device for reliable operation, safe power use, appropriate movement, and presentation readiness.
- Present the animatronic device and explain the design process, internal components, control system, and final performance.

Resources

- Technology Student Association – Animatronics competition guidelines
  https://tsaweb.org/competitions-programs/tsa/themes-problems
- Arduino Education – Sensors, lights, and control systems
  https://www.arduino.cc/education
- Adafruit Learning System – Electronics, LEDs, sensors, and microcontrollers
  https://learn.adafruit.com/
- Instructables Circuits – Electronics and animatronics project examples
  https://www.instructables.com/circuits/