Robotics and Mechatronics I - AES

Level: 3
Career Cluster: Advanced Manufacturing
Program: Engineering
Pathway(s): Aerospace Engineering Technician

Course Catalog Description

Introduces foundational robotics and mechatronics concepts through hands-on work with mechanical, electrical, and programming systems in aerospace contexts. Students apply the engineering design process to build, test, and troubleshoot robotic systems with connections to avionics, unmanned aircraft systems, automation, and space-related applications.

Summary

Introduces students to the foundational concepts, tools, and practices used in modern robotic and automated systems while preparing them for continued study and careers in aerospace engineering technician and related fields. Through hands-on learning, students explore career pathways, workplace expectations, professionalism, ethics, and postsecondary opportunities in Colorado with attention to aerospace and advanced technology sectors. The course emphasizes safe engineering laboratory practices and the application of the engineering design process to solve robotics and automation challenges relevant to aircraft systems, unmanned aerial vehicles, spacecraft support technologies, and precision automated equipment. Students examine how mechanical systems, electrical circuits, sensors, actuators, embedded control devices, and programming logic work together within mechatronic systems, and they evaluate how these components support performance, reliability, and safety in aerospace applications. As they design, build, test, troubleshoot, and refine integrated robotic systems, students also strengthen technical documentation, communication, and problem-solving skills. The course culminates in a final design-build project in which students create and present a functional robotic or automated system inspired by an aerospace challenge and demonstrating their understanding of foundational mechatronics concepts.

Notes

This updated version strengthens alignment to the Aerospace Engineering Technician pathway and shifts the emphasis from a broad manufacturing automation survey to a more clearly sequenced robotics and mechatronics course with aerospace applications. The revised course adds stronger focus on engineering design, integrated systems, technical documentation, troubleshooting, leadership, and work-based learning, while also making the student outcomes more explicit and instructionally organized. It further increases attention to career exploration, professionalism, Colorado postsecondary opportunities, and authentic project experiences that connect mechanical, electrical, sensor, actuator, and programming concepts to real aerospace contexts.

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. Foundations of Robotics, Mechatronic Systems, and Aerospace Applications

Objective: *Students will analyze the structure and purpose of mechatronic systems in order to explain how mechanical, electrical, and computational components work together in robotic, automated, and aerospace systems.*

5) Define robotics and mechatronics and their relationship to engineering and aerospace systems
6) Identify the core components of a mechatronic system including sensors, actuators, controllers, and structures
8) Classify common applications of robotics in industry, transportation, aerospace, and daily life
8) Classify common applications of robotics in industry, transportation, and daily life
9) Analyze system inputs, processes, and outputs in simple robotic systems
10) Evaluate the advantages and limitations of automated systems

3. Safety Tools and Engineering Laboratory Practices

Objective: *Students will apply safe work practices and proper tool use to minimize risk while working with robotics, mechatronic systems, and aerospace-related equipment and environments.*

11) Interpret safety procedures related to electrical, mechanical, automated, and aerospace systems
12) Demonstrate proper use of tools, equipment, and lab materials

13) Apply personal protective equipment and safe workspace organization
14) Identify hazards associated with robotics systems including moving parts, electrical risks, and mission-critical system failures in aerospace environments
15) Analyze unsafe conditions and propose appropriate corrective actions
16) Evaluate lab work for adherence to safety standards and procedures

4. Engineering Design Process, Problem Solving, and Aerospace Challenges

Objective: *Students will apply the engineering design process to develop and refine solutions to robotics, automation, and aerospace engineering challenges.*

17) Define steps of the engineering design process including problem identification, ideation, prototyping, and testing
18) Develop multiple design solutions to a given engineering challenge
19) Construct prototypes based on defined criteria and constraints
20) Analyze test results to determine design effectiveness
21) Revise designs based on feedback and data
22) Evaluate solutions based on performance, efficiency, and feasibility

5. Mechanical Systems and Structural Design

Objective: *Students will apply mechanical principles to design and construct structures and motion systems for robotic and aerospace applications.*

23) Identify mechanical components such as gears, linkages, levers, and structural elements
24) Explain how mechanical systems create motion and transfer force
25) Construct mechanical assemblies that achieve specific movement or function
26) Analyze how gear ratios affect speed and torque
27) Design mechanical solutions that meet stability and performance requirements
28) Evaluate mechanical systems for strength, efficiency, and functionality

6. Electrical Systems and Circuit Integration

Objective: *Students will construct and analyze basic electrical circuits used to power and control robotic systems and aerospace-related devices.*

29) Identify components such as power sources, wires, switches, and resistive elements
30) Explain the role of electrical systems in powering robotic devices
31) Construct basic circuits using appropriate tools and techniques
32) Measure voltage and current using electronic test equipment
33) Analyze circuit functionality and identify faults
34) Evaluate circuit performance and safety in system integration

7. Sensors and Data Acquisition

Objective: *Students will analyze how sensors collect data and apply them to control and improve robotic systems, aircraft subsystems, and aerospace monitoring applications.*

35) Define the function of sensors and their role in mechatronic systems
36) Identify common sensors such as light, touch, ultrasonic, and temperature sensors

37) Explain how sensors convert physical signals into usable data
38) Integrate sensors into a robotic system
39) Interpret sensor data to inform system behavior
40) Evaluate sensor effectiveness and accuracy in system applications

8. Actuators Motion and Control Devices

Objective: *Students will apply knowledge of actuators to control movement and output in robotic systems.*

41) Identify types of actuators including motors, servos, and pneumatic devices
42) Explain how actuators convert energy into motion
43) Demonstrate control of actuators within a robotic system
44) Analyze how actuator selection affects system performance
45) Integrate actuators with sensors and controllers
46) Evaluate actuator performance based on speed, torque, and precision

9. Programming and Control Systems Fundamentals

Objective: *Students will develop basic control algorithms and implement programming logic to operate robotic systems used in automation and aerospace applications.*

47) Define basic programming concepts such as variables, loops, and conditionals
48) Develop simple control algorithms for robotic tasks
49) Program a robotic system using an appropriate platform
50) Analyze how code affects system behavior and performance
51) Modify programs to improve system efficiency or accuracy
52) Evaluate effectiveness of program logic in achieving desired outcomes

10. Integrated Mechatronic System Design for Aerospace Applications

Objective: *Students will synthesize mechanical, electrical, and programming components to create fully functional robotic systems with aerospace-inspired performance requirements.*

53) Combine subsystems including structure, circuits, sensors, and programming into one system
54) Design integrated robotic systems that meet defined specifications
55) Construct systems using appropriate materials and techniques
56) Analyze system performance under real-world conditions
57) Refine system design based on testing and feedback
58) Evaluate system effectiveness in solving engineering challenges

11. Troubleshooting Diagnostics and System Optimization

Objective: *Students will diagnose system failures and optimize performance using systematic problem-solving strategies in robotic, automated, and aerospace-related systems.*

59) Identify common mechanical, electrical, and programming faults
60) Apply a structured troubleshooting process to isolate issues
61) Test components to determine root causes of failure
62) Analyze system performance data to identify inefficiencies

63) Implement corrective actions to improve functionality
64) Evaluate system reliability after modifications

12. Technical Documentation and Engineering Communication

Objective: *Students will document and communicate technical information related to robotics systems and aerospace applications clearly and professionally.*

65) Document design processes, system components, and testing results
66) Create diagrams, schematics, and layouts for robotic systems
67) Use technical vocabulary appropriately in written and verbal communication
68) Present system designs and results to peers and instructors
69) Explain design decisions using evidence and reasoning
70) Evaluate documentation for clarity, completeness, and accuracy

13. Robotics Design Build and Final Project with Aerospace Context

Objective: *Students will design, construct, and present a complete robotic system that demonstrates mastery of foundational mechatronics concepts through an aerospace-inspired challenge.*

71) Define a problem or challenge requiring a robotic solution
72) Design a system that meets specific criteria and constraints
73) Construct a functional robotic prototype
74) Program and integrate all system components
75) Test system performance and reliability
76) Refine the design based on test results
77) Present the final system and design process
78) Reflect on learning, problem-solving strategies, and technical growth

14. Leadership

Objective: *Students will develop leadership skills by demonstrating responsibility, collaboration, initiative, ethical decision-making, and effective communication in classroom, laboratory, CTSO, and project-based settings.*

79) Demonstrate leadership skills through teamwork, collaboration, and shared problem-solving
80) Practice professionalism, responsibility, and accountability in academic and technical settings
81) Apply ethical decision-making and respectful communication when working with peers, instructors, and industry partners
82) Set personal and team goals and evaluate progress toward achieving them
83) Participate in leadership development opportunities through CTSO, service, or classroom activities

15. Work-Based Learning

Objective: *Students will connect classroom learning to career readiness by exploring workplace expectations, engaging with industry experiences, and applying technical and employability skills in authentic work-based learning contexts.*

84) Identify the purpose and value of work-based learning experiences in career development
85) Demonstrate employability skills such as punctuality, communication, teamwork, and adaptability in authentic workplace settings
86) Examine workplace roles, responsibilities, and expectations related to robotics, mechatronics, and aerospace careers
87) Apply technical and professional skills during job shadows, industry guest interactions, internships, or project-based experiences when available
88) Reflect on work-based learning experiences to evaluate personal strengths, growth areas, and career interests

16. 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: Robotics and Mechatronics I
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 who listen actively and respectfully; pose thoughtful questions, acknowledge the ideas of others; and contribute ideas to further the group's attainment of an objective.	Students work in teams to design, build, integrate, and troubleshoot robotic and mechatronic systems while communicating task roles, safety procedures, and system logic and listening and responding to feedback during iterative design and testing for aerospace-inspired challenges.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences and varied purposes.	Students explain system architecture, control strategies, and performance results as they present project designs and demonstrations and communicate technical decisions and troubleshooting outcomes clearly in

			robotic and aerospace-related contexts.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts to build knowledge and to better understand the human experience.	Students read technical manuals, schematics, wiring diagrams, PLC and robotics documentation, informational texts on sensors, actuators, controllers, and integrated systems, and safety and industry guidelines for mechatronics, robotics, and aerospace labs.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts, command a variety of word-learning strategies to assist comprehension, and make effective choices for meaning or style when writing and speaking.	Students use precise robotics, electronics, control systems, and aerospace terminology, interpret symbolic, numeric, and procedural technical language, and adapt language for documentation, presentation, safety, and troubleshooting contexts.
Standard 3: Writing and Composition	Prepared Graduate 6 – Craft arguments	Craft arguments using techniques specific to the genre.	Students justify system designs, component selection, and control strategies, defend troubleshooting decisions using test data and system behavior, and support conclusions with evidence, engineering constraints, and aerospace performance considerations.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- O NET Online (careers robotics mechatronics engineering pathways) https://www.onetonline.org/
- My Next Move (career exploration robotics engineering technician) https://www.mynextmove.org/
- CareerOneStop (training certification technical careers STEM) https://www.careeronestop.org/
- CCCS Career Advising (Colorado postsecondary pathways engineering) https://cccs.edu/career-advising/

2. Foundations of Robotics, Mechatronic Systems, and Aerospace Applications

- TeachEngineering (robotics systems fundamentals engineering lessons) https://www.teachengineering.org/
- MIT OpenCourseWare Robotics (robotics systems concepts integration) https://ocw.mit.edu/
- FIRST Robotics Resources (robotics systems foundations applications) https://www.firstinspires.org/resources
- Carnegie Mellon Robotics Academy (robotics fundamentals system design) https://www.cmu.edu/roboticsacademy/

3. Safety Tools and Engineering Laboratory Practices

- OSHA (workplace safety standards robotics electrical hazards) https://www.osha.gov/
- CDC NIOSH (engineering lab safety hazard prevention) https://www.cdc.gov/niosh/
- Robotics Safety Resources (robotics lab safety procedures) https://www.robotics.org/robotics
- Tool Box Talks (shop safety procedures machining robotics labs) https://www.toolbox-talks.com/

4. Engineering Design Process, Problem Solving, and Aerospace Challenges

- Engineering Design Process NASA (engineering design steps problem solving) https://www.nasa.gov/stem
- TeachEngineering Design (engineering design process examples projects) https://www.teachengineering.org/
- STEM Careers Engineering Design (design thinking problem solving engineering) https://stemcareers.org/
- MIT OpenCourseWare Design (engineering design methodology systems thinking) https://ocw.mit.edu/

5. Mechanical Systems and Structural Design

- Khan Academy Mechanical Physics (mechanics forces motion basics) https://www.khanacademy.org/science/physics

- Learn Engineering YouTube (mechanical systems gears mechanisms explanation) https://www.youtube.com/@LearnEngineering
- TeachEngineering Mechanical Systems (mechanisms gears robotics structures) https://www.teachengineering.org/
- BBC Bitesize Forces (mechanical systems forces motion engineering) https://www.bbc.co.uk/bitesize

6. Electrical Systems and Circuit Integration

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

7. Sensors and Data Acquisition

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

8. Actuators Motion and Control Devices

- Robotics Academy Actuators (motors servos actuators robotics systems) https://www.cmu.edu/roboticsacademy/
- Arduino Motors and Actuators (motor control robotics systems) https://www.arduino.cc/
- Learn Engineering Motors (electric motors actuators explanation animation) https://www.youtube.com/@LearnEngineering
- Electronics Tutorials Motors (electromechanical devices actuators basics) https://www.electronics-tutorials.ws/

9. Programming and Control Systems Fundamentals

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

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

10. Integrated Mechatronic System Design for Aerospace Applications

- MIT OpenCourseWare Systems Engineering (system integration robotics mechatronics) https://ocw.mit.edu/
- TeachEngineering Systems (systems integration engineering robotics applications) https://www.teachengineering.org/
- FIRST Robotics Design (robot integration systems design projects) https://www.firstinspires.org/
- Autodesk Design Academy (system design CAD integrated engineering) https://academy.autodesk.com/

11. Troubleshooting Diagnostics and System Optimization

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

12. Technical Documentation and Engineering Communication

- Purdue OWL Technical Writing (engineering documentation communication) https://owl.purdue.edu/
- Lucidchart (schematics diagrams system documentation tools) https://www.lucidchart.com/
- IEEE Resources (engineering documentation standards communication) https://www.ieee.org/
- Autodesk Design Academy Docs (technical drawing CAD documentation standards) https://academy.autodesk.com/

13. Robotics Design Build and Final Project with Aerospace Context

- Instructables Projects (robotics build projects engineering design ideas) https://www.instructables.com/
- FIRST Robotics Challenges (robot design build competition projects) https://www.firstinspires.org/
- Maker Ed (project based learning robotics engineering design) https://makered.org/
- NASA Engineering Design Challenges (robotics engineering problem solving projects) https://www.nasa.gov/stem

14. Leadership

- Overcoming Obstacles (communication decision making goal setting leadership skills) https://www.overcomingobstacles.org/
- Leading Teams Open Textbook (teamwork collaboration leadership group dynamics) https://pressbooks.usnh.edu/leadingleadingteams/
- CU Boulder Career Services Teamwork (teamwork collaboration conflict resolution professional skills) https://www.colorado.edu/career/myskills/teamwork
- Stanford Online Free Content (leadership communication professional development learning) https://online.stanford.edu/free-content

15. Work-Based Learning

- SkillsUSA Work-Based Learning (career readiness employability workplace learning model) https://www.skillsusa.org/students/work-based-learning/
- U.S. Department of Labor Career Preparation and Work-Based Learning (career planning work readiness youth employment skills) https://www.dol.gov/agencies/odep/program-areas/individuals/youth/career-preparation?lang=en
- Youth.gov Career Exploration and Skill Development (career exploration mentoring internships job shadowing employability) https://youth.gov/youth-topics/youth-employment/career-exploration-and-skill-development
- MCSD Work-Based Learning (job shadow site visits workplace learning career pathways) https://www.ccr.mcsd.org/work-based-learning

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.
- Test robot performance before competition and make adjustments to improve reliability, control, and task completion.
- Operate the robot during the timed challenge while completing required tasks within the allotted window.
- Troubleshoot, repair, or adjust the robot during competition when needed while following 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, 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
- Tinkercad Circuits – Circuit simulation and prototyping https://www.tinkercad.com/circuits
- VEX Robotics STEM Labs – Mechanisms, sensors, and programming https://education.vex.com/

Technology Student Association – National Competitive Events

Manufacturing Prototype

Objective: *Students will design, document, fabricate, evaluate, and present a manufactured prototype that meets TSA Manufacturing Prototype requirements for production quality, technical documentation, materials, and product communication.*

- Research the annual TSA Manufacturing Prototype challenge and identify the product requirements, constraints, and intended audience.
- Develop a prototype concept using sketches, technical drawings, CAD models, schematics, or other design-planning tools.
- Create working drawings, detail drawings, a parts list, and documentation needed to communicate the design.
- Fabricate a prototype using appropriate manufacturing processes, materials, tools, equipment, and components.
- Document construction, testing, revisions, strengths, weaknesses, materials, and production decisions in a portfolio.
- Prepare a bill of materials and work log that communicate the manufacturing process.
- Present a sales pitch explaining the product, design decisions, production process, cost considerations, and final prototype.

Resources

- Technology Student Association – Manufacturing Prototype competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Autodesk Fusion – CAD/CAM design and manufacturing tools https://www.autodesk.com/products/fusion-360/education
- Onshape Education – Browser-based CAD and product design tools https://www.onshape.com/en/education/
- Xometry – Manufacturing and prototyping process resources https://www.xometry.com/resources/