Robotics and Automated Systems

Level: 3
Career Cluster: Advanced Manufacturing
Program: Engineering
Pathway(s): Engineering Applications UAS, Engineering

Course Catalog Description

Students explore robotics and automation systems as they learn how technologies are designed, programmed, tested, and applied to solve real-world problems. The course emphasizes engineering practices, system components, safety, ethics, and technical communication through hands-on design and analysis.

Summary

Engineering course in which students explore how robotics and automation technologies are designed, programmed, tested, and used to solve real-world problems. Through career exploration, students examine industry pathways, postsecondary opportunities, professionalism, and the legal and ethical responsibilities associated with these fields. Students study the evolution of robotics and automation, analyze how sensors, electronics, control systems, and mechanical components work together, and develop programming logic for robotic and autonomous functions. They apply concepts such as feedback loops, motion, power transmission, safety, maintenance, and system performance evaluation while collecting and interpreting data to improve reliability and efficiency. By the end of the course, students design, test, document, and present a robotic or automated solution using technical vocabulary, engineering practices, and responsible decision-making.

Notes

This revised version presents a more clearly sequenced and comprehensive engineering progression. While the earlier course emphasized core topics such as safety, robotics history, programming, sensors, electronics, mechanics, feedback loops, and maintenance, the new document expands and reorganizes that content into more distinct instructional areas, including ethical innovation, system architecture, autonomy, data systems, testing and quality assurance, leadership, and work-based learning. The update also strengthens the course's emphasis on technical communication, responsible decision-making, and real-world problem solving through a defined applied design project, making the course more aligned to modern engineering and automation pathways while preserving the foundational robotics concepts of the original course. In addition, the revised course increases rigor by organizing learning into clearly defined strands that move from foundational knowledge to application and performance. The previous course focused heavily on exposure to robotics concepts and component functions, whereas this version more intentionally emphasizes analysis, evaluation, documentation, and design. Students are now expected not only to understand how robotic and automated systems work, but also to interpret data, justify design choices, assess system reliability, and communicate results using technical language and engineering processes.

Student Learning Outcomes

1. Career Exploration & Postsecondary Opportunities

Objective: *Students will analyze career pathways in engineering 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 engineering
    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 engineering
    a. Criticism and evaluation
    b. Presentation
    c. Assessment
3) Recognize laws, regulations, and ethics significant to the fields of engineering
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. Robotics Foundations and the Evolution of Automation

Objective: *Students will explain the historical development and modern uses of robotics and automation.*

5) Summarize the historical development of robotics and automated systems
6) Explain why robots are used in specific environments and industries
7) Compare automated systems used in advanced manufacturing, medicine, agriculture, and aerospace
8) Analyze the benefits and limitations of robotic systems in real-world applications
9) Interpret how automation improves efficiency, safety, precision, and repeatability
10) Relate the evolution of robotics to autonomous systems and intelligent machine behavior

3. Ethical Innovation, Safety, and Responsible System Design

Objective: *Students will evaluate ethical, legal, and safety considerations related to robotics and automation systems.*

11) Interpret classroom and lab safety rules for robotics and automated system work
12) Explain the purpose of safety equipment and safe operating procedures
13) Analyze ethical issues involved in producing and using automated technologies
14) Evaluate how privacy, surveillance, bias, safety, and reliability affect acceptance of automated systems
15) Defend responsible decisions related to robotics and automation in society

16) Apply safe procedures when building, testing, and maintaining robotic and automated systems

4. Programming Logic and Robotic Control

Objective: *Students will develop programs that control robotic and automated systems using structured programming processes.*

17) Define the stages of a robotic system programming cycle
18) Construct a flowchart for a robotic or automated task
19) Convert a flowchart into a working program
20) Test and modify code to improve performance and reliability
21) Optimize program behavior for efficiency and precision
22) Write a technical explanation evaluating the performance of a robotic or automated control program
23) Develop basic logic for autonomous system actions such as sequencing, routing, condition-based responses, or obstacle avoidance

5. Sensors, Inputs, Outputs, and Data Systems

Objective: *Students will analyze how sensors and input/output systems allow robotic and automated platforms to interact with their environments.*

24) Identify common input and output devices used in robotic systems
25) Explain how sensors provide information to an automated system
26) Log, store, and export data from two or more sensors
27) Interpret why sensor data collection is useful for testing, optimization, and mission analysis
28) Compare sensor roles in robotic and automated systems, including distance, light, motion, temperature, and camera-based sensing
29) Analyze how sensors support stabilization, navigation, monitoring, and autonomous decision-making in automated systems
30) Evaluate data quality and reliability from robotic or automated subsystems

6. Computers, Electronics, and System Architecture

Objective: *Students will examine the electronic and computing components that make robotic and automated systems function as integrated platforms.*

31) Describe the parts needed to make a robot and distinguish it from a standard computer or a non-robotic machine
32) Identify major system components such as microprocessors, sensors, controls, motors, and communication modules
33) Explain how electronic components support system input, processing, and output
34) Compare the architecture of different robotic and automated systems
35) Analyze how controllers, processors, and power systems support system functionality
36) Design a simple system diagram that shows how a robotic or automated platform processes information and responds to commands

7. Feedback Loops, Autonomy, and Intelligent Behavior

Objective: *Students will apply feedback-control principles to understand how robots and automated systems monitor conditions and adjust behavior automatically.*

37) Explain the purpose of a feedback loop in a robotic system
38) Analyze how feedback improves control, stability, and performance
39) Compare open-loop and closed-loop systems
40) Interpret how automated systems use sensor feedback to maintain position, timing, or operating conditions
41) Evaluate how feedback systems support safe autonomous operation and robotic movement
42) Develop an example of a closed-loop control process for a robotic or automated subsystem

8. Mechanics, Motion, and Power Transmission

Objective: *Students will analyze the mechanical principles that influence robotic motion and apply those concepts to automated system design.*

43) Use mechanical tools and systems such as motors, gears, and gear trains in robotic or automated designs
44) Identify where forces act at different points in a system
45) Explain the relationships among force, torque, work, and power
46) Develop a system that demonstrates how these principles affect a robotic or automated subsystem
47) Compare mechanical motion in different robotic and automated systems
48) Evaluate how mechanical design influences efficiency, payload, movement, and control

9. Testing, Maintenance, Documentation, and Quality Assurance

Objective: *Students will evaluate robotic and automated system performance through testing, maintenance, measurement, and technical documentation.*

49) Use appropriate instruments to measure electrical, light, audio, or other outputs of a robotic system
50) Compare measured performance data to acceptable norms
51) Document whether a system operates within expected parameters
52) Perform maintenance or follow procedures to correct malfunctions or underperformance
53) Create a service and maintenance report on a robotic or automated system
54) Apply testing and documentation practices to automated systems, including sensor, controller, and actuator performance
55) Recommend improvements based on testing evidence and observed performance issues

10. Applied Robotics and Automated System Design Project

Objective: *Students will design and evaluate a robotic or automated system that solves a real-world problem.*

56) Define a real-world problem that can be addressed through robotics or automation
57) Develop a design concept using appropriate sensors, controls, and mechanical components
58) Construct a basic workflow or control logic for the system

59) Test the system or simulation and collect performance data
60) Analyze results to determine whether the design meets criteria and constraints
61) Present the completed system or concept using engineering and robotics vocabulary

11. Leadership

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

62) Demonstrate leadership skills such as responsibility, initiative, dependability, and accountability in individual and team-based settings
63) Apply effective communication, collaboration, and conflict-resolution strategies when working with peers, instructors, and project stakeholders
64) Model ethical behavior, professionalism, and positive decision-making in classroom, lab, and career-focused environments
65) Participate in leadership development activities through classroom roles, team projects, or career and technical student organizations

12. Work-Based Learning

Objective: *Students will connect classroom learning to real-world applications through work-based learning experiences that build career readiness, technical skills, professionalism, and industry awareness.*

66) Identify how classroom learning connects to workplace expectations, technical applications, and career opportunities in engineering, robotics, and automation
67) Engage in work-based learning experiences such as industry guest speakers, job shadows, internships, mentorships, or project-based industry collaboration
68) Demonstrate professional skills including punctuality, communication, teamwork, problem solving, and adaptability in real-world workplace settings
69) Reflect on work-based learning experiences to evaluate personal strengths, areas for growth, and future career goals

13. 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 & 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 & Communicating Crosswalk

Course: Robotics and Automated Systems
Colorado Academic Standards – Reading, Writing, & 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.	Students work in teams to design, program, test, and maintain robotic systems; collaborate during troubleshooting and optimization.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences and varied purposes.	Students explain robotic and automated system designs, communicate programming logic and performance results, and share findings orally with peers and instructors.
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 technical manuals, datasheets, schematics, programming documentation, safety procedures, and career

			information related to robotics and automation.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts.	Students use and interpret discipline-specific technical language such as sensors, actuators, feedback loops, control systems, programming syntax, and engineering terminology.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational/explanatory texts using techniques specific to the genre.	Students write technical reports evaluating robotic program performance and document system operation, testing results, and maintenance procedures.
Standard 3: Writing and Composition	Prepared Graduate 9 – Writing Process	Demonstrate mastery of their own writing process with clear, coherent, and error-free polished products.	Students draft, revise, and finalize technical documentation and produce polished reports and service or maintenance documentation.
Standard 4: Research Inquiry and Design	Prepared Graduate 10 – Research & Ethics	Gather information from a variety of sources; analyze and evaluate its quality and relevance; and use it ethically.	Students research historical and current uses of robotics, investigate ethical considerations of automated systems, and collect, analyze, and document sensor and system data to support conclusions.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- Bureau of Labor Statistics Robotics Careers (robotics careers engineering jobs education pathways)
  https://www.bls.gov/ooh
- CareerOneStop Engineering Careers (career pathways certifications workforce skills robotics automation)
  https://www.careeronestop.org
- NASA STEM Careers (engineering robotics aerospace workforce skills opportunities)
  https://www.nasa.gov/stem
- FIRST Robotics Resources (robotics competitions careers STEM workforce development)
  https://www.firstinspires.org

2. Robotics Foundations and the Evolution of Automation

- NASA Robotics Overview (history robotics automation space exploration systems)
  https://www.nasa.gov/robotics
- IEEE Robotics and Automation Society (robotics history standards research applications)
  https://www.ieee-ras.org
- National Geographic Robotics (robotics history automation impact society industry)
  https://www.nationalgeographic.org
- Boston Dynamics Robotics Videos (robotics applications autonomous systems real world use)
  https://www.bostondynamics.com

3. Ethical Innovation, Safety, and Responsible System Design

- Common Sense Digital Citizenship (ethics technology safety privacy responsible use)
  https://www.commonsense.org/education
- IEEE Ethics in Engineering (engineering ethics robotics technology responsibility)
  https://www.ieee.org
- AI Ethics Guidelines European Commission (ethical design automation artificial intelligence safety)
  https://digital-strategy.ec.europa.eu
- CISA Cybersecurity Awareness (system safety risk mitigation secure operations)
  https://www.cisa.gov

4. Programming Logic and Robotic Control

- Code.org Programming Fundamentals (coding logic algorithms loops conditionals basics)
  https://code.org
- VEX Robotics Programming (robotics coding control systems autonomous programming)
  https://www.vexrobotics.com
- Arduino Programming Basics (microcontroller coding sensors actuator control)
  https://www.arduino.cc

- Scratch MIT Programming (intro coding logic simulation automation basics)
  https://scratch.mit.edu

5. Sensors, Inputs, Outputs, and Data Systems

- SparkFun Sensors Guide (sensors inputs outputs electronics data collection basics)
  https://learn.sparkfun.com
- Arduino Sensor Projects (sensor integration data collection robotics applications)
  https://projecthub.arduino.cc
- NASA Remote Sensing Basics (sensors data collection earth observation systems)
  https://earthobservatory.nasa.gov
- Adafruit Sensor Tutorials (input output systems microcontrollers sensor integration)
  https://learn.adafruit.com

6. Computers, Electronics, and System Architecture

- Khan Academy Computer Systems (computers hardware software systems architecture basics)
  https://www.khanacademy.org
- HowStuffWorks Microprocessors (microprocessors computing architecture embedded systems)
  https://computer.howstuffworks.com
- Arduino Electronics Basics (circuits microcontrollers robotics embedded systems)
  https://www.arduino.cc
- Raspberry Pi Computing Projects (embedded systems programming robotics automation applications)
  https://www.raspberrypi.org

7. Feedback Loops, Autonomy, and Intelligent Behavior

- MIT Control Systems Basics (feedback loops control systems automation fundamentals)
  https://ocw.mit.edu
- NASA Control Systems Explanation (feedback control systems flight stability automation)
  https://www.grc.nasa.gov
- Khan Academy Systems and Control (feedback loops system response stability concepts)
  https://www.khanacademy.org
- VEX Robotics Autonomous Systems (autonomous control robotics behavior feedback systems)
  https://www.vexrobotics.com

8. Mechanics, Motion, and Power Transmission

- Khan Academy Work and Energy (force torque work power motion physics)
  https://www.khanacademy.org
- NASA Forces and Motion (forces motion engineering physics systems)
  https://www.grc.nasa.gov

- MIT Kinematics Basics (motion mechanics engineering systems movement)
  https://ocw.mit.edu
- Engineering Explained Mechanics (mechanical systems gears motors motion concepts)
  https://www.engineeringexplained.com

9. Testing, Maintenance, Documentation, and Quality Assurance

- IEEE Engineering Standards (testing standards quality assurance engineering systems)
  https://www.ieee.org
- ISO Quality Management Basics (quality assurance standards system testing processes)
  https://www.iso.org
- NASA Systems Engineering Handbook (testing validation verification engineering systems)
  https://www.nasa.gov
- Khan Academy Scientific Method (testing analysis data evaluation engineering processes)
  https://www.khanacademy.org

10. Applied Robotics and Automated System Design Project

- DroneBlocks Mission Programming (drone missions coding automation waypoint planning)
  https://droneblocks.io
- DJI Education Resources (drone systems mission planning automation applications)
  https://edu.dji.com
- NASA Engineering Design Projects (engineering design problem solving robotics applications)
  https://www.nasa.gov/stem
- ESRI Drone Mapping Projects (drone applications mapping GIS data mission design)
  https://www.esri.com

11. Leadership

- Lead4Change Student Leadership Resources (leadership teamwork communication problem solving service learning)
  https://lead4change.org
- National Association of Student Councils Leadership Development (student leadership goal setting civic engagement project planning)
  https://www.natstuco.org/leadership-development/
- Edutopia Building Leadership Skills in Students (student voice collaboration communication leadership program strategies)
  https://www.edutopia.org/article/building-leadership-skills-students
- SkillsCommons Getting Ready for the Workplace (professionalism teamwork communication adaptability workplace success)
  https://support.skillscommons.org/getting-ready-for-the-workplace/

12. Work-Based Learning

- CareerOneStop Skills Assessment (workplace skills employability soft skills career readiness self-assessment)
  https://www.careeronestop.org/ExploreCareers/Assessments/skills.aspx
- CareerOneStop Skills Matcher (career pathways workplace competencies job matching employability)
  https://www.careeronestop.org/Toolkit/Skills/skills-matcher.aspx
- SkillsCommons Skills for Employability and Career Advancement (employability workplace readiness communication teamwork career advancement)
  https://support.skillscommons.org/skills-for-employability-and-career-advancement/
- SkillsCommons Apprenticeship and Work-Based Learning Showcase (apprenticeship work-based learning employer engagement career training resources)
  https://support.skillscommons.org/showcases/

Technology Student Association – National Competitive Events

Drone Challenge (UAV)

Objective: *Students will design, build, document, test, and present an open-source UAV drone that meets TSA Drone Challenge requirements for flight performance, safety, documentation, programming, and mission completion.*

- Research the annual TSA Drone Challenge specifications, mission requirements, and applicable drone-flight regulations.
- Design or modify an open-source UAV drone that meets TSA size, motor, propeller, guard, payload, camera, and mission-function requirements.
- Assemble and wire drone components, including motors, flight controllers, electronic speed controllers, cameras, antennas, and related systems.
- Document the UAV through a portfolio that includes a photo log, wiring schematics, programming explanation, engineered drawings, bill of materials, and work log.
- Program and configure the drone for flight functioning, stabilization, and mission-specific operation.
- Complete safety inspection, flight practice, drone testing, and mission performance procedures.
- Participate in an interview explaining the drone design, programming, components, safety decisions, and mission performance.

Resources

- Technology Student Association – Drone Challenge (UAV) competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Federal Aviation Administration – Drone safety and regulations https://www.faa.gov/uas
- ArduPilot Documentation – Open-source autopilot software https://ardupilot.org/
- PX4 Autopilot User Guide https://docs.px4.io/

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, document, troubleshoot, 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, controls, sensors, motors, feedback, or programmable components to solve the assigned problem.
- 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 or documentation record describing design decisions, testing, revisions, and final 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