Digital Electronics - AES

Level: 2
Career Cluster: Advanced Manufacturing
Program: Engineering
Pathway: Aerospace Engineering Technician, Engineering, Engineering Applications UAS

Course Catalog Description

Introduces students to the principles and applications of digital systems through hands-on circuit construction, logic design, and technical problem solving with a strong aerospace emphasis. Students build and troubleshoot digital circuits while applying concepts such as logic gates, binary numbers, Boolean algebra, combinational and sequential logic, technical documentation, and the role of digital electronics in avionics, sensing, instrumentation, communications, navigation, and control systems used in aircraft, spacecraft, satellites, and uncrewed systems.

Summary

Engineering course in which students explore the principles, components, and applications of modern digital systems through hands-on investigation, circuit design, and technical problem solving. With an aerospace and avionics focus, students examine how digital electronics support aircraft, spacecraft, satellites, and uncrewed aerial systems through sensing, communication, navigation, instrumentation, automation, and control. Students develop an understanding of how digital electronics differ from analog systems and apply core concepts including logic gates, TTL and CMOS devices, binary number systems, arithmetic circuits, Boolean algebra, truth tables, and combinational and sequential logic. Students also strengthen collaboration, communication, and career-readiness skills by documenting their work and completing a capstone-style project to design, build, and present a digital system relevant to aerospace engineering technician pathways.

Notes

The updated course reflects a shift from a primarily theory- and component-focused electronics course to a more comprehensive, application-driven and aerospace-integrated engineering program. The original course emphasized foundational concepts such as logic gates, binary systems, and basic circuit analysis with limited contextual application. In contrast, the revised course expands these principles into a structured framework that includes hands-on circuit construction, advanced combinational and sequential logic, troubleshooting methodologies, and the integration of digital systems into aerospace applications such as avionics, navigation, and control systems. Additionally, the updated version incorporates technical documentation, programmable devices, leadership, work-based learning, and a culminating design project, strengthening alignment with current CTE expectations by emphasizing real-world application, systems thinking, and career readiness while maintaining core digital electronics concepts.

Student Learning Outcomes

1. Career Exploration and Postsecondary Opportunities

***Objective**: Students will explore and analyze career pathways related to aerospace engineering technician by examining professional roles, tools, work environments, ethical and legal responsibilities, certifications, professional organizations, and Colorado postsecondary education options 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 Aerospace Digital Electronics

***Objective**: Students will understand and compare the fundamental concepts of digital and analog systems and analyze how digital electronics are used in modern engineered devices, including avionics, sensors, instrumentation, communications, and aerospace control systems.*

5) Define digital electronics and explain its role in modern technology, including aerospace systems.
6) Differentiate between analog and digital variables and systems.
7) Describe advantages of analog systems and advantages of digital systems.
8) Explain how digital electronics support devices such as computers, phones, avionics displays, and control systems.
9) Analyze why digital signals improve storage, speed, and reliability in engineering systems such as navigation, monitoring, and flight-control interfaces.

3. Safety, Tools, and Aerospace Lab Practices

***Objective**: Students will apply safe practices and demonstrate proper use of tools, components, and procedures when building and testing digital circuits, with attention to aerospace-quality handling, ESD control, and reliability expectations.*

10) Interpret classroom and lab safety expectations related to electronics work.
11) Identify the intended use of safety equipment and ESD-related precautions when handling

components.
12) Demonstrate safe operating procedures with tools, breadboards, and digital components.
13) Inspect tools and electronic equipment for safe and proper use before operation.
14) Evaluate how safe lab habits improve troubleshooting accuracy and system reliability.

4. Logic Gates and Basic Circuit Construction

***Objective**: Students will identify, build, and test fundamental logic circuits using standard digital components and relate their operation to aerospace subsystems such as status indicators, simple control logic, and cockpit interface functions.*

15) Identify the basic logic gates including AND, OR, NOT, NAND, and NOR.
16) Describe the input and output behavior of each basic logic gate.
17) Build simple TTL logic circuits on a breadboard.
18) Troubleshoot TTL logic circuits using appropriate techniques.
19) Analyze how combinations of basic logic gates produce more complex outcomes.

5. TTL, CMOS, and Special Purpose Gates

***Objective**: Students will compare and apply different digital logic families and evaluate special-purpose functions used in circuit design.*

20) Identify the logic gates available in CMOS devices.
21) Locate important specifications such as ESD considerations in TTL and CMOS datasheets.
22) Explain the operation of XOR and XNOR logic functions.
23) Implement logic circuits using AND-OR-Invert chips.
24) Explain the purpose of Schmitt trigger circuits.
25) Compare TTL and CMOS devices in terms of application, handling, and circuit use, including considerations relevant to avionics and embedded aerospace electronics.

6. Binary Numbers and Digital Number Systems

***Objective**: Students will convert, represent, and compute values in binary and related number systems used in digital electronics, data handling, and aerospace instrumentation.*
26) Explain numbers in unsigned and signed binary form.
27) Convert numbers among decimal, binary, octal, hexadecimal, and BCD formats.
28) Represent negative binary numbers in two's complement form.
29) Add, subtract, multiply, and divide signed and unsigned binary numbers.
30) Add numbers in BCD format.
31) Analyze how binary systems support digital processing and circuit design.

7. Arithmetic Circuits and Combinational Logic

***Objective**: Students will design and analyze combinational circuits that perform arithmetic and logic functions used in digital systems and aerospace decision-making applications.*

32) Build a half-adder circuit using TTL gates.
33) Build a full-adder circuit using TTL gates.
34) Build a 4-bit adder using a TTL adder chip.
35) Build a 4-bit BCD adder using a TTL adder chip.

36) Explain how combinational logic supports arithmetic operations in digital systems, including aerospace instrumentation and control logic.
37) Evaluate circuit performance by comparing expected and observed outputs.

8. Boolean Algebra and Logic Representation

***Objective**: Students will translate and simplify digital logic using Boolean algebra, truth tables, and circuit diagrams to represent engineering and aerospace control logic clearly and accurately.*

38) Write Boolean expressions for basic logic gates.
39) Write Boolean expressions for combinational logic circuits.
40) Write Boolean expressions from truth tables.
41) Simplify Boolean expressions using valid methods.
42) Translate among logic circuits, truth tables, and Boolean expressions.
43) Apply DeMorgan's Theorem to simplify logic circuits.

9. Troubleshooting and Circuit Analysis

***Objective**: Students will diagnose, test, and refine digital circuits using systematic troubleshooting methods.*

44) Use a logic probe to identify open pins or traces.
45) Use a logic probe to identify shortened pins or traces.
46) Develop a troubleshooting methodology for a digital circuit that could be used by a new technician in an aerospace or avionics setting.
47) Analyze circuit behavior to determine probable sources of error.
48) Evaluate whether a circuit meets intended design criteria after repair or redesign.

10. Sequential Logic, Flip-Flops, and Counters

***Objective**: Students will explain and apply sequential logic concepts using flip-flops and counters to control digital systems, timing functions, and aerospace monitoring processes.*

49) Explain the operation of an SR latch, gated SR latch, and master-slave latch.
50) Use state tables to explain D, T, and JK flip-flop behavior.
51) Implement a frequency divider circuit using JK flip-flops.
52) Explain the operation of synchronous and asynchronous counters.
53) Construct modulus synchronous counters and asynchronous up/down counters using JK flip-flops.
54) Evaluate advantages and limitations of synchronous and asynchronous counters.

11. Registers, Encoding, and Display Systems

***Objective**: Students will analyze and construct digital systems that store, encode, decode, and display information used in engineering and aerospace instrumentation systems.*

55) Explain the operation of Johnson counters and ring counters.
56) Compare serial and parallel data transmission.
57) Explain the operation of an 8-3 octal encoder and a 3-8 decoder.

58) Explain Gray coding and its purpose.
59) Build a display circuit using a 7-segment decoder.
60) Map the pins of a 7-segment LED display using a logic probe.

12. Programmable Devices, Design Process, and Technical Documentation

***Objective**: Students will apply the engineering design process to develop and document digital systems using technical communication and programmable implementation when available, with connections to aerospace electronics and avionics integration.*

61) Identify a problem requiring a digital circuit solution.
62) Apply an identified design process to solve the problem using digital electronics.
63) Produce drawings and schematics for a digital circuit design.
64) Predict results from the design before implementation.
65) Implement digital circuits using programmable devices when available.
66) Document testing, revisions, and troubleshooting using clear technical notation.

13. Final Assessment Project

***Objective**: Students will synthesize digital electronics knowledge to design, build, test, troubleshoot, and communicate a complete digital system for an aerospace-relevant application.*

67) Collaborate with peers to analyze, design, and test digital circuits.
68) Communicate design intent, circuit behavior, and troubleshooting results clearly in written and oral forms.
69) Design a complex digital system using combinational and sequential logic.
70) Construct and test the digital system using appropriate tools and methods.
71) Evaluate the final system against design requirements, constraints, and expected results.
72) Present and defend the completed system, design choices, and performance results to an audience.

14. Leadership

***Objective**: Students will demonstrate leadership skills through goal setting, teamwork, ethical decision-making, communication, and responsibility in classroom, project, and career-focused settings.*

73) Demonstrate leadership behaviors such as responsibility, initiative, dependability, and respect in classroom and lab settings.
74) Collaborate with peers to set goals, delegate tasks, and contribute productively to team outcomes.
75) Apply effective verbal, written, and interpersonal communication skills when leading or participating in projects.
76) Use ethical decision-making and problem-solving strategies when addressing challenges, conflicts, or project needs.
77) Evaluate personal leadership strengths and areas for growth to improve future academic and career performance.

15. Work-Based Learning

***Objective**: Students will connect classroom learning to workplace expectations by exploring job roles, professional skills, documentation, and real-world applications of digital electronics in industry and aerospace-related settings.*

78) Identify workplace expectations related to attendance, punctuality, professionalism, safety, and communication.
79) Examine how digital electronics knowledge and technical skills are applied in industry, including aerospace, avionics, manufacturing, and engineering environments.
80) Develop and maintain workplace-style documentation such as logs, notes, project records, or technical summaries.
81) Demonstrate appropriate professional behaviors during guest speaker sessions, site visits, simulations, internships, or other work-based learning experiences.
82) Reflect on work-based learning experiences to evaluate career interests, skill development, and readiness for future education or employment.

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: Digital Electronics
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 in teams to design and troubleshoot digital circuits, share responsibility for system development, and discuss logic, errors, and design decisions in aerospace and avionics contexts.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences.	Students explain aerospace digital system designs, communicate how circuits function, and present and justify design solutions for avionics-style applications.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts.	Students read and interpret technical documentation, datasheets, circuit specifications, diagrams, safety procedures, and standards relevant to

			digital electronics and aerospace systems.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts.	Students use discipline-specific technical language and symbolic or logical representations such as truth tables, logic notation, and aerospace instrumentation terminology.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational and explanatory texts.	Students produce technical explanations of circuits, design documentation, and system descriptions tied to aerospace and avionics applications.
Standard 3: Writing and Composition	Prepared Graduate 9 – Writing Process	Demonstrate mastery of their own writing process.	The course requires iterative documentation, revision, and maintenance of clear, accurate, and polished technical records for digital systems and aerospace-relevant design work.
Standard 4: Research Inquiry and Design	Prepared Graduate 10 – Research and Ethics	Gather information from a variety of sources.	Students research electronic components and system behavior, evaluate datasheets and reference materials, and apply researched information to digital system design for aerospace-relevant problems.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- AOPA Foundation High School Aviation STEM Curriculum (aviation pathways technician careers aerospace education)
  youcanfly.aopa.org/high-school/high-school-curriculum
- FAA High School Programs (aviation education student opportunities aerospace careers)
  www.faa.gov/education/programs/highschool
- CareerOneStop (career exploration certifications salary education pathways)
  www.careeronestop.org
- Colorado Community College System (Colorado programs degrees certificates pathways)
  www.cccs.edu

2. Foundations of Aerospace Digital Electronics

- All About Circuits (digital electronics basics logic systems concepts)
  www.allaboutcircuits.com
- NASA NESC Academy Sensors and Instrumentation (sensors instrumentation aerospace systems monitoring)
  nescacademy.nasa.gov/catalogs/si
- MIT Open Learning (engineering systems computing fundamentals)
  openlearning.mit.edu
- Engineer Fix Avionics Overview (avionics subsystems displays navigation digital systems)
  engineerfix.com/how-an-avionics-system-works-from-subsystems-to-displays

3. Safety, Tools, and Aerospace Lab Practices

- OSHA (electronics safety workplace practices handling equipment)
  www.osha.gov
- NASA Lesson Learned: Electrostatic Discharge Control in Flight Hardware (ESD procedures reliability aerospace hardware)
  llis.nasa.gov/lesson/732
- ASA Best Practice Handling of ESD Sensitive Parts (aviation parts handling storage protection)
  www.aviationsuppliers.org/asa/files/ccLibraryFiles/Filename/000000002260/2019-5-1ASABestPracticeESDRev1.pdf
- Fluke Education (electrical measurement safety testing tools)
  www.fluke.com/en-us/learn/blog/education

4. Logic Gates and Basic Circuit Construction

- Logic Gate Simulator (interactive logic circuits gate operations)
  logic.ly/demo
- All About Circuits Digital Logic (logic gates circuit building tutorials)
  www.allaboutcircuits.com/textbook/digital
- Electronics Hub (logic gate examples circuit construction)
  www.electronicshub.org

- CircuitVerse (digital circuit simulator logic gate design)
  circuitverse.org

5. TTL, CMOS, and Special Purpose Gates

- Electronics Tutorials Logic Families (TTL CMOS gate comparisons characteristics)
  www.electronics-tutorials.ws/logic/logic_1.html
- Texas Instruments Education (datasheets TTL CMOS design resources)
  www.ti.com/education
- SparkFun Tutorials (CMOS TTL basics practical circuits)
  learn.sparkfun.com
- DigiKey Education (logic gates technical specs datasheets)
  www.digikey.com

6. Binary Numbers and Digital Number Systems

- Khan Academy Binary (binary numbers conversions number systems)
  www.khanacademy.org/computing/computer-science
- RapidTables (binary hex decimal conversion tools)
  www.rapidtables.com
- Math is Fun Binary (binary number explanations concepts)
  www.mathsisfun.com/binary-number-system.html
- Nand2Tetris (binary arithmetic digital logic computing)
  www.nand2tetris.org

7. Arithmetic Circuits and Combinational Logic

- All About Circuits Arithmetic (adders combinational logic circuits)
  www.allaboutcircuits.com/textbook/digital/chpt-8
- Electronics Hub Adders (half adder full adder circuit design)
  www.electronicshub.org
- CircuitVerse Arithmetic Circuits (adders combinational design simulation)
  circuitverse.org
- GeeksforGeeks Digital Logic (combinational circuits and logic design)
  www.geeksforgeeks.org

8. Boolean Algebra and Logic Representation

- Boolean Algebra Tutorials (logic expressions simplification rules)
  www.electronics-tutorials.ws/boolean
- Karnaugh Map Solver (logic simplification truth tables K map tools)
  www.dcode.fr/karnaugh-map
- All About Circuits Boolean (truth tables logic simplification)
  www.allaboutcircuits.com/textbook/digital/chpt-7
- MathWorld Boolean Algebra (concepts logic operations theory)
  mathworld.wolfram.com

9. Troubleshooting and Circuit Analysis

- Fluke Troubleshooting Guides (circuit testing diagnostics electronics repair) www.fluke.com/en-us/learn/blog
- Electronics Notes Troubleshooting (circuit fault finding techniques) www.electronics-notes.com
- SparkFun Troubleshooting (breadboard debugging circuit testing) learn.sparkfun.com
- DigiKey Troubleshooting (electronic diagnostics repair methods) www.digikey.com

10. Sequential Logic, Flip-Flops, and Counters

- All About Circuits Sequential Logic (flip flops counters circuits) www.allaboutcircuits.com/textbook/digital
- Electronics Tutorials Flip Flops (SR JK D T flip flop explanation) www.electronics-tutorials.ws
- GeeksforGeeks Sequential Circuits (flip flops counters design concepts) www.geeksforgeeks.org
- CircuitVerse Sequential Logic (flip flop counter simulations) circuitverse.org

11. Registers, Encoding, and Display Systems

- Electronics Tutorials Shift Registers (registers encoders decoders explanation) www.electronics-tutorials.ws
- SparkFun LED Displays (7 segment display circuits design) learn.sparkfun.com
- CircuitVerse Display Circuits (encoder decoder display simulation) circuitverse.org
- DigiKey Display Circuits (LED display and decoder design resources) www.digikey.com

12. Programmable Devices, Design Process, and Technical Documentation

- Arduino Education (programmable devices microcontrollers circuit design) www.arduino.cc/education
- MIT Scratch (logic programming design thinking fundamentals) scratch.mit.edu
- Autodesk Tinkercad Circuits (circuit simulation design testing) www.tinkercad.com
- Purdue OWL Technical Writing (engineering documentation writing communication) owl.purdue.edu

13. Final Assessment Project

- Google Workspace (collaboration communication project documentation tools) docs.google.com
- Canva (visual presentations design communication tools) www.canva.com

- MIT Engineering Communication (technical presentations design communication)
  ocw.mit.edu

14. Leadership

- Lead4Change (student leadership teamwork communication goal setting)
  lead4change.org
- Overcoming Obstacles (decision-making communication life skills leadership)
  www.overcomingobstacles.org
- TEEN TRUTH Student Leadership Activities (student leadership activities motivation service)
  teentruth.net/student-leadership-activities

15. Work-Based Learning

- CTECS Workplace Readiness Skills (employability professionalism workplace expectations)
  wrs.ctecs.org
- NAF Work-Based Learning Experiences for High School Students (internships mentorship career exposure)
  naf.org/news_articles/work-based-learning-experiences-for-high-school-students
- ACTE Resources for Career Development (career planning postsecondary pathways job search)
  www.acteonline.org/wp-content/uploads/2024/10/Career_Toolkit_2024_FINAL.pdf

Technology Student Association – National Competitive Events

System Control Technology

Objective: *Students will design, build, troubleshoot, document, and demonstrate an operable system-control device or model that responds to a TSA-provided problem.*

- Interpret the TSA-provided system-control problem and document the team's understanding in an inventor's log.
- Design a device or model that uses electronic, mechanical, and/or programmable control elements to solve the assigned problem.
- Construct an operable system within the competition time limit using approved materials, tools, and equipment.
- Test the device or model to verify that it functions correctly and can be reset before evaluation.
- Troubleshoot system issues related to wiring, logic, programming, mechanical operation, or reliability.
- Explain the design process, control strategy, and system operation to judges during evaluation.
- Evaluate the final system using TSA criteria for problem interpretation, functionality, design quality, documentation, and communication.

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
- PhET Interactive Simulations – Circuit Construction Kit https://phet.colorado.edu/

Technology Student Association – National Competitive Events

Robotics

Objective: *Students will design, build, document, test, and operate a robot that meets the annual TSA Robotics challenge specifications.*

- Analyze the annual TSA Robotics design challenge and identify the robot's required tasks, constraints, and performance criteria.
- Design and build a robot that follows the yearly theme, stated specifications, and required safety expectations.
- Integrate mechanical, electrical, and control components into a functional robotic system.
- Test the robot during setup and testing time, making adjustments before the timed challenge.
- Operate the robot during the challenge within the required running-clock time limit.
- Prepare documentation that explains the robot's design, construction, testing, and problem-solving process.
- Participate in a semifinalist interview explaining robot systems, design decisions, troubleshooting, and team roles.

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

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.*

- Design an animatronic device that responds to the annual TSA theme and fits within the required starting dimensions.
- Construct an exterior shell or skin that can be removed to show internal components to judges.
- Incorporate at least three separate movements using required systems such as fluid power, gearing, linkages, cabling, or related mechanisms.
- Integrate sound, lights, sensors, and control technology into the animatronic model.
- Test the device for reliable operation, safe power use, appropriate movement, and presentation readiness.
- Prepare and deliver a presentation/interview explaining the design process, control system, internal components, and final performance.
- Evaluate the device using TSA criteria for technical function, creativity, movement, control, construction quality, and communication.

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/