Introduction to Engineering Design - AES

Level: 1
Career Cluster: Advanced Manufacturing and Transportation
Program: Engineering with Aerospace Applications
Pathway: Aerospace Engineering Technician, Engineering

Course Catalog Description

Teaches students how engineers solve real-world problems through design, research, and testing with an added emphasis on aerospace systems, flight, and space applications. Students build skills in CAD, prototyping, teamwork, and technical communication while exploring engineering and aerospace careers and pathways.

Summary

Introduces students to the principles, practices, and pathways that shape modern engineering, with a strong emphasis on aerospace engineering technician careers and postsecondary opportunities in Colorado. Throughout the course, students examine engineering disciplines, safety expectations, professional responsibilities, and the role of engineering in solving real-world and global challenges through aerospace contexts such as flight systems, spacecraft structures, remote sensing, and aviation operations. Students apply the engineering design process to research problems, generate ideas, analyze criteria and constraints, and develop, test, and refine solutions through iteration. They also build technical skills in sketching, CAD, measurement, data analysis, mathematical modeling, and the study of mechanical and electrical systems, including forces affecting flight, materials, structures, energy, motion, sensors, and basic circuits. In addition, students strengthen project management, teamwork, communication, and documentation skills as they present and defend design ideas using evidence and industry-appropriate practices. By the end of the course, students are prepared to think critically, work collaboratively, and communicate effectively as emerging engineering learners with awareness of aerospace applications and career pathways.

Notes

The updated course reflects a shift from a traditional introductory engineering course focused on basic design concepts and general engineering skills to a more comprehensive, systems-oriented and aerospace-integrated CTE program. The original course emphasized foundational topics such as the engineering design process, sketching, measurement, and simple problem solving with limited contextual application. In contrast, the revised course expands these foundations into a structured framework that integrates aerospace applications, systems thinking, data analysis, CAD modeling, and iterative design practices. Additionally, the updated version includes stronger emphasis on project management, technical communication, collaboration, ethics, leadership, work-based learning, and a formal final assessment project. These enhancements improve alignment with current CTE expectations by emphasizing real-world application, interdisciplinary engineering skills, and career readiness while maintaining the core principles of engineering design.

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 Engineering and Systems

***Objective:** Students will understand and analyze the role of engineering within systems and evaluate how engineering impacts technology, society, and global challenges, including aviation and space exploration.*

5) Define engineering and its relationship to science, technology, and mathematics through examples that include aerospace systems and flight technologies.
6) Describe various engineering disciplines and their applications, including aerospace, mechanical, electrical, civil, and systems engineering.
7) Explain how engineering solves real-world problems, including challenges in aircraft, spacecraft, and aerospace mission design.
8) Analyze how engineering innovations impact society, economy, and environment, including aerospace advances in transportation, communication, and Earth observation.
9) Evaluate the role of engineers in addressing global challenges through aerospace solutions such as satellite systems, sustainable aviation, and space exploration.

3. Engineering Safety and Professional Practices

***Objective:** Students will apply safety procedures and demonstrate professional behaviors required in engineering environments.*

10) Explain safety procedures and classroom/lab expectations.
11) Identify hazards and appropriate safety equipment.
12) Apply safe practices when using tools and equipment.
13) Demonstrate professionalism in teamwork and project environments.
14) Evaluate the impact of safety and professionalism on engineering outcomes.

4. Engineering Design Process and Problem Solving

Objective: *Students will apply and evaluate the engineering design process to solve problems and develop effective solutions.*

15) Identify steps of the engineering design process.
16) Compare the engineering design process to the scientific method.
17) Apply design process steps to solve engineering problems.
18) Analyze constraints, criteria, and stakeholder needs.
19) Evaluate solutions based on performance and effectiveness.
20) Refine solutions through iteration and redesign.

5. Research, Ideation, and Design Thinking

Objective: *Students will conduct research and generate solutions using structured ideation and design thinking strategies.*

21) Research engineering problems using reliable sources.
22) Summarize findings to inform design decisions.
23) Generate multiple design ideas using brainstorming methods.
24) Analyze trade-offs between alternative solutions.
25) Select the most effective solution based on criteria and constraints.

6. Engineering Graphics, Sketching, and CAD

Objective: *Students will create and interpret technical drawings and digital models to communicate engineering designs, including aerospace components and systems.*

26) Identify elements of technical sketches and engineering drawings, including aerospace parts, assemblies, and system layouts.
27) Create freehand sketches to represent design ideas for products, structures, or aerospace systems.
28) Develop 2D and 3D CAD models of engineering designs, including aerospace-inspired components.
29) Interpret technical drawings and visual representations used in engineering and aerospace contexts.
30) Evaluate design accuracy using modeling tools.

7. Measurement, Data, and Mathematical Modeling

Objective: *Students will apply measurement and data analysis to support engineering design decisions, including calculations relevant to aerospace performance and testing.*

31) Measure physical properties using standard and metric systems.
32) Calculate ratios, forces, and simple engineering relationships used in design and aerospace applications.
33) Collect and organize data from testing and experiments.
34) Analyze data using graphs and basic statistical tools.
35) Apply mathematical modeling to improve designs, including predicting performance in flight or systems testing scenarios.

8. Engineering Systems: Mechanics, Energy, and Circuits

Objective: *Students will analyze and apply principles of mechanical and electrical systems in engineering design, including systems relevant to aircraft, spacecraft, and aerospace technologies.*

36) Identify simple and complex machines and their functions, including mechanisms used in aerospace systems.
37) Explain energy, force, and motion concepts in systems, including principles that affect flight and propulsion.
38) Apply Ohm's Law to basic electrical circuits.
39) Analyze how systems components interact in mechanical, electrical, and aerospace systems.
40) Evaluate system performance and efficiency.

9. Prototyping and Testing

Objective: Students will develop and test prototypes to evaluate engineering solutions.

41) Construct physical or digital prototypes of designs.
42) Develop test procedures to evaluate prototypes.
43) Analyze results from testing and experiments.
44) Evaluate prototype performance against design criteria.
45) Recommend improvements based on test results.

10. Project Management and Workflow

Objective: Students will organize and manage engineering projects using structured processes. Students will be able to: 42. Define project goals, scope, and deliverables.

46) Develop project schedules and timelines.
47) Apply project management steps (planning, executing, monitoring).
48) Analyze cost factors and resource allocation.
49) Evaluate project progress and outcomes.

11. Engineering Communication and Documentation

Objective: Students will communicate and document engineering work using industry-standard methods.

50) Prepare engineering documentation (notebooks, reports, plans).
51) Organize data, drawings, and project records.
52) Present design solutions to an audience.

53) Defend design decisions using evidence.
54) Evaluate clarity and effectiveness of communication.

12. Collaboration, Ethics, and Professional Responsibility

Objective: Students will demonstrate collaboration and evaluate ethical considerations in engineering design.

53) Describe how engineering teams function.
54) Apply teamwork strategies to solve problems.
55) Evaluate ethical considerations in engineering decisions.
56) Analyze environmental and societal impacts of designs.
57) Demonstrate accountability and responsibility in team roles.

13. Leadership

Objective: *Students will develop and demonstrate leadership skills through collaboration, decision-making, initiative, and responsible participation in engineering and aerospace learning environments.*

58) Demonstrate leadership skills by setting goals, taking initiative, and contributing positively to team success.
59) Apply effective communication strategies to guide discussions, share ideas, and support collaborative decision-making.
60) Evaluate leadership styles and behaviors that promote responsibility, accountability, and ethical participation in engineering environments.
61) Demonstrate problem-solving and conflict-resolution strategies when working with peers on engineering and aerospace projects.
62) Reflect on personal leadership growth and identify areas for continued improvement.

14. Work-Based Learning

Objective: *Students will connect classroom learning to workplace expectations through career exploration, industry engagement, employability skill development, and authentic work-based learning experiences related to engineering and aerospace pathways.*

63) Identify workplace expectations, professional behaviors, and employability skills relevant to engineering and aerospace careers.
64) Analyze how classroom learning connects to technical tasks, roles, and responsibilities in industry settings.
65) Demonstrate career readiness skills such as time management, communication, adaptability, and collaboration in authentic learning experiences.
66) Explore work-based learning opportunities such as job shadows, guest speakers, internships, industry projects, or career-connected experiences.
67) Reflect on workplace experiences and evaluate how they influence future academic and career goals.

15. Final Assessment Project

Objective: *Students will apply course knowledge and technical skills to complete a culminating engineering design project that demonstrates problem-solving, documentation, communication, and reflection on the design process.*

68) Apply the engineering design process to plan and complete a culminating project that addresses a defined problem or challenge.
69) Create project documentation that includes research, design sketches or models, testing data, revisions, and final recommendations.
70) Demonstrate technical knowledge and skill proficiency through the development of a final engineering or aerospace-focused solution.
71) Present and defend the final project by clearly communicating design decisions, evidence, and outcomes to an audience.
72) Evaluate the effectiveness of the final project and reflect on strengths, challenges, and areas for future improvement.

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: Introduction to Engineering Design
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 engineering design teams, serve as team members and leaders, and use collaborative discussions during the design process, including when evaluating 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 present design solutions, communicate engineering ideas to peers or evaluators, and explain and justify design decisions, including aerospace concepts such as structures, flight, or systems performance.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts to build knowledge.	Students read technical and informational engineering

			materials and interpret design briefs, safety guidelines, project documentation.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts.	Students use technical and discipline-specific language when writing design documentation, explaining engineering solutions, and communicating.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational/explanatory texts using techniques specific to the genre.	Students produce design briefs, engineering notebooks, and technical explanations and reports, including documentation for aerospace-themed design projects.
Standard 3: Writing and Composition	Prepared Graduate 9 – Writing Process	Demonstrate mastery of their own writing process.	The engineering design process requires drafting, revising, and refining documentation and producing polished project artifacts.
Standard 4: Research Inquiry and Design	Prepared Graduate 10 – Research and Ethics	Gather information from a variety of sources; analyze and evaluate its quality and relevance.	Students research design constraints and solutions, evaluate information to inform engineering decisions, and investigate aerospace systems, careers, and technologies as part of inquiry-based projects.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- CareerOneStop (career exploration certifications salary education pathways) https://www.careeronestop.org/
- O*NET Online (career profiles tools workplace skills job expectations) https://www.onetonline.org/
- Bureau of Labor Statistics Occupational Outlook Handbook (job outlook education pathways salary data) https://www.bls.gov/ooh/
- Colorado Community College System (Colorado programs degrees certificates pathways) https://cccs.edu/

2. Foundations of Engineering and Systems

- TeachEngineering (engineering fundamentals, integration real world problems) https://www.teachengineering.org
- MIT Open Learning (engineering systems design thinking manufacturing concepts) https://openlearning.mit.edu
- NASA STEM Engagement (aerospace engineering applications space systems problem solving) https://www.nasa.gov/stem
- Engineering Explained (engineering concepts systems innovation examples) https://www.engineeringexplained.com

3. Engineering Safety and Professional Practices

- OSHA (workplace safety PPE hazard identification compliance) https://www.osha.gov
- CDC NIOSH (health safety workplace risk prevention) https://www.cdc.gov/niosh/
- SafetyCulture (safety inspections procedures compliance workplace practices) https://safetyculture.com
- Manufacturing Institute (workplace expectations safety culture professional skills) https://themanufacturinginstitute.org

4. Engineering Design Process and Problem Solving

- TeachEngineering Design Process (engineering design steps problem solving framework) https://www.teachengineering.org/designprocess
- IDEO Design Thinking (human centered design ideation creativity) https://designthinking.ideo.com
- Engineering Design Guide (problem solving iterative design strategies process) https://www.teachengineering.org/design/designguide.php
- GoLeanSixSigma (problem solving structured processes decision making tools) https://goleansixsigma.com

5. Research Ideation and Design Thinking

- Purdue OWL (research writing technical communication evaluating sources)
  https://owl.purdue.edu
- Stanford d school (design thinking ideation brainstorming strategies)
  https://dschool.stanford.edu/resources
- Google Scholar (research sources academic engineering topics)
  https://scholar.google.com
- MIT Scratch (creative problem solving coding ideation tools)
  https://scratch.mit.edu

6. Engineering Graphics Sketching and CAD

- Autodesk Education (CAD tools 3D modeling engineering design software)
  https://www.autodesk.com/education
- Tinkercad (beginner 3D modeling prototyping design tools)
  https://www.tinkercad.com
- Open Oregon Blueprint Reading (technical drawing sketching fundamentals)
  https://openoregon.pressbooks.pub/blueprint/
- LibreTexts Engineering Graphics (visualization technical communication drawing concepts)
  https://libretexts.org

7. Measurement Data and Mathematical Modeling

- NIST Education (measurement standards accuracy engineering precision)
  https://www.nist.gov/education
- Khan Academy (math modeling algebra statistics engineering fundamentals)
  https://www.khanacademy.org
- Desmos Graphing Calculator (data visualization modeling analysis tools)
  https://www.desmos.com
- Engineering Toolbox (measurement conversions engineering calculations)
  https://www.engineeringtoolbox.com

8. Engineering Systems Mechanics Energy and Circuits

- PhET Simulations (circuits energy forces physics simulations interactive learning)
  https://phet.colorado.edu
- All About Circuits (electronics basics Ohm's law circuit design)
  https://www.allaboutcircuits.com
- NASA Engineering Design (systems modeling energy motion engineering applications)
  https://www.nasa.gov/stem/engineering-design-process
- CK 12 (mechanics energy systems STEM concepts)
  https://www.ck12.org

9. Prototyping and Testing

- Science Buddies (engineering projects prototyping testing experiments design validation)
  https://www.sciencebuddies.org

- Autodesk Fusion 360 (prototyping CAD modeling simulation testing tools) https://www.autodesk.com/products/fusion-360
- Maker Ed (hands on prototyping iteration maker education) https://makered.org
- Fab Foundation (digital fabrication prototyping innovation labs) https://fabfoundation.org

10. Project Management and Workflow

- Trello (project management task tracking workflow organization) https://trello.com
- Smartsheet (project templates scheduling workflow planning tools) Smartsheet
- Asana (project planning collaboration timelines team workflow) https://asana.com
- PMI (project lifecycle planning monitoring management strategies) https://www.pmi.org

11. Engineering Communication and Documentation

- Purdue OWL Technical Writing (engineering writing reports documentation) https://owl.purdue.edu
- Google Docs and Slides (collaboration documentation presentations tools) https://workspace.google.com/products/docs/
- Canva (visual communication presentations design tools) https://www.canva.com
- IEEE (engineering communication standards technical reporting) https://www.ieee.org

12. Collaboration Ethics and Professional Responsibility

- National Society of Professional Engineers (engineering ethics professional standards) https://www.nspe.org
- Ethics Education Library (engineering ethics case studies decision making) https://www.onlineethics.org
- Edutopia Collaboration (teamwork communication collaboration strategies) https://www.edutopia.org

13. Leadership

- Overcoming Obstacles (leadership communication decision making goal setting life skills) https://www.overcomingobstacles.org/
- Texas A&M Center for Teaching Excellence Group Work Guide (teamwork collaboration accountability communication) https://cte.tamu.edu/resources/practical-guide-effective-group-work.html
- George Mason University Leadership and Team Building Activities (leadership teamwork communication group activities) https://clie.gmu.edu/leadershipteamactivities/

- University of Colorado Boulder Leadership Styles Exercise (leadership styles self awareness feedback collaboration)
  https://fieldsafe.colorado.edu/sites/default/files/2024-06/Module%202_Leadership%20Styles%20Exercise.pdf

14. Work-Based Learning

- CareerOneStop GetMyFuture (career exploration job search training resumes work experience)
  https://www.careeronestop.org/GetMyFuture/default.aspx
- University of Florida Internship Co-op and Work-Based Learning (internships co-ops experiential learning career readiness)
  https://careerhub.ufl.edu/channels/internship-co-op-work-based-learning/
- San José State University Free Digital Career Tools (resume interview career planning job simulations)
  https://careercenter.sjsu.edu/resources/free-digital-career-tools/
- Central Virginia Community College Work Based Learning (internships apprenticeships job shadowing professional skills)
  https://centralvirginia.edu/work-based-learning

15. Final Assessment Project

- Northeastern University Sample Documents for Capstone (proposal report presentation final project examples)
  https://ece.northeastern.edu/fac-ece/dimarzio/capstone/samples/index.html
- Rensselaer Polytechnic Institute Final Design Report Guide (final report documentation executive summary project reflection)
  https://designlab.eng.rpi.edu/edn/projects/capstone-support-dev/wiki/Final_Design_Report
- Rutgers University Capstone Project Report Guidelines (project structure methods results standards final report)
  https://ece.rutgers.edu/sites/default/files/2024-03/Capstone-Project-Report-Guidelines.pdf
- Colorado School of Mines Capstone Design Showcase (final presentations engineering projects showcase examples)
  https://capstone.mines.edu/showcase/

Technology Student Association – National Competitive Events

Engineering Design

Objective: *Students will identify an engineering problem, develop a researched solution, create a prototype or model, document the engineering design process, and present the final solution in alignment with TSA Engineering Design competition requirements.*

- Identify and define an engineering problem with clear criteria, constraints, and intended impact.
- Research existing solutions, relevant technologies, user needs, and design considerations connected to the selected problem.
- Develop and evaluate multiple design concepts before selecting a final solution.
- Create a prototype or model that represents and supports the proposed engineering solution.
- Prepare a display that communicates the problem, design process, prototype, and final solution clearly and professionally.
- Compile documentation that records research, design development, testing, revisions, and final decisions.
- Present and defend the engineering solution using TSA evaluation criteria for problem identification, innovation, prototype/model quality, documentation, and communication.

Resources

- Technology Student Association – Engineering Design competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Engineering Design Process – TeachEngineering https://www.teachengineering.org/k12engineering/designprocess
- NASA Engineering Design Process https://www.nasa.gov/stem-content/engineering-design-process/
- Autodesk Fusion – Design, modeling, and prototyping tools https://www.autodesk.com/products/fusion-360/education

Technology Student Association – National Competitive Events

Technology Problem Solving

Objective - *Students will work as a team to solve an on-site engineering and technology challenge by designing, constructing, testing, and refining a finite solution using limited materials and tools.*

- Analyze an on-site problem, evaluation criteria, and available materials within a limited time frame.
- Collaborate with a partner to plan, construct, and refine a physical solution.
- Use only approved materials, tools, adhesives, and measuring devices during the construction process.
- Apply safe tool use and required safety eyewear procedures throughout the event.
- Construct a solution that can be tested using an objective measure such as time, distance, strength, or performance.
- Evaluate design choices based on efficiency, accuracy, durability, and measurable performance.
- Reflect on team communication, problem solving, creativity, and design tradeoffs after testing.

Resources

- Technology Student Association – Technology Problem Solving competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- TeachEngineering – Hands-on engineering design challenges https://www.teachengineering.org/
- Science Buddies – Engineering Design Process https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps
- OSHA – Young Worker Safety and Health https://www.osha.gov/young-workers

Technology Student Association – National Competitive Events

System Control Technology

Objective: *Students will design, construct, program, demonstrate, and explain a working control-system solution that responds to a stated problem and meets TSA System Control Technology competition criteria.*

- Analyze a system-control problem and identify the required attributes, constraints, and performance criteria.
- Design a working system that integrates mechanical, electrical, and/or programmable components.
- Construct a solution using efficient material choices and organized assembly practices.
- Develop a logical program structure that controls the system and allows the solution to function as intended.
- Test and troubleshoot the system to improve reliability, accuracy, and performance.
- Demonstrate the completed system for judges and explain how the solution meets the problem criteria.
- Communicate the design process, programming decisions, and leadership or 21st century skills used during development.

Resources

- Technology Student Association – System Control Technology competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Arduino Education – Electronics, coding, and control systems https://www.arduino.cc/education
- VEX Robotics STEM Labs – Mechanisms, sensors, and programming https://education.vex.com/
- PhET Interactive Simulations – Circuit Construction Kit https://phet.colorado.edu/