# Introduction to Engineering Design

**Level:** 1
**Career Cluster:** Advanced Manufacturing
**Program:** Engineering
**Pathway:** Aerospace Engineering Technician, Engineering

## Course Catalog Description

Teaches students how engineers solve real-world problems through design, research, and testing. Students build skills in CAD, prototyping, teamwork, and technical communication while exploring engineering careers and pathways.

## Summary

Introduces students to the principles, practices, and pathways that shape modern engineering, with a focus 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. 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 machines, energy, force, motion, 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.

## Notes

This revised document reflects a more intentionally structured and modernized course framework that better aligns with current engineering education expectations and CTE pathway design. The updated version expands beyond a general introduction to engineering concepts by organizing the course into clearer instructional strands, including foundations of engineering systems, safety and professional practices, the engineering design process, research and ideation, technical sketching and CAD, measurement and data analysis, engineering systems, prototyping and testing, project management, communication, collaboration, leadership, and work-based learning. In contrast to the earlier course, the new document places stronger emphasis on authentic application of knowledge through iterative design, documentation, presentation, and reflection, while also strengthening connections to career exploration, postsecondary opportunities, workplace readiness, ethics, and professional responsibility. Overall, the revised course is more comprehensive, better sequenced for instruction, and more clearly designed to prepare students for advanced engineering coursework, industry-aligned experiences, and future postsecondary and career pathways.

## Student Learning Outcomes

### 1. Career Exploration and Postsecondary Opportunities

***Objective**: Students will explore and analyze career pathways related to engineering 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 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. 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.*

5) Define engineering and its relationship to science, technology, and mathematics.
6) Describe various engineering disciplines and their applications.
7) Explain how engineering solves real-world problems.
8) Analyze how engineering innovations impact society, economy, and environment.
9) Evaluate the role of engineers in addressing global challenges.

### 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.*

26) Identify elements of technical sketches and engineering drawings.
27) Create freehand sketches to represent design ideas.
28) Develop 2D and 3D CAD models of engineering designs.
29) Interpret technical drawings and visual representations.
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.*

31) Measure physical properties using standard and metric systems.
32) Calculate ratios, forces, and simple engineering relationships.
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.

## 8. Engineering Systems: Mechanics, Energy, and Circuits

***Objective:*** *Students will analyze and apply principles of mechanical and electrical systems in engineering design.*

36) Identify simple and complex machines and their functions.
37) Explain energy, force, and motion concepts in systems.
38) Apply Ohm's Law to basic electrical circuits.

39) Analyze how systems components interact.
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.

## 12. Final Assessment Project

***Objective:*** *Students will complete a comprehensive engineering project that demonstrates technical knowledge, design process application, communication, and professional skills.*

58) Complete a final engineering project that integrates research, design, prototyping, testing, and presentation.
59) Apply course knowledge and technical skills to develop a solution to an engineering challenge.
60) Document the project process, decisions, and results using industry-appropriate formats.
61) Present and defend the final project using evidence, technical language, and reflection on outcomes.

## 13. Leadership

***Objective:*** *Students will develop leadership skills through collaboration, initiative, decision-making, and participation in career and technical student organization activities or other professional learning experiences.*

62) Demonstrate leadership skills such as responsibility, initiative, and accountability in individual and team settings.
63) Apply communication, collaboration, and conflict-resolution strategies to support group success.
64) Participate in leadership development activities connected to engineering or CTSO experiences.
65) Reflect on personal leadership strengths and areas for growth in academic and workplace contexts.

## 14. Work-Based Learning

***Objective:*** *Students will connect classroom learning to workplace expectations through career exploration, industry engagement, and authentic professional experiences.*

66) Explore work-based learning opportunities related to engineering, such as job shadows, internships, mentorships, apprenticeships, or industry-sponsored projects.
67) Demonstrate workplace readiness skills, including punctuality, communication, teamwork, problem-solving, and professional conduct.
68) Apply classroom knowledge and technical skills in authentic workplace settings.
69) Reflect on work-based learning experiences to evaluate personal strengths, career interests, and areas for growth.

## 15. 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 discussion during the design process. |
| 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. |
| 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, and project documentation. |

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|---|---|---|---|
| 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 professionally within teams. |
| 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. |
| 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 and evaluate information to inform engineering decisions. |

## Free Resource Links

### 1. Career Exploration and Postsecondary Opportunities

- CareerOneStop (career exploration certifications salary education pathways)
  CareerOneStop
- O*NET Online (career profiles tools workplace skills job expectations)
  O*NET Online
- Bureau of Labor Statistics Occupational Outlook Handbook (job outlook education pathways salary data)
  BLS Occupational Outlook
- Colorado Community College System (Colorado programs degrees certificates pathways)
  Colorado Community College System

### 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 (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)
  Engineering Design Guide
- GoLeanSixSigma (problem solving structured processes decision making tools)
  GoLeanSixSigma

### 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) Google 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. Final Assessment Project

- Utah State Board of Education Engineering Capstone Rubric (capstone project rubric presentation criteria prototype testing evaluation) https://schools.utah.gov/cte/_cte/strands/EngineeringCapstoneProjectRubric.pdf
- RIT Culminating Project Scoring Guide (presentation rubric research content organization delivery) https://www.rit.edu/educationaleffectiveness/sites/rit.edu.educationaleffectiveness/files/documents/1%20Capstone%20Rubric%20PDF.pdf
- PSU ECE Capstone Forms and Downloads (self assessment project schedule test plan oral presentation rubric) https://sites.google.com/pdx.edu/psu-ece-capstone/forms-and-downloads

- ANU Capstone Design Project Assessment Guide (project audits reflection showcase assessment timeline)
  https://eng.anu.edu.au/engage/capstone-design-project/information-students/assessment-guide-capstone-project

## 14. Leadership

- DiscoverE Engineering Projects for Group Work (teamwork collaboration project management engineering challenges)
  https://discovere.org/stem-activities/engineering-projects-for-group-work/
- Cornell Group Teambuilding Games and Initiatives (communication teamwork leadership problem solving activities)
  https://scl.cornell.edu/sites/scl/files/downloads/basic_page/Group%20Teambuilding%20Games%20and%20Initiatives%20.pdf
- Worksheet Zone Leadership Skills Activities for Students (communication decision making accountability teamwork)
  https://worksheetzone.org/blog/leadership-skills-activities-for-students
- Teen Truth Student Leadership Activities and Lessons (student leadership service motivation discussion activities)
  https://teentruth.net/student-leadership-activities/

## 15. Work-Based Learning

- Forage (virtual job simulations career readiness workplace tasks professional skills)
  https://www.theforage.com/
- IBM SkillsBuild (career readiness digital credentials workplace technology skills)
  https://skillsbuild.org/
- Job Corps (career training workplace preparation employability pathways)
  https://www.jobcorps.gov/
- U.S. Department of Labor Skills Training Grants (workforce development training grants career pathways)
  https://www.dol.gov/agencies/eta/skills-training-grants

## 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/