Applied Engineering Design

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

Course Catalog Description

Students investigate real-world problems and develop practical engineering solutions through research, design, prototyping, and testing. Students apply math, science, technical communication, and teamwork to plan, refine, and present projects while exploring engineering careers, ethics, safety, and innovation.

Summary

Engineering course that prepares students to investigate real-world problems and develop practical, evidence-based design solutions. Through exploration of engineering careers, ethics, safety, and innovation, students build an understanding of professional responsibilities and postsecondary pathways in the field. Students apply scientific inquiry, mathematical reasoning, measurement, and systems thinking to analyze problems, test ideas, and make informed design decisions. They create technical drawings, reports, presentations, and engineering documentation to communicate ideas clearly, while also using the engineering design process to define problems, evaluate constraints, develop prototypes, and optimize solutions based on data and feedback. Emphasis is placed on collaboration, project management, and professional communication as students work in teams to plan, execute, and present engineering projects from concept to final delivery. Students also strengthen leadership abilities and workplace readiness through team-based problem solving, professional interactions, and reflection on project outcomes. By the end of the course, learners are prepared to connect classroom engineering experiences to future education, training, and career opportunities in the engineering field.

Notes

This revised document significantly expands and modernizes the course structure by organizing content into clearer, more comprehensive learning domains and adding greater emphasis on technical communication, systems thinking, stakeholder-informed design planning, prototype optimization, leadership, and work-based learning. While the previous course focused primarily on broad engineering concepts such as ethics, scientific investigation, safety, measurements, control systems, economics, and team projects, the new version builds those ideas into a more detailed progression of objectives and performance indicators that better reflect current engineering practices and college- and career-readiness expectations. Updates also include stronger attention to design documentation, project management, collaboration, professionalism, and career preparation, resulting in a course that is more explicit, applied, and aligned to contemporary CTE instructional priorities. In addition, the revised format provides clearer guidance for instruction, assessment, and curriculum alignment across course units. These changes make the course easier to implement consistently while offering students a more intentional progression of engineering knowledge, technical skills, and workplace competencies.

Student Learning Outcomes

1. Career Exploration and 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. Engineering Ethics and Innovation

Objective: *Students will analyze the role of engineers in society, differentiate engineering from related fields, and evaluate how ethics, innovation, and intellectual property shape engineering practice.*

5) Explain how engineering and technology have evolved over time and predict how emerging technologies may influence future design work.
6) Evaluate the impact of engineering innovation on quality of life, industry, and the economy.
7) Analyze ethical expectations and professional responsibilities in engineering practice.
8) Explain the purpose of patents and intellectual property protections in engineering and invention.
9) Assess how engineering decisions can affect communities, sustainability, and public safety.
10) Examine case studies of engineering successes and failures to draw conclusions about ethics and responsibility.

3. Scientific Inquiry and Engineering Investigation

Objective: *Students will apply scientific reasoning and evidence-based investigation methods to explore engineering questions and support design decisions.*

11) Define science and describe its limitations in solving engineering problems.
12) Distinguish between hypotheses, theories, and engineering assumptions.
13) Plan and conduct descriptive, comparative, and experimental investigations.
14) Formulate testable questions and hypotheses related to engineering challenges.

15) Select and use appropriate tools, equipment, and technologies during investigations.
16) Collect, organize, and interpret qualitative and quantitative data with accuracy and precision.
17) Analyze data to identify patterns, trends, and relationships that inform design decisions.
18) Communicate valid conclusions using lab reports, visuals, journals, oral presentations, and digital tools.
19) Design a fair test that isolates variables in an engineering investigation.
20) Evaluate the reliability of data sources, methods, and test results.

4. Safety, Resources, and Responsible Engineering Practice

Objective: *Students will demonstrate safe and responsible engineering practices while managing materials, tools, and resources in laboratory and design environments.*

21) Demonstrate safe practices during engineering laboratory and field activities.
22) Apply procedures for proper use, conservation, disposal, and recycling of materials.
23) Evaluate how safety, environmental, and social concerns influence engineering decisions.
24) Create a basic safety plan for a design activity or prototype build.
25) Inspect and select tools and materials appropriate to a given design task.
26) Justify responsible material choices based on cost, waste, durability, and sustainability.

5. Engineering Math, Measurement, and Systems Thinking

Objective: *Students will apply mathematics, measurement, and systems concepts to develop, test, and refine engineering solutions.*

27) Apply scientific processes and engineering concepts to solve design problems.
28) Apply mathematical procedures and functions relevant to engineering design challenges.
29) Select and use appropriate mathematical models to support engineering solutions.
30) Judge the reasonableness of mathematical models and calculated results.
31) Investigate the chemical, mechanical, biological, electrical, and physical properties of materials as they relate to design choices.
32) Identify inputs, processes, outputs, controls, and feedback in engineered systems.
33) Compare and contrast open-loop and closed-loop control systems.
34) Make accurate measurements, specify tolerances, and use customary and SI units appropriately.
35) Convert between measurement systems to solve real-world engineering problems.
36) Construct simple free-body diagrams to represent forces acting on an object.
37) Interpret graphs, formulas, and technical data to support design decisions.
38) Use spreadsheets or digital tools to organize calculations and compare design variables.

6. Technical Communication and Engineering Documentation

Objective: *Students will communicate engineering ideas clearly through sketches, drawings, technical writing, data displays, and formal presentations.*

39) Create visual representations of ideas through sketches and technical drawings using engineering conventions.
40) Read and interpret technical documents, specifications, and procedures.

41) Prepare professional written documents such as emails, design proposals, technical reports, and procedural directions.
42) Organize and present information using charts, graphs, tables, and other visual formats for different audiences.
43) Evaluate the quality and relevance of sources and cite them appropriately.
44) Defend a design solution through a structured oral or multimedia presentation.
45) Maintain an engineering notebook that chronicles ideas, sketches, tests, revisions, and reflections.
46) Develop labeled diagrams and annotated design notes that explain the function of a prototype.
47) Tailor communication style and format for technical, client, and peer audiences.

7. Problem Definition, Constraints, and Design Planning

Objective: *Students will define engineering problems and develop design plans that account for criteria, constraints, resources, and stakeholder needs.*

48) Identify and define an engineering problem clearly.
49) Formulate goals, objectives, and requirements for a successful solution.
50) Determine design parameters such as materials, personnel, resources, time, funding, feasibility, and manufacturability.
51) Evaluate constraints related to health, safety, environment, ethics, law, and regulations.
52) Research existing engineered and natural solutions to inform planning.
53) Generate multiple possible solutions using strategies such as brainstorming and reverse engineering.
54) Write a design brief that defines the problem, audience, criteria, and constraints.
55) Analyze stakeholder needs and user requirements before selecting a solution path.
56) Prioritize design criteria to guide trade-off decisions during development.

8. Prototyping, Testing, and Design Optimization

Objective: *Students will create, test, and refine prototypes using data, decision-making tools, and iterative design practices.*

57) Create models, prototypes, mock-ups, simulations, or experimental tests to evaluate a proposed solution.
58) Apply structured decision-making tools such as decision trees, design matrices, and cost-benefit analysis to justify a preferred solution.
59) Predict performance, reliability, and likely failure modes of a design solution.
60) Analyze and critique findings from product testing and project results.
61) Revise a design based on evidence from testing, feedback, and performance data.
62) Compare alternative materials, structures, or mechanisms to improve performance.
63) Use digital modeling or CAD tools to visualize and refine a proposed solution.
64) Optimize a design to better balance function, cost, safety, and usability.

9. Applied Engineering Design Project

Objective: *Students will collaborate in teams to manage an engineering project from planning through final presentation and reflection.*

65) Participate in a real-world engineering project using project management phases such as initiating, planning, executing, monitoring, controlling, and closing.
66) Develop a project plan and timeline for completion of a design challenge.
67) Work collaboratively in teams and share responsibilities effectively.
68) Compare and perform the roles of team leader and contributing team member.
69) Manage project resources needed to complete a design task.
70) Use a budget to identify strategies for meeting cost constraints.
71) Create a basic risk assessment for an engineering design project.
72) Prepare a final project report documenting designs, decisions, testing, and revisions across the engineering design process.
73) Present a final engineering solution to an audience and justify design decisions with evidence.
74) Reflect on individual and team performance to identify strengths, challenges, and next steps.
75) Use peer and instructor feedback to improve the final design deliverable.

10. Leadership

Objective: *Students will demonstrate leadership skills by collaborating effectively, taking initiative, communicating professionally, and contributing to successful team and project outcomes in engineering settings.*

76) Demonstrate effective leadership skills in classroom, laboratory, and project environments.
77) Apply collaboration, conflict resolution, and decision-making strategies to support team success.
78) Model accountability, dependability, and ethical behavior when completing responsibilities.
79) Demonstrate initiative and leadership in planning, organizing, and completing engineering-related tasks and activities.
80) Communicate professionally with peers, instructors, mentors, and stakeholders in collaborative settings.

11. Work-Based Learning

Objective: *Students will connect classroom learning to workplace expectations by exploring work-based learning experiences, demonstrating employability skills, and reflecting on career readiness in engineering-related contexts.*

81) Identify the purpose and benefits of work-based learning experiences such as internships, job shadows, mentorships, apprenticeships, and industry projects.
82) Demonstrate employability skills such as punctuality, communication, teamwork, adaptability, and professionalism in authentic workplace settings.
83) Apply technical and workplace safety knowledge during work-based learning experiences or career-connected projects.
84) Reflect on work-based learning experiences to evaluate personal strengths, growth areas, and future career goals.
85) Develop career readiness materials such as resumes, portfolios, interview responses, or professional reflections aligned to engineering pathways.

12. 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: Applied 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 teams, participate in collaborative design, testing, and refinement, and demonstrate leadership and active listening during project development.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences.	Students present design solutions, explain engineering decisions and results, and communicate findings to peers, instructors, and stakeholders.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts.	Students read and interpret technical and scientific information, engineering specifications and data, and safety guidelines and research materials.

Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts.	Students use discipline-specific engineering language and adapt communication for technical versus non-technical audiences.
Standard 3: Writing and Composition	Prepared Graduate 6 – Craft Arguments	Craft arguments using techniques specific to the genre.	Students justify design choices, defend solutions with evidence and reasoning, and explain why selected designs best meet criteria and constraints.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational and explanatory texts.	Students produce engineering reports, technical explanations, and documentation of processes and systems.
Standard 3: Writing and Composition	Prepared Graduate 9 – Writing Process	Demonstrate mastery of their own writing process.	Applied Engineering Design requires iterative drafting, revising, and refining, resulting in clear, accurate, and polished technical products.
Standard 4: Research Inquiry and Design	Prepared Graduate 10 – Research and Ethics	Gather information from a variety of sources.	Students conduct research to inform designs, analyze and evaluate data, and use information ethically to support conclusions.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- Engineering Career Explorer O NET Online (engineering careers job data skills outlook)
  https://www.onetonline.org
- Explore Engineering Careers TryEngineering (engineering pathways career exploration student resources)
  https://tryengineering.org
- STEM Career Resources NASA STEM Engagement (STEM careers engineering pathways workforce insight)
  https://www.nasa.gov/stem
- Career Planning Tools CareerOneStop (career planning certifications salary data pathways)
  https://www.careeronestop.org

2. Engineering Ethics and Innovation

- Engineering Ethics National Society of Professional Engineers NSPE (engineering ethics professional responsibility case studies)
  https://www.nspe.org/resources/ethics
- Intellectual Property Basics United States Patent and Trademark Office USPTO (patents intellectual property invention protection)
  https://www.uspto.gov
- Engineering Innovation Resources MIT OpenCourseWare (engineering innovation design thinking emerging technologies)
  https://ocw.mit.edu
- Engineering Case Studies Engineers Without Borders (real world engineering challenges ethics global impact)
  https://www.ewb-usa.org

3. Scientific Inquiry and Engineering Investigation

- Science and Engineering Practices Next Generation Science Standards NGSS (scientific inquiry engineering investigation practices)
  https://www.nextgenscience.org
- Data Analysis Tools CODAP Common Online Data Analysis Platform (data visualization analysis student investigations)
  https://codap.concord.org
- Engineering Experiments TeachEngineering (engineering investigations experiments classroom lessons)
  https://www.teachengineering.org
- Lab Report Resources Purdue OWL (technical writing lab reports data communication)
  https://owl.purdue.edu

4. Safety, Resources, and Responsible Engineering Practice

- Engineering Lab Safety Flinn Scientific (lab safety procedures equipment safety guidelines)
  https://www.flinnsci.com
- OSHA Workplace Safety Occupational Safety and Health Administration OSHA (safety standards workplace regulations hazard prevention)
  https://www.osha.gov
- Environmental Responsibility EPA Education Environmental Protection Agency (sustainability environmental impact engineering responsibility)
  https://www.epa.gov/students
- Safety Training Resources CareerSafe (workplace safety training risk management OSHA basics)
  https://www.careersafeonline.com

5. Engineering Math, Measurement, and Systems Thinking

- Engineering Math Tutorials Khan Academy (measurement algebra geometry engineering math skills)
  https://www.khanacademy.org
- Systems Thinking Resources Waters Center for Systems Thinking (systems thinking models feedback loops engineering systems)
  https://waterscenterst.org
- Engineering Simulation Tools PhET Interactive Simulations (scientific modeling measurement systems simulations)
  https://phet.colorado.edu
- Unit Conversion Calculator NIST (measurement conversions SI units engineering calculations)
  https://www.nist.gov

6. Technical Communication and Engineering Documentation

- Technical Writing Resources Purdue OWL (technical writing reports engineering communication)
  https://owl.purdue.edu
- Engineering Drawing Basics Engineering Toolbox (technical drawings diagrams communication standards)
  https://www.engineeringtoolbox.com
- Presentation Skills Toastmasters Resources (public speaking presentations professional communication)
  https://www.toastmasters.org/resources
- Engineering Notebook Guide Science Buddies (engineering notebook documentation process design records)
  https://www.sciencebuddies.org

7. Problem Definition, Constraints, and Design Planning

- Engineering Design Process NASA Engineering Design (problem solving design constraints planning process)
  https://www.nasa.gov/stem/engineering-design-process
- Design Thinking Toolkit IDEO Design Kit (design thinking brainstorming prototyping user centered design)
  https://www.designkit.org
- Project Planning Tools Smartsheet Project Management Basics (project planning timeline task management)
  https://www.smartsheet.com/project-management
- Brainstorming Techniques MindTools (idea generation problem solving strategies planning)
  https://www.mindtools.com

8. Prototyping, Testing, and Design Optimization

- Prototyping Resources Autodesk Education (CAD prototyping modeling design optimization)
  https://www.autodesk.com/education
- Testing and Analysis TeachEngineering (prototype testing evaluation design improvement)
  https://www.teachengineering.org
- CAD Modeling Tutorials Tinkercad (3D modeling prototyping beginner CAD design tools)
  https://www.tinkercad.com
- Engineering Optimization Resources MathWorks (optimization data analysis modeling engineering design improvement)
  https://www.mathworks.com

9. Applied Engineering Design Project

- Project Management Basics Project Management Institute PMI (project management teamwork planning execution)
  https://www.pmi.org
- Collaboration Tools Microsoft Learn (team collaboration digital tools communication workflows)
  https://learn.microsoft.com
- Teamwork Skills SkillsYouNeed (collaboration communication teamwork problem solving)
  https://www.skillsyouneed.com
- Presentation and Portfolio Resources Canva Design School (presentation design portfolio communication visuals)
  https://www.canva.com/learn

10. Leadership

- Engineering Leadership Development Penn State Engineering (leadership development teamwork innovation communication)
  https://www.sedi.psu.edu/eld/index.aspx
- Engineering Communications Program Cornell Engineering (professional communication presentations technical communication)
  https://www.duffield.cornell.edu/engineering-communications-program/
- Engineering Leadership Program University of Colorado Boulder (leadership inquiry character complex challenges)
  https://www.colorado.edu/engineering/academics/engineering-leadership-program
- Leadership Courses Michigan Engineering (leadership strategies team motivation communication skills)
  https://ope.engin.umich.edu/pe/leadership/

11. Work-Based Learning

- Work-Based Learning Colorado Community College System (apprenticeships earn and learn career-connected learning)
  https://cccs.edu/academic-student-affairs/workforce-development/work-based-learning/
- Job Shadows Oregon State University Career Development Center (job shadow career exploration workplace observation)
  https://career.oregonstate.edu/explore-careers/job-shadows
- Discovery Learning Apprenticeship University of Colorado Boulder (research apprenticeship engineering experience mentorship)
  https://www.colorado.edu/engineering/discovery-learning-apprenticeship-dla-program
- Work-Based Learning Great Plains Technology Center (internships job shadowing apprenticeships career readiness)
  https://www.greatplains.edu/wbl

Technology Student Association – National Competitive Events

Engineering Design

Objective: *Students will research a grand engineering challenge, develop and test a prototype or model, document the engineering design process, and present a solution aligned with TSA Engineering Design competition requirements.*

- Research the annual TSA Engineering Design theme and connect it to one of the National Academy of Engineering Grand Challenges.
- Identify a specific engineering problem with clear goals, constraints, users, and design requirements.
- Develop alternative solutions and select a preferred design using research, testing, and engineering reasoning.
- Create and test a prototype or model that represents the proposed engineering solution.
- Prepare a documentation portfolio that records research, design development, testing, revisions, and final decisions.
- Create a display that clearly communicates the problem, prototype/model, design process, and final solution.
- Deliver a team presentation and respond to judge questions about the engineering solution, design decisions, and project impact.

Resources

- Technology Student Association – Engineering Design competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- National Academy of Engineering – Grand Challenges for Engineering https://www.engineeringchallenges.org/
- NASA Engineering Design Process https://www.nasa.gov/stem-content/engineering-design-process/
- Autodesk Fusion – CAD, modeling, simulation, and prototyping tools https://www.autodesk.com/products/fusion-360/education

Technology Student Association – National Competitive Events

Data Science and Analytics

Objective: *Students will collect, analyze, visualize, document, and present a large data set connected to the annual TSA Data Science and Analytics theme.*

- Research the annual TSA Data Science and Analytics theme and identify a focused topic for investigation.
- Collect or compile a data set of at least 500 rows from credible and relevant sources.
- Analyze data to identify patterns, trends, relationships, limitations, and possible conclusions.
- Create a digital scientific poster that communicates the research question, data, analysis, visualizations, and findings.
- Prepare a documentation portfolio that explains the data source, methods, analysis, and conclusions.
- Present the digital scientific poster within the TSA time limit using clear, evidence-based communication.
- Complete an on-site semifinal challenge by creating a visual representation and brief synopsis from a provided data set.

Resources

- Technology Student Association – Data Science and Analytics competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Kaggle Datasets – Public data sets for analysis https://www.kaggle.com/datasets
- Google Dataset Search https://datasetsearch.research.google.com/
- Tableau Public – Data visualization tools https://public.tableau.com/

Technology Student Association – National Competitive Events

Senior Solar Sprint

Objective: *Students will design, construct, test, document, and race a solar-powered model vehicle that meets TSA Senior Solar Sprint competition requirements.*

- Research solar vehicle design, energy transfer, materials, performance factors, and the annual TSA Senior Solar Sprint requirements.
- Design a solar-powered model car that meets dimensional, material, and construction specifications.
- Construct a model vehicle that demonstrates creativity, originality, quality construction, and engineering design.
- Create a display and decorated shoebox that professionally present the solar model and design concept.
- Test and refine the vehicle to improve performance, reliability, alignment, and race-readiness.
- Participate in time trials, inspection, interview, and final race procedures according to TSA competition rules.
- Evaluate the final vehicle using TSA criteria for model design, creativity, construction quality, display, interview, and race performance.

Resources

- Technology Student Association – Senior Solar Sprint competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- National Renewable Energy Laboratory – Solar energy basics https://www.nrel.gov/research/re-solar.html
- U.S. Department of Energy – Solar Energy Technologies Office https://www.energy.gov/eere/solar/solar-energy-technologies-office
- Autodesk Fusion – CAD/CAM tools for vehicle design and prototyping https://www.autodesk.com/products/fusion-360/education