Principles of Manufacturing - AES

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

Course Catalog Description

Principles of Aerospace Manufacturing introduces students to the basic concepts and skills used in modern manufacturing with an emphasis on aerospace systems, components, and production environments. Students explore aerospace manufacturing processes, safety, tools, materials, quality requirements, and career pathways while building problem-solving and employability skills.

Summary

Principles of Aerospace Manufacturing introduces students to the foundational knowledge and skills used in modern manufacturing systems and aerospace careers. Students explore aerospace manufacturing career pathways, postsecondary opportunities in Colorado, and the professional, ethical, legal, and regulatory responsibilities required in the field. Through the study of aerospace manufacturing processes, advanced materials, tools, equipment, automation, precision measurement, and safety practices, students learn how aircraft and spacecraft components are designed, produced, inspected, assembled, and improved. The course also develops students' ability to read technical drawings, interpret specifications and tolerances, apply quality control principles, and analyze workflow, traceability, and continuous improvement in production settings. Students engage in problem solving, technical communication, and design-based learning to better understand how aerospace manufacturing connects to engineering, technology, national defense, commercial aviation, and the global economy. By the end of the course, students build a strong foundation in both technical and employability skills needed for future education and success in aerospace manufacturing careers.

Notes

The updated course reflects a shift from a primarily introductory, process-focused course to a more comprehensive, industry-aligned aerospace manufacturing program. The original course centered on general manufacturing concepts such as basic tools, materials, safety, and production processes, with less emphasis on context or application. In contrast, the revised course organizes these foundational topics into a structured framework with clearly defined learning strands that emphasize aerospace-specific manufacturing systems, quality control, workflow analysis, and technical communication. Additionally, the updated version incorporates career exploration, employability skills, leadership, work-based learning, and a formal final assessment project, while strengthening connections to real-world manufacturing practices such as continuous improvement, precision measurement, and engineering design. These changes enhance alignment with current CTE expectations by emphasizing application, career readiness, and integration of technical and professional skills.

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 Manufacturing Systems

***Objective:** Students will understand and analyze the role of aerospace manufacturing systems in transforming raw materials into flight-ready components and evaluate how aerospace production influences economic, technological, and global systems.*

5) Define aerospace manufacturing and distinguish it from engineering, science, and general manufacturing.
6) Describe the role of aerospace manufacturing in the Colorado, U.S., and global economy.
7) Summarize how aerospace manufacturing systems convert raw materials into finished aircraft, spacecraft, or support components.
8) Explain how technology has influenced aerospace manufacturing processes over time, including automation, composites, and digital production tools.
9) Classify types of aerospace manufacturing systems such as prototype, low-volume precision production, and batch manufacturing.
10) Compare manufacturing systems based on efficiency, cost, and flexibility.

3. Aerospace Safety and Workplace Practices

***Objective:** Students will apply safe practices and analyze hazards to ensure safe, ethical, and responsible behavior in aerospace manufacturing environments.*

11) Explain the importance of safety, compliance, and risk reduction in aerospace manufacturing environments.
12) Identify workplace hazards, foreign object damage risks, and required PPE in aerospace production settings.
13) Apply safe procedures for tools, equipment, and machines.
14) Demonstrate proper workstation setup and safe work habits.
15) Analyze how safety practices impact production quality and efficiency.

4. Tools, Equipment, and Aerospace Manufacturing Technology

Objective: *Students will identify and apply appropriate tools and technologies while evaluating their role in modern aerospace manufacturing systems.*

16) Identify common aerospace manufacturing tools, machines, inspection devices, and production equipment.
17) Explain the function and purpose of manufacturing tools and systems.
18) Demonstrate proper selection of tools for specific tasks.
19) Compare manual vs. automated manufacturing technologies.
20) Evaluate the role of automation, robotics, CNC, and digital manufacturing technologies in aerospace production.

5. Aerospace Manufacturing Processes and Materials

Objective: *Students will analyze and apply aerospace manufacturing processes and material properties to determine appropriate production methods for flight-related components.*

21) Describe major aerospace manufacturing processes such as machining, forming, composite layup, additive manufacturing, and assembly.
22) Differentiate between additive, subtractive, and forming processes.
23) Explain how material properties of aluminum alloys, titanium, composites, and other aerospace materials affect manufacturing choices.
24) Analyze advantages and limitations of various manufacturing processes.
25) Apply process selection criteria to real-world production scenarios.

6. Blueprint Reading and Technical Communication

Objective: *Students will interpret and create technical drawings to communicate manufacturing requirements accurately and effectively.*

26) Identify symbols, line types, and features in technical drawings.
27) Interpret basic blueprints, including dimensions and scale.
28) Explain how drawings communicate manufacturing specifications.
29) Create basic sketches or technical diagrams to represent designs.
30) Evaluate technical drawings for clarity, accuracy, and completeness.

7. Measurement, Quality, and Precision

Objective: *Students will measure and evaluate product quality using appropriate tools and techniques to ensure accuracy and consistency.*

31) Define quality and explain its importance in manufacturing.
32) Describe measurement tools and their applications.
33) Measure components using appropriate tools and techniques.
34) Analyze tolerance, variation, and precision in manufacturing.
35) Apply quality control practices to maintain consistency.

8. Manufacturing Systems, Production, and Workflow

Objective: *Students will analyze and evaluate manufacturing workflows and systems to improve productivity and efficiency.*

36) Describe the sequence of operations in a manufacturing process.
37) Explain how workflow and layout impact production efficiency.
38) Compare production types (mass, batch, custom).
39) Analyze factors affecting productivity (time, cost, labor, materials).
40) Evaluate trade-offs between efficiency, quality, and cost.

9. Quality Assurance and Continuous Improvement

Objective: *Students will apply and evaluate quality assurance processes to improve manufacturing outcomes and reduce variation.*

41) Explain the purpose of quality assurance systems.
42) Describe continuous improvement principles in manufacturing.
43) Analyze how variation impacts product quality.
44) Apply problem-solving strategies to improve processes.
45) Evaluate improvement outcomes using data or observations.

10. Design, Production, and Problem Solving

Objective: *Students will design, test, and refine manufacturing solutions using engineering and production principles.*

46) Describe the relationship between product design and manufacturing.
47) Apply design-thinking or engineering design processes.
48) Develop a plan to build or improve a manufactured product.
49) Test and evaluate product performance or process efficiency.
50) Revise designs or processes based on testing results.

11. Professional Skills and Employability in Manufacturing

Objective: *Students will demonstrate and evaluate professional behaviors and employability skills required for success in manufacturing careers.*

51) Explain employer expectations in manufacturing environments.
52) Demonstrate effective teamwork and collaboration skills.
53) Communicate technical information using appropriate terminology.
54) Apply critical thinking to solve manufacturing problems.
55) Evaluate personal performance and professional growth.

12. Leadership

Objective: *Students will develop and demonstrate leadership skills by taking initiative, communicating effectively, collaborating with others, and reflecting on their growth in manufacturing and CTE settings.*

56) Demonstrate leadership behaviors such as initiative, responsibility, dependability, and ethical decision-making in classroom and project settings.
57) Communicate goals, ideas, and feedback effectively while working with peers, instructors, and industry partners.
58) Apply teamwork and conflict-resolution strategies to support group success and shared decision-making.
59) Participate in leadership activities through CTSO, classroom roles, or collaborative manufacturing tasks.
60) Evaluate personal leadership strengths and areas for growth using reflection and feedback.

13. Work-Based Learning

Objective: *Students will connect classroom learning to workplace experiences by applying technical, academic, and employability skills in authentic work-based learning environments.*

61) Identify career goals and workplace expectations related to manufacturing and aerospace career pathways.
62) Apply technical and employability skills during job shadows, industry-sponsored projects, internships, simulations, or other work-based learning experiences.
63) Demonstrate professional communication, time management, and workplace etiquette in authentic settings.
64) Document work-based learning experiences, tasks, and skill development using logs, journals, checklists, or portfolio evidence.
65) Reflect on workplace performance and use mentor or instructor feedback to improve readiness for future employment or education.

14. Final Assessment Project

Objective: *Students will complete a culminating project that integrates manufacturing knowledge, technical skills, problem solving, communication, and reflection to demonstrate readiness for continued study and career exploration.*

66) Develop a final project plan that identifies a problem, goal, process, materials, timeline, and expected outcomes.
67) Apply manufacturing concepts, safety practices, technical skills, and problem-solving strategies to complete the project.
68) Produce and revise project work based on testing, evidence, critique, or instructor feedback.
69) Present the final project process, results, and learning clearly using appropriate technical vocabulary and supporting evidence.
70) Evaluate the completed project and reflect on personal growth, technical skill development, and next steps for education or career pathways.

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: Principles of Manufacturing
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 collaboratively to explore manufacturing systems and production scenarios while participating in team-based discussions about manufacturing processes and safety, actively listening and contributing ideas to shared problem-solving tasks.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences and varied purposes.	Students verbally explain manufacturing concepts, workflows, and career pathways, present findings from introductory investigations and industry research, and communicate.

Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts to build knowledge.	Students read and interpret informational texts on manufacturing technologies and processes, review industry materials related to manufacturing careers and workplace expectations, and build understanding of how manufacturing systems operate through technical explanations.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts.	Students learn manufacturing-specific terminology and workplace vocabulary, use discipline-specific language in technical, career, and safety contexts, and apply strategies to comprehend unfamiliar technical terms common.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational/explanatory texts using techniques specific to the genre.	Students write explanatory summaries of manufacturing processes and technologies, produce informational writing on manufacturing careers and industry trends, and organize technical information.

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
- U.S. Bureau of Labor Statistics – Occupational Outlook Handbook (job outlook, education pathways, industry trends)
  https://www.bls.gov/ooh/
- Colorado Community College System (Colorado programs, degrees, certificates, pathways)
  https://cccs.edu

2. Foundations of Aerospace Manufacturing Systems

- Learn Lean Sigma (manufacturing fundamentals, Lean concepts, DMAIC, systems thinking)
  https://www.learnleansigma.com/guides/
- MIT Open Learning – Manufacturing Processes (manufacturing systems, production, cost, flow)
  https://openlearning.mit.edu/courses-programs/mitx-courses/fundamentals-manufacturing-processes
- SME Education Resources (manufacturing fundamentals, industry overview)
  https://www.sme.org/technologies/
- HowStuffWorks Manufacturing (basic concepts, how products are made, systems overview)
  https://science.howstuffworks.com/innovation

3. Aerospace Safety and Workplace Practices

- OSHA (workplace safety, PPE, hazard identification, safety standards)
  https://www.osha.gov
- SafetyCulture – Good Manufacturing Practices (GMP, safety, quality procedures)
  https://assets.ctfassets.net/ueprkma36dz5/5bx2jofIF95ISyuWLQQuGe/c65147cc67be9a4c9350658e805cdd16/A-Comprehensive-Guide-to-GMP-Good-Manufacturing-Practices.pdf
- CDC Workplace Safety (hazard prevention, health and safety guidelines)
  https://www.cdc.gov/niosh/
- Manufacturing Institute (workplace expectations, safety culture, industry practices)
  https://themanufacturinginstitute.org

4. Tools, Equipment, and Aerospace Manufacturing Technology

- Tooling U-SME (manufacturing tools, equipment, machining basics)
  https://www.toolingu.com
- Manufacturing Skills Institute (tools, workplace readiness, manufacturing careers)
  https://www.manufacturingskillsinstitute.org

- MITx Manufacturing (technology, automation, systems, operations) https://micromasters.mit.edu/pom/
- AutomationDirect Learning Center (automation, robotics, industrial systems) https://www.automationdirect.com/adc/education

5. Aerospace Manufacturing Processes and Materials

- MIT Manufacturing Processes Course (machining, forming, casting, additive manufacturing) https://openlearning.mit.edu/courses-programs/mitx-courses/fundamentals-manufacturing-processes
- MatWeb Material Database (material properties, metals, plastics, composites) https://www.matweb.com
- Engineers Edge (manufacturing processes, materials science basics) https://www.engineersedge.com
- Manufacturing Guide (process overview, forming, machining, assembly methods) https://www.custompartnet.com

6. Blueprint Reading and Technical Communication

- Open Oregon Blueprint Reading Textbook (lines, dimensions, technical drawings) https://openoregon.pressbooks.pub/blueprint/
- LibreTexts Blueprint Reading (technical drawing interpretation, symbols, visualization) https://batch.libretexts.org/print/Letter/Finished/workforce-5176/Full.pdf
- CCSU Blueprint Reading (interpretation, visualization, drawings in manufacturing) https://pe.ccsu.edu/blueprint-reading/
- Drafting Standards (symbols, dimensioning, technical communication basics) https://www.g-wonlinetextbooks.com

7. Measurement, Quality, and Precision

- NIST Education (measurement, standards, precision, calibration) https://www.nist.gov/education
- Six Sigma Study Guide (quality, variation, measurement systems) https://www.sixsigmacouncil.org
- Statology (basic statistics, data analysis, variation) https://www.statology.org
- Engineering Toolbox (measurement systems, units, tolerances) https://www.engineeringtoolbox.com

8. Manufacturing Systems, Production, and Workflow

- Lean Enterprise Institute (workflow, systems design, efficiency, value stream) https://www.lean.org
- GoLeanSixSigma Resources (process flow, production systems, efficiency) https://goleansixsigma.com/lean-and-six-sigma-resources/
- APICS/ASCM (supply chain, operations, production planning) https://www.ascm.org

- iSixSigma (process flow, system performance, manufacturing optimization)
  https://www.isixsigma.com

9. Quality Assurance and Continuous Improvement

- American Society for Quality (ASQ) (quality systems, continuous improvement, standards)
  https://asq.org
- Lean Six Sigma Resource Library (quality tools, continuous improvement, DMAIC)
  https://www.lssrefresh.com/
- Ever-So-Lean Toolbox (quality tools, 5S, process improvement templates)
  https://eversolean.com/toolbox/
- KPI Fire Resources (continuous improvement, project examples, quality management)
  https://www.kpifire.com/blog/best-free-lean-six-sigma-resources/

10. Design, Production, and Problem Solving

- TeachEngineering (engineering design process, problem solving, projects)
  https://www.teachengineering.org
- IDEO Design Thinking (design process, innovation, problem solving)
  https://designthinking.ideo.com
- Autodesk Education (design tools, CAD, prototyping, manufacturing design)
  https://www.autodesk.com/education
- MIT Design and Manufacturing (design to production systems, engineering design)
  https://micromasters.mit.edu/pom/

11. Professional Skills and Employability in Manufacturing

- CareerReady101 (soft skills, workplace readiness, communication)
  https://www.careerready101.com
- Employability Skills Framework (teamwork, communication, problem solving)
  https://www.cde.state.co.us/standardsandinstruction/essentialskills
- Manufacturing Institute Workforce Resources (career readiness, industry expectations)
  https://themanufacturinginstitute.org/workforce

12. Leadership

- Lead4Change (student leadership, teamwork, communication, service learning)
  https://lead4change.org/
- OER Commons Leadership Resources (leadership lessons, activities, reflection)
  https://oercommons.org/browse?f.keyword=leadership
- edX Free Leadership Courses (leadership, communication, decision making, teamwork)
  https://www.edx.org/courses?q=free+leadership+courses

13. Work-Based Learning

- NAF Work-Based Learning Resources (internships, job shadows, mock interviews, workplace readiness)
  https://ash.naf.org/public/wbl/explore-wbl

- Jobs for the Future Work-Based Learning Framework (career awareness, exploration, preparation, experience)
  https://www.jff.org/idea/work-based-learning-framework/
- ConnectED Work-Based Learning Resources (quality criteria, outcomes, planning tools)
  https://connectednational.org/learn/key-resources/work-based-learning/

14. Final Assessment Project

- University of North Georgia Capstone Toolkit (capstone planning, assessment, revision, evaluation)
  https://ung.edu/center-teaching-learning-leadership/_uploads/files/capstone-toolkit-2025-final.pdf
- EP3 Guide – Capstone Experiences (project design, final product, presentation, reflection)
  https://ep3guide.org/guide/capstone-experiences/
- Oregon State University Showcase Projects (student project examples, prototypes, presentations)
  https://projects.engineering.oregonstate.edu/browse

Technology Student Association – National Competitive Events

Manufacturing Prototype

Objective: *Students will design, document, fabricate, and present a manufactured prototype that meets TSA Manufacturing Prototype requirements for production quality, technical documentation, materials, and product communication.*

- Research the annual TSA Manufacturing Prototype challenge and identify the product requirements, constraints, and intended audience.
- Develop a prototype concept using sketches, technical drawings, CAD models, or other design-planning tools.
- Create working drawings, detail drawings, a parts list, and other documentation needed to communicate the design.
- Fabricate a prototype using appropriate manufacturing processes, materials, tools, and equipment.
- Document construction, testing, revisions, strengths, weaknesses, materials, and production decisions in a portfolio.
- Prepare a bill of materials and work log that communicate the manufacturing process.
- Present a sales pitch explaining the product, design decisions, production process, cost considerations, and final prototype.

Resources

- Technology Student Association – Manufacturing Prototype competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Autodesk Fusion – CAD/CAM design and manufacturing tools https://www.autodesk.com/products/fusion-360/education
- Xometry – Manufacturing and prototyping process resources https://www.xometry.com/resources/
- Onshape Education – Browser-based CAD and product design tools https://www.onshape.com/en/education/

Technology Student Association – National Competitive Events

Technology Problem Solving

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

- Analyze an on-site TSA problem and identify the required task, constraints, materials, and scoring criteria.
- Collaborate with a partner to plan and construct a working solution within the competition time limit.
- Use approved materials, tools, adhesives, measuring devices, and safety procedures during construction.
- Apply engineering, manufacturing, and technology concepts to improve the performance of the solution.
- Test the solution using the required objective measure, such as strength, distance, time, accuracy, or task completion.
- Revise the solution based on observed performance and available time.
- Evaluate the final product using TSA criteria for problem solving, construction quality, teamwork, and measurable performance.

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

Promotional Design

Objective: *Students will design, produce, document, and present promotional materials that meet TSA Promotional Design requirements for branding, visual communication, production quality, and portfolio documentation.*

- Research the annual TSA Promotional Design theme, target audience, required products, and branding expectations.
- Develop a consistent visual identity using appropriate typography, layout, color, imagery, and design principles.
- Create required promotional items that communicate a clear theme, message, and purpose.
- Use digital design tools and production methods to prepare clean, professional, and usable final products.
- Document the design process through sketches, drafts, production notes, references, and required portfolio materials.
- Prepare final promotional products for submission or display according to TSA event procedures.
- Evaluate the final entry using TSA criteria for creativity, consistency, production quality, communication, and theme alignment.

Resources

- Technology Student Association – Promotional Design competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Adobe Express – Promotional graphics and design tools https://www.adobe.com/express/
- Canva – Branding, layouts, and promotional design templates https://www.canva.com/
- Adobe Illustrator – Vector design and production graphics https://www.adobe.com/products/illustrator.html