Aerodynamics - AES

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

Course Catalog Description

Introduces students to the principles of aerodynamics within a broader aerospace context, including the forces that affect atmospheric flight and the ways those principles inform aircraft, launch vehicles, reentry systems, and other space-related applications. Students apply concepts such as lift, drag, stability, control, and performance through analysis, modeling, and technical communication while exploring safety, aerospace careers, and postsecondary pathways.

Summary

This course provides students with a comprehensive introduction to aerodynamics through the study of airflow, pressure, lift, drag, stability, and vehicle performance across a range of aerospace applications. Students examine the four forces of flight, the behavior of airflow over airfoils, and the ways wing design, angle of attack, and vehicle configuration affect lift, drag, and overall efficiency in aircraft, uncrewed aerial systems, rockets during atmospheric flight, and spacecraft during launch and reentry. The course also explores flight stability and control, performance factors such as weight, balance, propulsion, and environmental conditions, as well as the aerodynamic considerations involved in takeoff, landing, ascent, descent, stalls, and other safety-related scenarios. In addition, students interpret aerodynamic data, use models or simulations to analyze performance, and communicate technical findings using appropriate aerospace vocabulary, diagrams, and written explanations. Career exploration, professionalism, ethics, and postsecondary opportunities in aeronautics, astronautics, and aerospace-related fields are embedded throughout the course to support informed academic and career planning. Federal Aviation Administration: https://www.faa.gov/regulations_policies/

Notes

The updated course reflects a shift from a primarily theory-based study of flight concepts to a more comprehensive, application-driven aerospace course. The original course focused mainly on foundational principles such as lift, drag, airflow, and basic aircraft performance with limited applied context. In contrast, the revised course expands these core concepts into a structured framework that emphasizes analysis, modeling, and application across a wider range of aerospace systems, including aircraft, uncrewed aerial systems, rockets, and reentry vehicles. Additionally, the updated version incorporates data analysis, simulation, technical communication, safety and risk evaluation, and real-world performance scenarios, while embedding career exploration, leadership, work-based learning, and a formal final project. These updates strengthen alignment with current CTE expectations by emphasizing applied learning, systems thinking, and career readiness in aerospace contexts while maintaining foundational aerodynamic principles.

Student Learning Outcomes

1. Career Exploration and Postsecondary Opportunities

Objective: *Students will analyze career pathways in aerospace engineering technician 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 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 Aerodynamics

Objective: *Students will explain foundational aerodynamic concepts and terminology, relate atmospheric conditions to flight behavior, and describe airflow over airfoils and external vehicle surfaces in order to build a conceptual base for analyzing aircraft and space system performance during atmospheric flight.*

5) Define key aerodynamic terminology (airflow, pressure, lift, drag).
6) Explain the relationship between air density, pressure, temperature, and altitude.
7) Describe how airflow behaves over and around an airfoil.
8) Summarize historical developments in aerodynamics and the design of aircraft, rockets, spacecraft, and other aerospace vehicles.

3. Forces of Flight

Objective: *Students will analyze the four forces of flight and apply their relationships to common flight conditions in order to predict how changes in lift, weight, thrust, and drag affect aircraft motion.*

9) Explain lift, weight, thrust, and drag and how they act on an aircraft.
10) Apply force relationships to simple flight scenarios.
11) Illustrate how changes in one force influence the others.
12) Demonstrate understanding of equilibrium and unbalanced forces in flight.

4. Lift and Airfoil Design

Objective: *Students will evaluate airfoil geometry and wing design variables (camber, angle of attack, shape) using Bernoulli's principle and Newton's laws in order to explain how lift is generated and optimized.*

13) Identify parts of an airfoil and wing structure.
14) Explain Bernoulli's principle and Newton's laws as they apply to lift.
15) Analyze the effects of angle of attack, camber, and wing shape on lift generation.
16) Compare different wing designs and their aerodynamic purposes.

5. Drag and Aircraft Efficiency

Objective: *Students will distinguish types of drag and examine design strategies to reduce drag in order to explain how aerodynamic efficiency influences speed, range, and fuel consumption.*

17) Differentiate between induced, parasite, and profile drag.
18) Analyze how aircraft design and configuration affect drag.
19) Explain methods used to reduce drag and improve aerodynamic efficiency.
20) Interpret the relationship between drag, speed, and fuel efficiency.

6. Stability and Control

Objective: *Students will describe stability concepts and connect control surfaces to aircraft axes in order to predict aircraft responses and explain how stability and control contribute to safe flight.*

21) Describe static and dynamic stability in aircraft.
22) Identify axes of flight and corresponding control surfaces.
23) Apply stability concepts to predict aircraft responses to control inputs.
24) Analyze how aerodynamic balance affects safe flight.

7. Performance and Flight Envelopes

Objective: *Students will use aerodynamic principles and basic performance data to interpret flight envelopes and evaluate how weight, balance, propulsion, and environment affect climb, glide, cruise, ascent, descent, and reentry-related performance.*

25) Apply aerodynamic principles to climb, glide, and cruise performance.
26) Analyze how weight, balance, and environmental conditions influence performance.
27) Interpret basic performance charts and flight envelopes.

8. Aerodynamics of Takeoff and Landing

Objective: *Students will apply aerodynamic concepts to takeoff and landing phases, including stall recognition and critical angle of attack, in order to evaluate procedures and conditions that support safe operations.*

28) Explain aerodynamic forces during takeoff and landing phases.
29) Analyze stall behavior and critical angle of attack.
30) Apply aerodynamic principles to safe takeoff and landing scenarios.

9. Safety and Aerodynamic Risk Factors

Objective: *Students will identify aerodynamic risk factors and evaluate flight scenarios for stalls, spins, and loss of control in order to recommend prevention and mitigation strategies grounded in aerodynamic understanding.*

31) Analyze aerodynamic contributors to stalls, spins, and loss of control.
32) Evaluate flight scenarios for aerodynamic risk.
33) Apply prevention strategies based on aerodynamic understanding.

10. Data, Modeling, and Simulation in Aerodynamics

Objective: *Students will interpret and analyze aerodynamic data from experiments and simulations and use models to predict performance changes in order to make evidence-based conclusions about lift, drag, stability, heating, and atmospheric flight behavior in aerospace systems.*

34) Interpret data from wind tunnel experiments or digital simulations.
35) Analyze lift, drag, and stability trends across conditions.
36) Use models to predict aircraft, launch vehicle, or reentry vehicle performance changes.

11. Technical Communication in Aerodynamics

Objective: *Students will communicate aerodynamic concepts clearly using appropriate technical vocabulary and formats by documenting investigations and creating visuals in order to produce professional, aerospace-relevant explanations of findings.*

37) Document aerodynamic experiments and findings.
38) Communicate aerodynamic concepts using correct technical vocabulary.
39) Create diagrams and written explanations suitable for aviation audiences.

12. Final Assessment Project

Objective: *Students will synthesize aerodynamic concepts, data analysis, modeling, and technical communication in order to complete a final assessment project that demonstrates mastery of course content through a professional aerospace-focused product or presentation.*

40) Design and complete a final project that applies key aerodynamic principles to an aerospace problem, scenario, or design challenge.
41) Integrate research, calculations, models, simulations, or experimental evidence to support project conclusions.
42) Present final project findings using appropriate aerospace terminology, visuals, and professional communication strategies.

13. Leadership

Objective: *Students will demonstrate leadership skills in aerospace-related learning environments in order to collaborate effectively, manage responsibilities, and contribute to safe, ethical, and goal-oriented team outcomes.*

43) Demonstrate leadership skills such as communication, initiative, accountability, and collaboration during class and project-based activities.
44) Apply ethical decision-making and professional behavior in team settings, especially in relation to safety, responsibility, and problem solving.
45) Reflect on personal leadership growth and identify strategies for continued development in academic, career, and CTSO contexts.

14. Work-Based Learning

Objective: *Students will connect classroom learning to workplace expectations in aerospace and engineering environments in order to develop career readiness, professional habits, and an understanding of how aerodynamics knowledge is applied in industry.*

46) Identify workplace expectations, roles, and professional practices relevant to aerospace and engineering careers.
47) Demonstrate career readiness skills such as time management, teamwork, problem solving, and professional communication in applied learning experiences.
48) Evaluate how classroom-based aerodynamics knowledge and technical skills transfer to internships, industry projects, job shadows, or other work-based learning opportunities.

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: Aerodynamics
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 who listen actively and respectfully; pose thoughtful questions, acknowledge the ideas of others; and contribute ideas to further the group's attainment of an objective.	Collaborative discussions on aerodynamic forces and flight performance; peer analysis of stability/control scenarios; inquiry-based investigations of flight principles.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences and varied purposes.	Verbal explanations of lift, drag, thrust, and weight; presentations interpreting airflow behavior and aircraft performance; technical communication during discussions/demonstrations.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts to build knowledge and to better understand the human experience.	Reading and interpreting FAA and aerospace reference materials; technical informational texts on airfoils, forces of flight, atmospheric flight, reentry, and performance envelopes; industry manuals and course materials.

Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts, command a variety of word-learning strategies to assist comprehension, and make effective choices for meaning or style when writing and speaking.	Correct use of discipline-specific aerodynamic and aerospace terminology; adapting technical language across contexts such as theory, data analysis, atmospheric flight, and space system applications.
Standard 3: Writing and Composition	Prepared Graduate 6 – Craft arguments	Craft arguments using techniques specific to the genre.	Data- and principle-based claims about aircraft performance; justified conclusions about effects of aerodynamic forces; explanations connecting observations to Newton's Laws and other principles.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational/explanatory texts using techniques specific to the genre.	Written explanations of aerodynamic forces and flight conditions; technical descriptions of airfoil behavior, stability, control, and atmospheric flight; explanatory responses grounded in physics and aerospace concepts.
Standard 3: Writing and Composition	Prepared Graduate 9 – Writing Process	Demonstrate mastery of their own writing process with clear, coherent, and error-free polished products.	Clear, accurate technical writing; revision for precise scientific/aviation terminology; polished responses aligned with aviation standards.
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; and use it ethically to answer complex questions.	Researching FAA, NASA, and industry resources; analyzing quantitative and qualitative data related to flight, airflow, and atmospheric vehicle performance; using research to explain relationships among aerodynamic forces in aerospace systems.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- My Colorado Journey (career pathways, training, and credentials in Colorado) https://mycoloradojourney.com/
- FAA Aviation and Space Education (aviation and space career exploration, educator resources) https://www.faa.gov/education
- AIAA Careers in Aerospace (aerospace careers, education pathways, and industry overview) https://www.aiaa.org/careers/

2. Foundations of Aerodynamics

- NASA Beginner's Guide to Aerodynamics (foundational concepts, vocabulary, interactives) https://www.nasa.gov/stem-content/beginners-guide-to-aerodynamics/
- NASA Basics of Space Flight (space systems, missions, and core concepts) https://www.nasa.gov/stem-content/basics-of-space-flight/
- NASA Glenn Guide to Aerodynamics (aerodynamics lessons, motion, lift, drag, and vehicles) https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/learn-about-aerodynamics/

3. Forces of Flight

- Smithsonian "Forces of Flight" (lift, weight, thrust, drag overview) https://howthingsfly.si.edu/forces-of-flight
- NASA Beginner's Guide – Four Forces (definitions and relationships) https://www.grc.nasa.gov/WWW/k-12/airplane/forces.html
- NASA Beginner's Guide – Motion of Flight (equilibrium and unbalanced forces) https://www.grc.nasa.gov/WWW/k-12/airplane/mof.html

4. Lift and Airfoil Design

- NASA FoilSim (airfoil lift/drag simulator) https://www.grc.nasa.gov/WWW/k-12/airplane/foil3.html
- AirfoilTools (airfoil database and performance plots) http://airfoiltools.com/
- NASA Beginner's Guide – Lift (Bernoulli and Newton explanations) https://www.grc.nasa.gov/WWW/k-12/airplane/lift1.html

5. Drag and Aircraft Efficiency

- NASA Beginner's Guide – Drag (types of drag and design impacts) https://www.grc.nasa.gov/WWW/k-12/airplane/drag1.html
- Smithsonian "Air in Motion" (turbulence, flow, and drag concepts) https://howthingsfly.si.edu/forces-of-flight/air-in-motion
- NASA Beginner's Guide – Induced Drag (lift-related drag explanation) https://www.grc.nasa.gov/WWW/k-12/airplane/induced.html

6. Stability and Control

- FAA Pilot's Handbook of Aeronautical Knowledge (stability, control, and flight theory) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak
- NASA Beginner's Guide – Flight Controls (axes and control surfaces) https://www.grc.nasa.gov/WWW/k-12/airplane/controls.html
- NASA Beginner's Guide – Stability (static and dynamic stability concepts) https://www.grc.nasa.gov/WWW/k-12/airplane/stabl.html

7. Performance and Flight Envelopes

- FAA Pilot's Handbook of Aeronautical Knowledge (performance charts and limitations) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak
- NASA Beginner's Guide – Atmosphere (density, pressure, temperature relationships) https://www.grc.nasa.gov/WWW/k-12/airplane/atmos.html
- NASA Re-Entry Aircraft (hypersonic flight, reentry, thermal protection, and performance tradeoffs) https://www.grc.nasa.gov/WWW/K-12/BGP/hihyper.html

8. Aerodynamics of Takeoff and Landing

- FAA Airplane Flying Handbook (takeoff/landing procedures and safety) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook
- NASA Beginner's Guide – Stall (critical angle of attack and stall behavior) https://www.grc.nasa.gov/WWW/k-12/airplane/stall.html
- Smithsonian "Aerodynamics" (angle of attack, lift and drag relationships) https://howthingsfly.si.edu/forces-of-flight/aerodynamics

9. Safety and Aerodynamic Risk Factors

- FAA Airplane Flying Handbook (stalls, spins, and loss of control prevention) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook
- FAA Pilot's Handbook of Aeronautical Knowledge (aerodynamic risk factors and stability) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak
- NASA Beginner's Guide – Spins (spin fundamentals and contributing factors) https://www.grc.nasa.gov/WWW/k-12/airplane/spins.html

10. Data, Modeling, and Simulation in Aerodynamics

- NASA Interactive Simulations (aerodynamics, aircraft motion, and related models) https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/bga-simulations/
- OpenFOAM Foundation (open-source CFD software and tutorials) https://www.openfoam.org/
- NASA Program Predicts Aerothermodynamics of Reentry, Subsonic Flight (modeling atmospheric flight and reentry behavior) https://spinoff.nasa.gov/Spinoff2017/it_2.html

11. Technical Communication in Aerodynamics

- FAA Handbooks and Manuals Library (technical writing models and aviation formats) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation
- MIT OpenCourseWare 16.100 Aerodynamics (example problem-solving writeups) https://ocw.mit.edu/courses/16-100-aerodynamics-fall-2005/
- NASA Glenn Beginner's Guide to Aerodynamics (reference visuals and definitions) https://www.grc.nasa.gov/WWW/k-12/airplane/

12. Final Assessment Project

- Smithsonian How Things Fly (flight concepts, aerospace explanations, and project inspiration) https://howthingsfly.si.edu/
- NASA Technical Reports Server (research reports, technical references, and aerospace project sources) https://ntrs.nasa.gov/
- FAA Data and Research (aviation data, statistics, and research resources for analysis projects) https://www.faa.gov/data_research

13. Leadership

- SkillsUSA Resources (chapter tools, officer materials, and professional development resources) https://www.skillsusa.org/resources/
- Technology Student Association (student leadership, competitions, and STEM chapter opportunities) https://tsaweb.org/

14. Work-Based Learning

- FAA Careers in Aviation and Space (career pathways, workplace roles, and industry expectations) https://www.faa.gov/education/about/careers-aviation-and-space
- FAA Aviation and Space Education (student career exploration, partnerships, and workforce pathways) https://www.faa.gov/education
- My Next Move – Aerospace Engineering and Operations Technologists and Technicians (job duties, skills, education, and salary information) https://www.mynextmove.org/profile/summary/17-3021.00

Technology Student Association – National Competitive Events

Flight Endurance

Objective: *Students will design, build, test, document, and fly a rubber-band-powered model aircraft that meets TSA Flight Endurance requirements for construction, inspection, documentation, and flight performance.*

- Research model aircraft design, flight technology, aerodynamics, propulsion, stability, and endurance factors.
- Design and construct a model aircraft that meets TSA requirements for wingspan, chord, fuselage length, propeller size, weight, wheels, landing gear, and rubber motor.
- Prepare a flight box that safely contains the model and meets TSA size requirements.
- Maintain a flight log documenting test flights, winds, time aloft, flight pattern, and trim adjustments.
- Prepare a documentation portfolio that includes technical attributes, part identification, modification analysis, assembly drawings, and scaled engineered drawings.
- Conduct test flights and make trim adjustments to improve endurance, stability, and landing performance.
- Participate in official flight trials, inspection, and scoring procedures using TSA competition criteria.

Resources

- Technology Student Association – Flight Endurance competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- NASA Glenn Research Center – Beginner's Guide to Aeronautics https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/
- Academy of Model Aeronautics – Model aircraft and flight resources https://www.modelaircraft.org/
- National Free Flight Society – Free-flight aircraft resources https://freeflight.org/

Technology Student Association – National Competitive Events

Dragster Design

Objective: *Students will design, draw, build, test, and present a CO2-powered dragster that meets TSA specifications for performance, construction quality, technical drawing, and dimensional accuracy.*

- Design a CO2-powered dragster that follows TSA construction specifications and annual design requirements.
- Create a full-size metric technical drawing showing top and side views of the complete vehicle.
- Apply technical drawing practices, dimensions, and production decisions to communicate the vehicle design.
- Build the dragster from approved materials using safe production methods such as hand tools, power tools, CNC milling, or 3D printing.
- Prepare a printed materials list documenting all parts and materials used in the dragster.
- Test the vehicle through qualifying race procedures and evaluate performance, safety, and specification compliance.
- Complete a short interview explaining the design, construction process, production decisions, and performance results.

Resources

- Technology Student Association – Dragster Design competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Autodesk Fusion – CAD/CAM tools for product design and fabrication https://www.autodesk.com/products/fusion-360/education
- Pitsco Education – CO2 dragster design and production resources https://www.pitsco.com/
- NASA Glenn Research Center – Forces on Vehicles and Aerodynamics Resources https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/

Technology Student Association – National Competitive Events

Transportation Modeling

Objective: *Students will research, design, produce, document, display, and present a scale transportation model that responds to the annual TSA Transportation Modeling design problem.*

- Research transportation design, model-building practices, and the annual TSA Transportation Modeling challenge.
- Develop concept drawings, sketches, renderings, or CAD models that communicate the transportation design.
- Create an original scale model that represents the selected transportation concept with attention to detail and quality.
- Prepare a display that professionally presents the model and supports the design concept.
- Compile a documentation portfolio that explains research, planning, scale, construction, materials, and design decisions.
- Participate in a semifinal interview explaining the model, design process, construction techniques, and response to the annual challenge.
- Evaluate the final entry using TSA criteria for model quality, display, documentation, creativity, accuracy, and communication.

Resources

- Technology Student Association – Transportation Modeling competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Autodesk Fusion – CAD/CAM modeling and design tools https://www.autodesk.com/products/fusion-360/education
- Onshape Education – Browser-based CAD and 3D modeling https://www.onshape.com/en/education/
- Smithsonian National Air and Space Museum – Aviation and aerospace learning resources https://airandspace.si.edu/