Aerodynamics - UAS

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 and the forces that affect aircraft and drone flight, including lift, drag, stability, control, propulsion, and performance. Students apply aerodynamic concepts through analysis, modeling, and technical communication while exploring UAS safety, aviation careers, FAA drone regulations, and postsecondary pathways.

Summary

This course provides students with a comprehensive introduction to aerodynamics through the study of airflow, pressure, lift, drag, stability, and aircraft and drone performance. Students examine the four forces of flight, the behavior of airflow over airfoils and propellers, and the ways wing design, angle of attack, rotor systems, and vehicle configuration affect lift, drag, thrust, and overall efficiency. The course also explores flight stability and control, performance factors such as weight, balance, payload, battery or power considerations, and environmental conditions, as well as the aerodynamics of takeoff, landing, hovering, stalls, and other safety-related flight scenarios. In addition, students interpret aerodynamic data, use models or simulations to analyze performance, and communicate technical findings using appropriate aviation and UAS vocabulary, diagrams, and written explanations. Career exploration, professionalism, ethics, FAA drone regulations, and postsecondary opportunities in aerospace, aviation, and unmanned aircraft systems are embedded throughout the course to support informed academic and career planning. Federal Aviation Administration: https://www.faa.gov/uas

Notes

This revised course is more focused with clearer alignment to Colorado CTE expectations and a stronger emphasis on unmanned aircraft systems and aviation applications. While the previous version centered more broadly on traditional aerodynamics concepts and general aircraft performance, this version is organized around measurable student outcomes, section objectives, and applied learning experiences that better support instruction, assessment, and course consistency. Major updates include expanded UAS and FAA-related content, stronger attention to technical communication, safety, and career readiness, and the addition of final assessment, leadership, and work-based learning components. Standards alignment and free resource links were also added to improve implementation and provide educators with more direct instructional support.

Student Learning Outcomes

1. Career Exploration and Postsecondary Opportunities

Objective: *Students will analyze career pathways in engineering and drones 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 and drones
    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 and drones
    a. Criticism and evaluation
    b. Presentation
    c. Assessment
3) Recognize laws, regulations, and ethics significant to the fields of engineering and drones
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 aircraft and drone flight behavior, and describe airflow over an airfoil and rotor system in order to build a conceptual base for analyzing flight performance.*

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 aircraft design.

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 or drone.
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, propeller design, and wing design variables using Bernoulli's principle and Newton's laws in order to explain how lift and thrust are generated and optimized in crewed aircraft and drones.*

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, endurance, and energy use in aircraft and drones.*

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, rotor speed changes, and flight controllers to aircraft and drone axes in order to predict flight responses and explain how stability and control contribute to safe operations.*

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, payload, battery life, and environmental conditions affect climb, glide, hover, and cruise 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, landing, hovering, and transition phases, including stall recognition and critical angle of attack, in order to evaluate procedures and conditions that support safe aircraft and drone 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 crewed and uncrewed flight scenarios for stalls, loss of control, rotor hazards, and operational limitations in order to recommend prevention and mitigation strategies grounded in aerodynamic understanding and FAA safety expectations.*

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, drone telemetry, and simulations and use models to predict performance changes in order to make evidence-based conclusions about lift, drag, thrust, and stability.*

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 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 aviation- and UAS-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 knowledge, technical communication, and safety practices by completing a culminating project in order to demonstrate course mastery through analysis, design, testing, and presentation.*

40) Develop a final project that applies aerodynamic principles to an aircraft or drone design, flight scenario, or performance problem.
41) Analyze data, evidence, or design choices to support conclusions and recommendations.
42) Present project findings using appropriate technical vocabulary, visuals, and professional communication.

13. Leadership

Objective: *Students will demonstrate leadership skills in technical and collaborative settings by contributing responsibly, communicating effectively, and reflecting on personal growth in order to prepare for success in education, training, and the workplace.*

43) Demonstrate leadership behaviors such as responsibility, initiative, dependability, and ethical decision-making.
44) Collaborate effectively in teams to plan, complete, and evaluate technical tasks or projects.
45) Reflect on leadership strengths, areas for growth, and strategies for continued professional development.

14. Work-Based Learning

Objective: *Students will connect classroom learning to real-world aerospace, aviation, and UAS contexts by examining workplace expectations, documenting experiences, and applying technical and employability skills in order to strengthen career readiness.*

46) Identify workplace expectations, safety practices, and professional behaviors relevant to aerospace, aviation, and UAS careers.
47) Apply technical knowledge and employability skills in simulations, industry-connected projects, or work-based learning experiences.
48) Document and evaluate work-based learning experiences, feedback, or career readiness evidence to inform future goals.

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 and Drone Flight
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, drone flight performance, and UAS mission planning; peer analysis of stability and control scenarios; inquiry-based investigations of crewed and uncrewed 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 or drone performance; technical communication during demonstrations of UAS applications and safety procedures.
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 aviation and UAS reference materials; technical

			informational texts on airfoils, propellers, forces of flight, 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, aviation, and UAS terminology; adapting technical language across contexts including theory, data analysis, mission planning, and flight application.
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, and control; explanatory responses grounded in physics and aviation 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 resources and industry manuals; analyzing quantitative/qualitative data related to flight and airflow; using research to explain relationships among aerodynamic forces.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- FAA Unmanned Aircraft Systems (drone careers, pilot pathways, and operational resources)
  https://www.faa.gov/uas
- My Colorado Journey (career pathways, training, and credentials in Colorado)
  https://mycoloradojourney.com/
- AIAA Students and Educators (professional organization, educator and student opportunities)
  https://www.aiaa.org/get-involved/students-educators

2. Foundations of Aerodynamics

- NASA Glenn Beginner's Guide to Aerodynamics (foundational concepts, vocabulary, interactives)
  https://www.grc.nasa.gov/WWW/k-12/airplane/
- Smithsonian "How Things Fly" (airflow, pressure, lift/drag explainers)
  https://howthingsfly.si.edu/
- MIT OpenCourseWare 16.100 Aerodynamics (lecture notes, assignments)
  https://ocw.mit.edu/courses/16-100-aerodynamics-fall-2005/

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 Unmanned Aircraft Systems Educator Guide (propeller design, navigation, and drone systems) https://www.nasa.gov/stem-content/unmanned-aircraft-systems-educator-guide/
- 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 Small Unmanned Aircraft Systems Regulations (Part 107 limits, operating requirements, and performance constraints) https://www.faa.gov/newsroom/small-unmanned-aircraft-systems-uas-regulations-part-107
- 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

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 Unmanned Aircraft Systems (safety guidance, airspace, and drone operations) https://www.faa.gov/uas
- 14 CFR Part 89 Remote Identification of Unmanned Aircraft (remote ID requirements and compliance) https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-89
- FAA Airplane Flying Handbook (stalls, spins, and loss of control prevention) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook

10. Data, Modeling, and Simulation in Aerodynamics

- NASA FoilSim (simple simulation and data comparisons) https://www.grc.nasa.gov/WWW/k-12/airplane/foil3.html
- OpenFOAM Foundation (open-source CFD software and tutorials) https://www.openfoam.org/
- NASA Beginner's Guide – Wind Tunnels (experimental methods and data collection) https://www.grc.nasa.gov/WWW/k-12/airplane/tunl.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

- University of Colorado Boulder Center for Teaching & Learning – Rubrics (assessment criteria, student project evaluation, and feedback tools) https://www.colorado.edu/center/teaching-learning/teaching-resources/assessment/assessing-student-learning/rubrics
- NASA Learning Resources (student engineering projects, STEM challenges, and aerospace design activities) https://www.nasa.gov/learning-resources/
- Utah State Board of Education Engineering Capstone Rubric (project presentation, prototype testing, and analysis criteria) https://schools.utah.gov/cte/_cte/strands/EngineeringCapstoneProjectRubric.pdf

13. Leadership

- National Coordinating Council for Career and Technical Student Organizations (CTSO integration, leadership development, and employability skills) https://www.ctsos.org/
- Colorado BMEF CTSO Information (student leadership, chapter activities, and professional development) https://cobmef.org/ctso-information/
- Oregon CTE Foundation – Teach CTSO (leadership tools, teamwork, and advisor/student resources) https://oregonctso.org/teachctso/

14. Work-Based Learning

- Chicago Public Schools Work-Based Learning Toolkit (job shadowing, internships, and employer-connected learning) https://www.cps.edu/academics/work-based-learning/toolkit/
- Federal Aviation Administration Students (aviation careers, student opportunities, and workforce pathways) https://www.faa.gov/jobs/students
- Massachusetts Department of Elementary and Secondary Education Work-Based Learning (career immersion, internships, and career development planning) https://www.doe.mass.edu/ccte/courses-learning/wbl/default.html

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/