AE3030 – Aerodynamics

Fall 2026, Section A, 4 Credits

Course Overview

Aerodynamics, as the name suggests, is the study of dynamics of air as it interacts with solid bodies, such as an aircraft wing or a rotor blade, and the forces and moments it generates on these bodies. This exciting yet challenging field covers a broad range of applications, such as civil/military aircraft, automotives, wind turbines, bio-inspired flights and atmospheric flows. This course is designed provide a first undergraduate-level introduction to a number of key topics and concepts in aerodynamics.

This course is structured in five parts. Part I introduces preliminary concepts and governing equations in aerodynamics. Part II discusses inviscid incompressible flow for airfoils and finite wings based on the potential flow theory. Part III extends the study to high-speed compressible flows. Part IV covers the topic of viscous flow, including boundary layer theory and an introduction to turbulence. Finally, advanced topics such as computational fluid dynamics are presented in Part V.

Course and Instructor Information

Prerequisite: AE2010

Lectures: 08:25 – 10:20, Tuesdays and Thursdays, Location: TBD

Instructor: Dr. Beckett Zhou (beckett.zhou@gatech.edu)

GTA: TBD

Office Hour: TBD, Location: Weber 211D

Course Material

Recommended Text:

- *Fundamentals of Aerodynamics* by J. D. Anderson, McGraw-Hill, 7th Edition.

Additional References:

- *Fluid Mechanics* by P. K. Kundu and I. M. Cohen, Academic Press, 4th Edition

- *Numerical Computation of Internal and External Flows* by C. Hirsch, Butterworth-Heinemann, 2nd Edition

Grading Scheme

AE3030A Grading Scale: **A≥90%; 90%>B≥75%; 75%>C≥60%; 60%>D≥50%; 50%>F**

3 x homework assignments, 10% each

All homework assignments will be posted on a Thursday and will be due the next Thursday at the start of the class.

- Homework #1: posted on TBD, due on TBD
- Homework #2: posted on TBD, due on TBD
- Homework #3: posted on TBD, due on TBD

2 x in-class exams, 15% each

- In-class Exam #1: TBD
- In-class Exam #2: TBD

Final exam, 40%

Late Policy: For homework assignments, all extensions must be approved, otherwise a late penalty of 25% (of the maximum grade) per day will be imposed. All work must be uploaded on Canvas.

For in-class exams, makeup exams are only given for approved absences; unapproved absences will be scored as a zero. Approvals must either be obtained from me or come through the Institute (Dean of Students). Both in-class exams are closed book and closed notes. Equation sheet provided.

Professor's Right Policy

The professor reserves the right to change the course within Georgia Tech policy. Due dates are tentative for general information. They may be shifted to other dates at the discretion of the professor.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor.

Students are expected to act according to the highest ethical standards.All graded components of this course (homework, midterm, projects) are to be the sole efforts of the individual student unless otherwise specifically stated in writing by the professor. Discussing the material or copying from another person's draft/final work is unethical and unacceptable. Use of anyone else's work (including old programs) is a direct violation of the GT Academic Honor Code. All violations will be adjudicated per GT policy; a description of the academic misconduct process can be reviewed at https://osi.gatech.edu/process/academic-misconduct-process. For any questions involving these or any other Academic Honor Code issues, please consult the professor or www.honor.gatech.edu.

Any student suspected of cheating or plagiarism on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

AI Policy

Generative AI-based assistance, such as, but not limited to ChatGPT and Copilot, is comparable to collaboration with other people – for an individual assignment the use of generative AI is a violation of the Honor Code.

This course is designed to teach you how to do graduate level writing, coding, and analysis, so all work you submit must be your own. You should never include in your assignment anything that was not written directly by you without proper citation (including quotation marks and in-line citation for direct quotes).

Inclusion of anything you did not write in your assignments (prose or code) without proper citation will be treated as an academic misconduct case. If you are unsure if you have gone to far consider these two simple guidelines: (1) avoid hitting ”copy” in a conversation with an AI assistant; (2) do not have both your assignment and the AI agent open at the same time. Avoid using tools that directly add content to your submission. Use of spell and grammar checkers are acceptable (and encouraged) for all assignments.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Learning Objectives

By the end of the course, students will be able to:

- Derive key governing equations of aerodynamics (eg. Navier-Stokes equations, Euler equations and boundary layer equations)
- Assess aerodynamic performance in terms of lift, drag, and pitching moment
- Understand how the potential flow theory can be used to predict incompressible and compressible inviscid aerodynamics over airfoils and wings
- Understand the concept of laminar and turbulent boundary layers and its importance in analysis of viscous flows
- Develop a preliminary understanding of turbulence and its modelling challenges
- Be introduced to numerical techniques such as panel method and vortex-lattice method

Learning Accommodations

If needed, the professor (and GT) will make classroom accommodations for students with documented disabilities. These accommodations must be arranged in advance and in accordance with the ADAPTS office (http://www.adapts.gatech.edu).

Health and Well-Being

Georgia Tech and the School of Aerospace Engineering understand that many students experience stress through a variety of academic, financial and personal experiences. We value you and want to make you aware of resources available to you should you need them. Your well-being and mental health are important, and we are here for you.

- Center for Assessment, Referral and Education (CARE): https://care.gatech.edu/
- Campus Police (any emergency): 404-894-2500 http://www.police.gatech.edu/
- Counseling Center: 404-894-2575 https://counseling.gatech.edu/
- Dean of Students Office: 404- 894-6367 https://studentlife.gatech.edu/
- Georgia Crisis and Access Line: 800-715-4225 Crisis Text Line: Text HOME to 741741
- National Suicide Prevention Lifeline: 800-273-TALK (8255) https://suicidepreventionlifeline.org/
- VOICE: Victims Survivor Support: (404) 385-4464 (or 4451) http://healthinitiatives.gatech.edu/well-being/voice
- Stamps Health Services: https://health.gatech.edu/contact

Course Outline

Part I – Introductory Concepts and Key Equations in Aerodynamics

I.A. Introductory Concepts in Aerodynamics

- Key fluid properties
- The Eulerian and Lagrangian descriptions of fluid motion; substantial derivative
- The continuum hypothesis (continuum vs. free molecule flow)
- Flow similarity
- Aerodynamic coefficients
- Pressure distributions, lift curves and drag polars
- Inviscid vs. viscous flows
- Boundary layers, velocity gradient and wall shear stress
- Flows over streamlined and bluff bodies (Attached vs. separated flows)
- Laminar and turbulent flows, transition
- Incompressible vs. compressible flows, transonic flows and shock waves

I.B. The Basic Equations of Fluid Dynamics

- Review of vector calculus
- General form of a conservation law; The concept of 'flux'
- The mass conservation equation
- The momentum conservation equation
- The energy conservation equation
- The constitutive equation for Newtonian fluid
- Thermodynamic laws

I.C. Some Important Quantities in Aerodynamics

- Aerodynamic forces and moments
- Center of pressure
- Pathlines and streamlines in a flow
- Angular velocity, vorticity, and circulation
- Stream function and velocity potential

Part II – Inviscid, Incompressible Flow

II. A. Fundamentals of Inviscid, Incompressible Flow

- Bernoulli's equation
- Incompressible potential flow: Laplace's equation
- Elementary incompressible flows: uniform flow, sources & sinks, doublet flow, vortex flow; Principle of linearity and superposition
    - Non-lifting flow over a cylinder (d'Alembert's paradox)
    - Lifting flow over a cylinder; Kutta-Joukowski theorem and generation of lift

II.B. Incompressible Flow over Airfoils

- Airfoil nomenclature and characteristics
- Philosophy of low-speed airfoil theory: vortex sheet
- The Kutta condition
- Kelvin's circulation theorem and starting vortex
- Classical thin airfoil theory
    - Symmetric airfoil
    - Cambered airfoil
- Lifting flow over airfoil of arbitrary shape and thickness: the vortex panel method

II. C. Incompressible Flow over Finite Wings

- Downwash and induced drag
- The vortex filament, the Biot-Savart Law and Helmholtz's theorems
- Prandtl's classical lifting line theory
    - Elliptical lift distribution
    - General lift distribution
- The lifting-surface theory and the vortex lattice method
- Aerodynamics of a Delta wing

Part III – Compressible Flow

III. A. Normal Shock Waves, Oblique Shock and Expansion Waves

- Basic normal shock equations

- Calculation of flow properties across a normal shock wave
- Oblique shock relations
- Prandtl-Meyer expansion waves

III. B. Compressible Flow over Airfoils

- The velocity potential equations and their linearization
- Prandtl-Glauert compressibility correction
- Critical Mach number, drag-divergence Mach number and supercritical airfoils
- Linearized supersonic flow

Part IV – Viscous Flow and Introduction to Turbulence

IV. A. Viscous Flows

- Special cases: Couette and Poiseuille flows
- Boundary layer theory
  - Boundary layer equations
  - Laminar boundary layer and the Blasius Solution
  - von Karman momentum-integral equation
  - Flow separation

IV. B. Introduction to Turbulence

- Flow instability
- Laminar-turbulence transition
- Overview of turbulent flows

Part V – Advanced Topics

V. A. Introduction to Computational Fluid Dynamics

- Simulation at different levels of fidelity: Euler/RANS/D(D)ES/LES/DNS
- The ‘closure problem’
- Turbulence modelling
- Numerical considerations: grid generation, accuracy and stability