AE 4040 – Computational Fluid Dynamics
Syllabus

Course Information

- **Hours:** 3-0-3
- **Semester:** Fall 2026
- **Section:** A (In-person, Atlanta main campus)
- **Instructor:** Sriram Parthasarathy Kalathoor
- **Classroom:** Klaus Advanced Computing Room 2443
- **Meeting Times:** Tuesdays & Thursdays 8:00AM - 9:15AM
- **Office Hours:** By appointment (TBD)

Catalog Description

Discretization of partial differential equations, stability and accuracy considerations, iterative and time/space marching schemes, and aerospace applications.

Prerequisites

AE 3021 or AE 3030. Some familiarity with numerical methods, and at least one programming language is preferred, but not required.

Course Objectives

Provide students with an introduction to numerical methods and understanding of various computational aerodynamics approaches. Provide experience with tools utilized in CFD analysis and an understanding of the role of CFD in engineering analysis.

Learning Outcomes

Students will be able to:

1. Describe the differences between equation sets and numerical capabilities of common CFD methodologies

2. Effectively utilize CFD grid generation software
3. Conduct CFD analysis associated with aerospace applications
4. Utilize CFD flow visualization software

Required Materials

- **Mandatory textbook:** None
- **Recommended textbook:** Applied Computational Aerodynamics: A Modern Engineering Approach, R. M. Cummings (Cambridge University Press), 1st Edition
- **Class Notes:** Will be posted on Canvas on a weekly basis
- You will require a laptop/computer with internet connection in order to access virtual desktops. Virtual desktop access is required for successful completion of this course.

Grading Policy

The following components count toward course grade:

- 2 in-class exams: 15% each
- 3 homework assignments: 10% each
- Final project: 40%
- Attendance & Participation: 10%

Extra credit opportunities may be provided through the course. The grade brackets for this course are as follows:

$$A \geq 87.5; \quad 87.5 > B \geq 75; \quad 75 > C \geq 50; \quad 50 > D \geq 40; \quad 40 > F$$

We might deviate from this grading scheme depending on class performance, but I will only curve in your favor.

Attendance & Participation

This course is offered in an in-person synchronous format. Since participation is a graded component of the course, students are encouraged to attend all the lectures. Participation will be assessed individually via either in-class questions, flash cards, before/after/in-class discussion, or office hours.

Criteria for Course Success

A successful student in this course will demonstrate regular attendance, informed participation and reasonable engagement with course content, have a mastery of fundamental concepts such as finite differencing, approximation/error/accuracy, stability analysis, introductory grid generation and flow visualization, and other ideas covered in the course, as well as the capability to use required software programs to solve relevant fluid mechanics problems.

Academic Integrity

The Georgia Tech Honor Code is central to the ideals of this course. Students are expected to be independently familiar with the Code and to recognize that their work in the course is to be their own original work that truthfully represents the time and effort applied. Violations of the Code are most serious and will be handled in a manner that fully represents the extent of the Code and that befits the seriousness of its violation. The Code can be found at http://www.policylibrary.gatech.edu/student-affairs/code-conduct

Etiquette

Students are expected to keep their mobile phones on vibrate/silent mode, and avoid doing non-course-related activities as a courtesy to their fellow students. Students are expected to be on time for classes, communicate responsibly, and contribute to a positive learning environment for everyone.

Accommodations for Students with Disabilities

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

Topical Outline

I. **Introduction** (3 hours)

- Experimental, theoretical, and numerical approaches (2 hours)
- Verification, validation, and certification (1 hour)

II. **Governing Equations** (4.5 hours)

- Navier–Stokes, Euler, full potential, and linearized potential equations (2 hours)
- Non-dimensionalization (0.5 hours)
- Mathematical classification of equations (1 hour)

III. **Linear Theory Aerodynamic Analysis** (5.5 hours)

- Panel method (1.5 hours)
- Vortex lattice method (1 hour)
- Integral boundary layer method overview (0.5 hours)
- Use of XFOIL and AVL codes (2 hours)
- Pressure and skin-friction integration to obtain forces (0.5 hours)

IV. **Discrete Modeling** (5 hours)

- Taylor series expansions (2 hours)

- Consistency, convergence, stability, convergence history, and criteria (3 hours)

V. **Computational Grids** (9 hours)

- Generalized coordinate transformation (2 hours)
- Grid requirements, structured topologies, unstructured terminology (2.5 hours)
- Grid generation methods: algebraic, elliptic, hyperbolic, unstructured (1.5 hours)
- Three-dimensional grid generation (3 hours)
- Use of POINTWISE
- Grid quality evaluation

VI. **Euler Equation Solution and Flow Visualization** (7 hours)

- Runge–Kutta schemes (2 hours)
- Roe's approximate Riemann solver (1 hour)
- Flux limiters and Total Variation Diminishing (TVD) methods (2 hours)
- Use of STAR-CCM+ or NASCART-GT (2 hours)
- Use of TECPLOT (2 hours)

VII. **Navier–Stokes Solution** (5 hours)

- Use of FLUENT (2 hours)
- Solution accuracy evaluation (2 hours)
- Boundary conditions: viscous wall, inflow/outflow (1 hour)

VIII. **Exams and Reviews** (5 hours)