Fall 2021
AE8803 Advanced Aerodynamics for Vertical Lift

Required Text: Professor's Notes
Strongly Recommended Text: J. Gordon Leishman, "Principles of Helicopter Aerodynamics," 2nd edition, Cambridge University Press.
This textbook explains in a more elaborate and deeper way most (but not all) of the topics that are discussed in class. Therefore, it is strongly recommended to students to read up on class contents using this textbook.

This course is a core requirement for the proposed Graduate Vertical Lift Certificate.

Prerequisites: Graduate Standing or Consent of the Instructor

Educational Objectives: Introduce students to aerodynamic topics of current interest in the vertical lift community including Urban Air Mobility and Unmanned Aerial Systems, as well as traditional and advanced configurations in rotorcraft. The focus is on the flow physics associated with vertical lift aircraft, to understand aerodynamic phenomena, relationships, tradeoffs and limitations. Design considerations, theory and modeling of rotor flows will also be covered.

Expected Outcomes:
- The ability to select and model basic rotor or multirotor systems with appropriate fidelity for its purpose (design, analysis, etc.)
- Develop an understanding of important aerodynamics necessary to design and analyze vertical lift vehicles and their components, for current and emerging configurations, including Urban Air Mobility and Unmanned Aerial Systems.
- Understand the interactional aerodynamics and their importance and role in designing, analyzing and evaluating unique configurations in Vertical Lift.

Topics
1. Introduction to vertical lift configurations
    a. How rotor blades differ from wings
    b. Basic rotor controls (collective, coning, cyclic)
    c. Different configurations: traditional, tilt-rotors, coaxial, quadrotors, etc.
2. Aerodynamic design issues associated with helicopters (RFPs, military vs. civil, etc.)
3. Methods of rotor analysis (Momentum Theory, BEMT, numerical comprehensive analysis, etc.) and when to apply which method
4. Rotor limits: compressibility effects (drag divergence Mach number, etc.), retreating blade stall, reverse flow, noise constraints, and what to do about it?
5. Discussion of aerodynamic characteristics of rotor airfoils
    a. Pressure distribution/integration, boundary layers, Reynolds and Mach number effects, optimum camber and thickness distributions
    b. Design goals, aerodynamic relationships and tradeoffs
6. Advanced rotor blade planform and tip design, effect on blade aero and performance
7. Static and dynamic stall: physical description and modeling
    a. Leading/trailing edge stall, thin airfoil stall, shock-induced separation
8. Physical description and characteristics of rotor wakes: tip vortices, vortex sheets, etc.

9. Modeling of rotor vortical wakes (prescribed/free wake analysis, CFD, comprehensive rotor codes, coupled CFD/CSD) based on use in industry today
10. Hub, fuselage, and empennage aerodynamics
11. Discussion of aerodynamic interactional phenomena on rotorcraft
    a. BVI, rotor/rotor interactions, multiprop/wing interactions, main/tail rotor and rotor/fuselage interactions, ground effect, brownout etc.
12. Discussion on the aerodynamics of advanced and emerging configurations of interest (e.g., eVTOL, Urban Air Mobility vehicles, drones/UAS)

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Instructor: Prof. Juergen Rauleder; juergen.rauleder@gatech.edu
Class Time: Tue and Thu, 5:00pm – 6:15pm
Office Hours: Video calls or in person; on demand; make appointment via email.
Grading Policy: Grading will be done without a curve, but course extra credit will be offered so that a curve should not be necessary.

Assessment: **Oral** Midterm (30%), Homework Assignments (40%),
Oral Final Exam (30%), Optional Project (Extra Credit)

Honor Code: The Georgia Tech Honor Code is in effect for this course.

Student Expectations: The student is expected to attend and participate in all classes (except for students in the distance learning section).

Learning Accommodations: If needed, classroom accommodations will be made 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