AE 8803 – Advanced Vertical Lift Aerodynamics

HOURS: 3-0-3

CATALOG DESCRIPTION:

Phenomenology focused class that addresses current and new concepts such as multirotor vehicles, coaxials, UAV and Advanced/Urban Air Mobility configurations, interactional aerodynamics, aero-propulsive interactions and aerodynamic problems/factors limiting modern designs.

PREREQUISITES: Graduate standing or permission by instructor

TEXTBOOKS:

Course Notes and Gordon Leishman: "Principles of Helicopter Aerodynamics," Cambridge Aerospace Series.

COURSE 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 interactional aerodynamic phenomena, relationships, tradeoffs and limitations. Understanding physical limitations in current and future designs, and how to design around them.

LEARNING OUTCOMES:

- Develop an understanding of important aerodynamics and physical limitations/challenges 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 aero-propulsive interactions, and their importance and role in designing, analyzing and evaluating unique configurations in Vertical Lift.

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 http://disabilityservices.gatech.edu/, 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.

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. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/. Any student suspected of cheating or plagiarizing 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.

Student-Faculty Expectations Agreement:
At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Course Requirements & Grading

Assignment	Information	Percentage Weight
Homework		50%
Midterm		20%
Final	See official GT finals schedule	30%

Extra Credit Opportunities

Extra credit assignments may be presented to the class towards the end of the semester at the discretion of the instructor.

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:
A 90-100%
B 80-89%
C 70-79%
D 60-69%
F 0-59%
Full credit is awarded for solutions that are correct and demonstrate an understanding of the concepts of the problem. Partial credit is given for solutions that, while incorrect, demonstrate some knowledge of the concepts.

TOPICAL OUTLINE

Topic	Hours
1. Review of vertical lift configurations and analysis methods	5
a. How rotor blades differ from wings b. Basic rotor controls (collective, coning, cyclic) c. Different configurations: traditional, tilt-rotors, coaxial, quadrotors, etc. d. Aerodynamic design issues associated with helicopters (RFPs, military vs. civil, etc.) e. Review of methods of rotor analysis (Momentum Theory, BEMT, numerical comprehensive analysis, etc.) and when to apply which method	
2. Rotor limits: compressibility effects (drag divergence Mach number, etc.), retreating blade stall, reverse flow, noise constraints, and what to do about it?	4
3. Hub, fuselage, and empennage aerodynamics/performance	5
4. Introduction of advanced and emerging configurations of interest (e.g., eVTOL, Urban Air Mobility vehicles, drones/UAS, rotorcraft in extra-terrestrial missions) Note: After this topic, all further topics include multiple rotor implications/influences	5
5. Discussion of aerodynamic characteristics of rotor airfoils and implications on aeromechanics, controls, performance	6
a. Pressure distribution/integration, boundary layers, Reynolds and Mach number effects, optimum camber and thickness distributions b. Advanced rotor blade planform and tip design, effect on blade aero and performance c. Flight controls (approaches, issues) d. Vibratory loads	
6. Physical description and characteristics of rotor wakes: tip vortices, vortex sheets, etc.	5
a. Modeling vortical wakes (prescribed/free wake analysis, CFD, comprehensive rotor codes, coupled CFD/CSD) based on use in industry today b. Impact on performance, vibratory loading, dynamic stall	
7. Static and dynamic stall: physical description	4
a. Leading/trailing edge stall, thin airfoil stall, shock-induced separation b. Methods for predicting dynamic stall c. Influence on aeromechanics	
8. Discussion of aeromechanical interactional phenomena on rotorcraft	8
a. BVI, rotor/rotor interactions, multiprop/wing interactions, main/tail rotor and rotor/fuselage interactions, ground effect, brownout etc.	
Exams	3
Total	**45**