O. Savas
6113 Etcheverry Hall

Office Hours: TuTh 13:00-14:30

Mechanical Engineering 163
ENGINEERING AERODYNAMICS
Fall 2019

August 21, 2019
Lectures in 60 Barrows Hall

Lecture Hours TuTh 11:10-12:30

Course Description:
Introduction to the lift, drag, and moment of two-dimensional airfoils, three-dimensional wings, and the complete airplane. Calculations of the performance and stability of airplanes in subsonic flight. The course run on two loosely aligned parallel tracks: a traditional sequence of lectures covering the basic topics in aerodynamics and a set of projects on vortex dynamics and aerodynamics that are loosely aligned with lectures. The distinguishing factor will be the extend of the projects assigned to the graduate level participants, which will be substantially more involved than those expected from the senior level participants.

COURSE
You are expected to be proficient in fundamental fluid dynamics and thermodynamics, such as those topics covered in Mechanical Engineering -40 Thermodynamics and Mechanical Engineering -106 Fluid Mechanics, and in mathematics inasmuch as it is needed for that proficiency. You are expected to have derived the equations of motion for continuum at least once. Mathematically, you should be comfortable with vector calculus and ordinary differential equations. Computationally, you are expected to be proficient in a high-level programming environment of your choice (e.g. Java, C/C++, Fortran, Mathematica, Matlab, IDL) to design algorithms and perform aerodynamics calculations. We will cover the following topics at appropriate levels for this course: flow kinematics, the atmosphere, potential flow, the lift, drag, and moment of two-dimensional airfoils, three-dimensional wings, vortex wake, and highspeed aerodynamics. Time permitting, we will look at bioaerodynamics. Also, some analysis of the performance and stability of airplane in subsonic flight will be presented.

I urge you to read the assigned material beforehand for most effective use of our classroom time.

GRADING: Original

Homework (~5)	20%
Midterm exam (Oct 12)	20%
Projects (3 x10)	30%
Final Project or Exam (Dec 6)	30%
TOTAL	100%

LETTER GRADE BOUNDARIES

A	85.0%
B	75.0%
C	65.0%
D	55.0%

POLICY
We are all bound by the UC Berkeley honor code.

The **main distinction** will be that the graduate students will be required to write their own THREE-DIMENSIONAL (3D) vortex panel code and apply it to 3D objects, such as finite wing, a fuselage or a combination of the two. The undergraduate students are required two write a TWO-DIMENSIONAL(2D) one which is an order of magnitude simpler than the 3D

All assigned material is to be done independently. Unless you have a good reason, no late assignment will be accepted, no makeup will be given. The midterm exam will be closed book with no internet access. No electronic communication is allowed. You may bring your handwritten notes and printed copies of the posted class notes. You may also bring a calculator. All results must be dimensionally correct. All numerical results must be presented in SI UNITS. It is your responsibility to communicate clearly your work!

PROJECT REPORTS
Your project reports must be typeset using LaTeX and submitted electronically in pdf format. The software is available freely on the web. Learn it. The page limit is 4, including figures. Fit it.

REFERENCES

1. Abbott I. R. & Von Doenhoff, A. E. 1959 Theory of wing sections. Dover.
2. Anderson, J.D. 1999 Aircraft performance and design. McGraw-Hill.

3. Anderson, J.D. 1991 Fundamentals of Aerodynamics, 2nd edition. McGraw-Hill.
4. Bertin, J.J. 2002 Aerodynamics for Engineers, 4th edition. Prentice-Hall.
5. Durand W.F. 1963 Aerodynamic Theory, Dover. Six Volumes.
6. Etkin, B. 1995 Dynamics of Flight, 3rd edition. Wiley.
7. Hale, F. 1984 Introduction to Aircraft Performance, Selection, and Design, Wiley.
8. Kuethe, A. M. & Chow, C-Y. 1998 Foundations of aerodynamics, 5th edition. Wiley. . . . . . TEXT BOOK
9. Milne-Thomson, L. M. 1973 Theoretical aerodynamics. Dover.
10. Lanchester, F. W. 1908 Aerodynamics. D. Van Nostrand Company.
11. Von Karman, T. 1963 Aerodynamics. McGraw-Hill

12. Von Mises, R. 1959 Theory of flight. Dover.
13. Culick, F. E. 2003 The Wright Brothers: First Aeronautical Engineers and Test Pilots, AIAA J., 41(6), 985-1006. https://doi.org/10.2514/2.2046
14. https://dlmf.nist.gov
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#	date		Topic	K & C	Homework & Projects
1.	Aug	29	Introduction, Thermodynamics, The Atmosphere	Ch. 1 & 8	
2.	Sep	3	Kinematics of flow field	Ch. 2	
3.	Sep	5	Stream/Path/Streak Lines	Ch. 2	
4.	Sep	10	Continuity, Stream function	Ch. 2	
5.	Sep	12	Deformation, vorticity, circulation	Ch. 2	
6.	Sep	17	Irrotational flow, Helmholtz' vortex theorems	Ch. 2	
7.	Sep	19	Dynamics of flow fields - Momentum equation	Ch. 3	Project 1
8.	Sep	24	Dynamics of flow fields - Bernoulli's equation	Ch. 3	
9.	Sep	26	Flow about a body - Source, Sink, Doublet	Ch. 4	
10.	Oct	1	Flow about a body - Vortices	Ch. 4	
11.	Oct	3	Flow about a body - Lifting bodies	Ch. 4	1.4.1, SP2. 8.4.1, 8.4.4, 8.8.1
12.	Oct	8	MID-TERM EXAM, CLOSED BOOK		
13.	Oct	10	Vortex sheet, Vortex panel method		
14.	Oct	15	Two-Dimensional airfoils - vortex sheet	Ch. 5	3.2.2, 3.3.4, 3.4.1, SP: 6,8,9,10,11
15.	Oct	17	Symmetric airfoil	Ch. 5	
16.	Oct	22	Cambered airfoil	Ch. 5	Project 2
17.	Oct	24	Cambered airfoil	Ch. 5	
18.	Oct	29	Finite wing	Ch. 6	
19.	Oct	31	Finite wing	Ch. 6	
20.	Nov	5	Boundary layer theory	Ch. 15	
21.	Nov	7	Boundary layer theory	Ch. 15	Project 3
22.	Nov	12	Airfoil design - Low Reynolds number		
23.	Nov	14	Airfoil design - High Reynolds number		
24.	Nov	19	High speed aerodynamics	Ch. 7,8,9	
25.	Nov	21	High speed aerodynamics	Ch. 10, 11, 12	SP: 14, 15, 16, 19
	Nov	26	APS/DFD meeting. No Class		
	Nov	28	Thanksgiving		
26.	Dec	3	Aircraft vortex wake, Helicopter aerodynamics		
27.	Dec	5	Helicopter aerodynamics		
	Dec	6	FORMAL CLASSES END		
	Dec	9	RRR week		
	Dec	13	Final Project Due: 5pm		
	Dec	13	LAST DAY OF INSTRUCTION		
	Dec	20	FALL SEMESTER ENDS		