AAE 333: FLUID MECHANICS
Fall 2013

"Isn't it astonishing that all these secrets have been preserved for so many years just so we could discover them!"
Orville Wright, 1903

This course is about discovering the secrets of fluid mechanics – encountered in everyday life as well as in every significant human technology – including the secrets of flight. The main goal of this course is to build the framework which will allow us to solve simple engineering problems involving fluid mechanics and give the basic understanding needed for further study in this area or to work on interdisciplinary problems involving fluid mechanics.

Objectives include developing abilities to:

Calculate aerodynamic forces and moments from pressure and shear stress distributions
Apply dynamic similarity to scale up data
Apply global conservation of mass and momentum to engineering systems
Apply Bernoulli's equation (relating pressure and velocity)
Calculate lift for an arbitrary airfoil using panel methods
Calculate drag for an arbitrary airfoil using integral boundary layer methods.

Necessary Background:
1. Vector calculus, ordinary differential equations, PDEs
2. Ability to write a computer program.

Day & Time: MWF 12:30-1:20 pm **Room:** MATH 175

Homework solutions, practice exams, F&A, etc will be available on Piazza:
https://piazza.com/purdue/fall2013/aae33300/home

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Teaching Assistants: Office Hours
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Textbook: John D. Anderson, "Fundamentals of Aerodynamics," McGraw Hill, 2007 (5th edition).

Additional references: (on reserve in Engineering Library)

1. R. W. Fox and A. T. McDonald, "Introduction to Fluid Mechanics," John Wiley, 1998 (6th ed.).
2. F. M. White, "Fluid Mechanics," McGraw Hill, 1986 (2^{nd} edition).
3. Abbott, I. H., and von Doenhoff, A. E., "Theory of Wing Sections," Dover, 1959.
4. J. Moran, "An Introduction to Theoretical and Computational Aerodynamics," Wiley 1984.
5. A. M. Kuethe and C.-Y. Chow, "Foundations of Aerodynamics," John Wiley, 1998 (5^{th} ed.).

Outline

1. Introduction: Definition of a fluid. Continuum hypothesis. Aerodynamic variables. Dimensional analysis. Fluid Statics. (Anderson Ch. 1)

2. Conservation Equations and Fundamental Principles: Review of vector calculus. Control volumes. Conservation of mass, momentum and energy. Eulerian and Lagrangian frames of reference. Substantial derivative. Streamlines. Vorticity and rate of strain. Circulation. Velocity potential and stream functions. (Anderson Ch. 2, Fox and McDonald Ch. 4, White Ch. 3)

3. Inviscid Incompressible Flow: Bernoulli's equation. Laplace's equation and fundamental solutions for two-dimensional potential flow. Kutta-Joukowski theorem. Kutta condition. Kelvin's circulation theorem. Modeling flows over airfoils. (Anderson Ch. 3 & 4.5-4.6)

4. Viscous Flow: Viscosity and thermal conductivity. Stress relation for a Newtonian fluid. Navier-Stokes equations. Dynamic similarity. Simple exact solutions. Boundary layer approximation. Blasius' solution. Thwaites' method for laminar boundary layer calculations. Introduction to transition and turbulence. (Anderson Ch. 15-19)

Grading:

Homework & Computer Projects & Quizzes	25%
Exam 1	25% or 10%
Exam 2	25% or 10%
Final Exam (day of the final exam)	25% or 40%

"In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course remotely:

a) announcements at course web-page on Blackboard Vista;
b) email communications from instructor and TA.

Your final grade will be computed two ways. First your homework, Exam 1, Exam 2, and the Final Exam will each be weighted at 25% of your final grade. In the second case, the lower of Exam 1 and Exam 2 will be weighted at 10%. The higher of Exam 1 and Exam 2 and your homework will be weighted at 25% of your grade, and your Final Exam will be counted as 40% of your final grade. You will receive the higher of these two final grades.

If a quiz is given it will be unannounced and during class. No makeup quizzes will be given.

The details of the exams will be discussed in class.

Computer Projects:
One or two mini-computer projects will be assigned. You will work in small groups for these projects. Department computer accounts are available by filling out a form in Lisa Crain's office (ARMS 3310). **If you do not have an account, please, get one as soon as possible.** You may use any high level language to do your programming, e.g. FORTRAN, C/C++, Java or MATLAB.

Homework:
Homework will be handed out on Fridays (with a few exceptions) and due in a week. Homework is due at the beginning of class; homework handed in at the end of class will be considered late. Late homework will be accepted (unless stated otherwise) up to class time on the Monday following the due date for 90% credit. No Homework will be accepted later than that, and all problems must be handed in at the same time. Exceptions will be granted only with permission and only under special circumstances. Unless otherwise noted, each problem will be graded on a scale of 0-5. Solution sets for the homework will be made available, and you are encouraged to check the solutions for any details you may have missed or to see alternate approaches. You may get help from one another on the homework, but you must hand in your own work. In writing up your homework follow the guidelines given below.

Guidelines for Homework (from Fox & McDonald)
Your work must be neat and easy to follow. If it is not, no credit will be given.

1. State briefly and concisely (in your own words --- do not just repeat the problem statement) the information given.

2. State the information to be found.

3. Draw a schematic of the system or control volume to be used in the analysis. Be sure to label the boundaries of the system or control volume and label appropriate coordinate directions.

4. Give the appropriate mathematical formulation of the basic laws that you consider necessary to solve the problem.

5. List the simplifying assumptions that you feel are appropriate in the problem. (Sometimes it is not clear ahead of time what assumptions are needed to make a problem tractable. In such cases, proceed to solve the problem and take note of the assumptions you make along the way.)

6. Carry the analysis to completion algebraically before substituting numerical values.

7. Substitute numerical values (using a consistent set of units) to obtain a numerical answer. The number of significant digits in the answer should be consistent with the given data. (All numerical answers must have the appropriate units given, unless the answer is nondimensional.)

8. Check the answer and review the assumptions made in the solution to make sure they are reasonable.

9. Label the answer. Many times the answer will be a formula rather than a number. You should check that the units are consistent in each of the terms, and that reasonable answers are obtained in limiting cases (by letting variables take on large or small values).

Academic Integrity

Students are reminded of the Student Code of Honor that states: The purpose of the Purdue University academic community is to search for truth and to endeavor to communicate with each other. Self-discipline and a sense of social obligation within each individual are necessary for the fulfillment of these goals. It is the responsibility of all Purdue students to live by this code, not out of fear of the consequences of its violation, but out of personal self-respect. As human beings we are obliged to conduct ourselves with high integrity. As members of the civil community we have to conduct ourselves as responsible citizens in accordance with the rules and regulations governing all residents of the state of Indiana and of the local community. As members of the Purdue University community, we have the responsibility to observe all University regulations.
To foster a climate of trust and high standards of academic achievement, Purdue University is committed to cultivating academic integrity and expects students to exhibit the highest standards of honor in their scholastic endeavors. Academic integrity is essential to the success of Purdue University's mission. As members of the academic community, our foremost interest is toward achieving noble educational goals and our foremost responsibility is to ensure that academic honesty prevails." http://www.purdue.edu/univregs/pages/stu_conduct/code_of_honor.html

Academic dishonesty will result in a zero for that assignment/exam and may result in a failing grade for the class. Furthermore, for all cases of academic dishonesty a report will be submitted to the Office of the Dean of Students, which may result in further disciplinary action. For more information go to: http://www.purdue.edu/odos/osrr/

Textbook Errata:

This is a new edition of the textbook in which many typos have been fixed. If you find a mistake in the 5th edition, please, send a description and correction by email to the instructor for a possible extra credit.

Greek Alphabet:

Α, α	alpha	(al-fah)	Β, β	beta	(bay-tah)	Γ, γ	gamma	(gam-ah)
Δ, δ	delta	(del-ta)	Ε, ε	epsilon	(ep-si-lon)	Ζ, ζ	zeta	(zay-tah)
Η, η	eta	(ay-tah)	Θ, θ	theta	(thay-tah)	Ι, ι	iota	(eye-o-tah)
Κ, κ	kappa	(cap-pah)	Λ, λ	lambda	(lamb-dah)	Μ, μ	mu	(mew)
Ν, ν	nu	(new)	Ξ, ξ	ksi	(zie)	Ο, ο	omicron	(om-e-cron)
Π, π	pi	(pie)	Ρ, ρ	pho	(roe)	Σ, σ, ς	sigma	(sig-mah)
Τ, τ	tau	(taw)	Υ, υ	upsilon	(up-si-lon)	Φ, φ	phi	(fie)
Χ, χ	chi	(kie)	Ψ, ψ,	psi	(sigh)	Ω, ω	omega	(oh-may-gah)

AAE333, Schedule and Reading Assignments, Fall 2013

	Monday	Wednesday	Friday
Week 1 (8/19-8/23)	Def. of fluid 1.1-1.3	Continuum Hypo., Aero. Forces 1.4-1.6,1.10	Aero. Forces, Dimension Analysis 1.12-1.14
Week 2 (8/26-8/30)	Buckingham Pi Theorem 1.7	Dynamic Similarity, 1.8, Design box	Fluid Statics 1.9
Week 3 (9/2-9/6)	**No Class** Labor Day	Review of Vector Calc. 2.1,2.2	Review of Vector Calc. 2.1,2.2
Week 4 (9/9-9/13)	Control Volumes 2.3	Conservation of Mass 2.4, 2.3.4	Conservation of Momentum 2.5
Week 5 (9/16-9/20)	Conservation of Momentum 2.6	Cons. of Mom. with Rect. Accel. (not in Anderson)	Conservation of Energy 2.7
Week 6 (9/23-9/27)	Substantial Derivative 2.9, 2.10	**EXAM 1**	Kinematics, Flow Lines 2.11
Week 7 (9/30-10/4)	Fluid Deformation 2.12	Circulation 2.13	Stream funct, Velocity Potent.ial 2.14-2.18
Week 8 (10/7-10/11)	**No class** October break	Bernoulli's Equation 3.2-3.6	Potential Flows 3.7-3.9
Week 9 (10/14-10/18)	Uniform flow, Source 3.10	Adding flows; Doublet, Vortex 3.11-3.14, 3.18	Method of Images, Lifting flow for a cylinder, 3.15
Week 10 (10/21-10/25)	Kutta Condition, Kelvin's Thm 4.5 & 4.6	Panel Methods 3.17-3.21	Panel Methods 3.17-3.21
Week 11 (10/28-11/1)	**EXAM 2**	Intro. Viscous Flow 1.11, 15.1, 15.2	Viscosity & Thermal Conductivity, 15.3
Week 12 (11/4-11/8)	Navier-Stokes Eqs 15.4-15.6	Navier-Stokes Eqs 15.4-15.6	Exact Solutions 15.7, 15.8,16.1-16.3
Week 13 (11/11-11/15)	Exact Solutions 15.7, 15.8,16.1-16.3	Poiseuille Flow 16.5	Accel. Plane Wall Not in Anderson
Week 14 (11/18-11/22)	Boundary Layers 17.1-17.5, 18.1	Boundary Layers 17.1-17.5, 18.1	Blasius Boundary Layer 18.2
Week 15 (11/25-11/29)	Thwaites' Method (not in And)	**No Class** Thanksgiving break	**No Class** Thanksgiving break
Week 16 (12/2-12/6)	Turbulence	Turbulence	Review