

# AME 460 Aerodynamic Theory

## University of Southern California – Spring 2019

### Course Syllabus

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|---------------------------|--|
| <b>Term</b>               | <b>Spring 2019</b> (Jan. 7 – May 8, 2019)  |
| <b>Lectures</b>           | Tuesdays and Thursdays, 9:30–10:50am, in VKC 260   |
| <b>Instructor</b>         | Alejandra URANGA     ▪     Email: <a href="mailto:auranga@usc.edu">auranga@usc.edu</a><br><u>Office Hours</u> : Tue. and Thurs. 11:00am–12:00pm in RRB 218 |
| <b>Teaching Assistant</b> | Arturo CAJAL     ▪     Email: <a href="mailto:cajal@usc.edu">cajal@usc.edu</a><br><u>Office Hours</u> : Mon. 8:00–9:30am and Wed. 4:30–6:00pm in VHE 202   |

### Course Description

The goal of the course is to teach the fundamental concepts and techniques used in aerodynamics—the study of the flow of air about a body—as applied to subsonic, transonic, and supersonic regimes. Topics covered include conservation principles, incompressible flows, potential flows, thin airfoil and lifting line theories, quasi-one-dimensional compressible flows and shocks, small disturbance approximation, and an introduction to viscous flows and boundary layer theory.

**Textbook** John D. Anderson Jr., *Fundamentals of Aerodynamics*, 6<sup>th</sup> edition, 2016, McGraw-Hill  
(*Note: an older edition can also be used*)

### Required Preparation

- AME 309 Dynamics of Fluids, or equivalent course in fluid mechanics
- Basic physics, vector calculus, and differential equations, at a level common to 1<sup>st</sup> year college

**Grading**

- Homework: 30% of final grade (two lowest grades dropped)
- Exam 1: 35% of final grade (in-class and take-home parts equally weighted)
- Exam 2: 35% of final grade (in-class and take-home parts equally weighted)

### Resources

**Blackboard course management system**     <https://blackboard.usc.edu>

Course material will be posted on **Blackboard**. This includes homework assignments, but *graded* homework and exams will only be available on **gradescope** (see below).

**Piazza Discussion Forum**     [https://piazza.com/usc/spring2019/20191\\_ame\\_460/home](https://piazza.com/usc/spring2019/20191_ame_460/home)

You are strongly encouraged to use the **Piazza discussion forum** (integrated within Blackboard) to ask questions, make comments, and answer questions from your peers. When discussing homework assignments, *do not give out the answers to questions!* That would be a violation of the Collaboration Policy. Public posts related to graded assignments should only be for clarification purposes. *No posts are allowed while a take-home exam is out.*

**Homework and Exam Grading on gradescope**     <https://gradescope.com>

Assignments will be graded on **gradescope**. You will submit your homeworks and exams on paper, and see your grade and comments online on gradescope once they are graded.

You will receive an email to your USC email address with instructions on how to log in after the first homework is graded.

## References

We will be following Anderson's textbook closely, but there are a number of other good books on aerodynamics. The following references are good complements for those students who want to get another perspective or go in more depth on the material.

### Fundamentals:

- J. Katz and A. Plotkin *Low-Speed Aerodynamics*, Cambridge University Press
- J.D. McLean, *Understanding Aerodynamics*, Wiley

### Advanced Topics:

- M. Drela, *Flight Vehicle Aerodynamics*, MIT Press
- F.M. White, *Viscous Fluid Flow*, McGraw-Hill
- H. Schlichting, *Boundary Layer Theory*, Springer

## Course Policies

These course policies are designed to help students learn the material effectively, and the course assessment system is designed to best test students on what they really know, and can effectively use, in a real-world context. To ensure fairness, the rules will be strictly enforced.

### Collaboration

- Collaboration of any sort on all matters that are not graded is strongly encouraged.
- Students may discuss the homework problems with one another, but no written or digital material can be part of such exchanges. *If it's not in your head, it isn't yours.* The corollary is that *you must develop and write your own solutions.*
- *Absolutely no collaboration is allowed on take-home exams:* these are individual efforts, and you are not allowed to discuss them with anyone else than the instructor.
- We will be very strict about academic integrity violations and report them as appropriate.

### Homework Assignments

- Weekly homework will be assigned on Thursdays and due the following Thursday most weeks (except before exams). It is due before class begins on the due date. To be fair to everyone, late submissions will incur a 20% penalty after the due *time* (9:30am) and for each 24h delay.
- Homework must be submitted in class to the instructor on paper on the assignment pages provided (hard-copies). If you are not able to make the lecture on a due date, email your submission to the instructor by the due time.
- The two lowest homework grades will be dropped when computing the homework portion of the final grade.
- In order to receive full credit, solutions must be presented in a clear manner, and show evidence of work: magical one-line answers do not make the cut. The reasoning is as important as the solution. *This also applies to the exams.*

### Office Hours

Office hours are held by both instructor and teaching assistant, and provide a good opportunity for you to get clarifications and better understand the course material. This time is best utilized when students come with *clear questions* and at least *an attempt at a solution*. The goal is for us to help you clarify the concepts and guide you through your thought process. *It is not meant as a way for you to effortlessly obtain the solutions.* So come often but prepared.

## Topics and Tentative Schedule

You are responsible for reading the chapter(s) in the textbook before the corresponding lecture.

| Week | Date                 | Topics   | Reading                 |
|------|----------------------|--|-------------------------|
| 1    | JAN 8, 10            | <b>I. Introduction</b><br><ul style="list-style-type: none"> <li>. Forces and moments</li> <li>. Flow similarity</li> <li>. Aerodynamic performance</li> </ul>   | Ch. 1                   |
| 2    | JAN 15, 17           | <b>II. Conservation laws</b><br><ul style="list-style-type: none"> <li>. Conservation of mass, momentum</li> <li>. Intrinsic coordinates, streamlines, stream function</li> </ul>  | Ch. 2                   |
| 3    | JAN 22, 24           |  |                         |
| 4    | JAN 29, 31           | <b>III. Incompressible potential flows</b><br><ul style="list-style-type: none"> <li>. Equations, flow modeling</li> <li>. Non-lifting and lifting flow models</li> <li>. 2D aero modeling</li> <li>. 3D aero modeling</li> </ul>  | Ch. 3, 6                |
| 5    | FEB 5, 7             |  |                         |
| 6    | FEB 12, 14           |  |                         |
| 7    | FEB 19, 21           |  |                         |
| 8    | FEB 26<br>FEB 28     | Exam 1 review<br><b>Exam 1: Thursday February 28</b>   |                         |
| 9    | MAR 5<br><br>MAR 7   | <b>IV. Shock-expansion theory</b><br><ul style="list-style-type: none"> <li>. Gas dynamics, energy equation</li> <li>. Normal shocks</li> <li>. Oblique shocks, expansion waves</li> </ul> <b>Exam 1 take-home part due: Thursday March 7</b>  | Ch. 7<br>Ch. 8<br>Ch. 9 |
| 10   | MAR 12, 14           | <i>No class: Spring Break</i>  |                         |
| 11   | MAR 19<br><br>MAR 21 | <b>IV. Shock-expansion theory (cont.)</b><br><ul style="list-style-type: none"> <li>. Quasi 1D flows and applications</li> </ul> <b>V. Inviscid compressible aero</b><br><ul style="list-style-type: none"> <li>. Full potential flow</li> <li>. Small disturbances, perturbation potential</li> <li>. Linearized compressible potential flow</li> <li>. Subsonic linearized potential flow, Prandtl-Glauert</li> <li>. Supersonic linearized potential flow</li> <li>. Transonic flows</li> </ul> | Ch. 10<br>Ch. 11, 12    |
| 12   | MAR 26, 28           |  |                         |
| 13   | APR 2<br>APR 4       |  |                         |
| 14   | APR 9, 11            | <b>VI. Viscous flows and boundary layer theory</b><br><ul style="list-style-type: none"> <li>. Viscous flows fundamentals</li> <li>. Boundary layer equations</li> <li>. Boundary layer parameters</li> </ul> <b>Exam 2 take-home part due: Thursday April 11</b>  | Ch. 15<br>Ch. 17        |
| 15   | APR 16, 18           | <ul style="list-style-type: none"> <li>. Laminar boundary layers</li> <li>. Turbulent boundary layers</li> <li>. Stability and transition</li> </ul>   | Ch. 18<br>Ch. 19        |
| 16   | APR 23<br>APR 25     |  |                         |

## Statement on Academic Conduct and Support Systems

### Academic Conduct:

Plagiarism — presenting someone else’s ideas as your own, either verbatim or recast in your own words — is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards”

<http://policy.usc.edu/scampus-part-b>.

Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

### Support Systems:

*Student Health Counseling Services* - (213) 740-7711 24/7 on call

<http://engemannshc.usc.edu/counseling>

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

*National Suicide Prevention Lifeline* - 1 (800) 273-8255 24/7 on call

<http://suicidepreventionlifeline.org>

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

*Relationship and Sexual Violence Prevention Services (RSVP)* - (213) 740-4900 24/7 on call

<http://engemannshc.usc.edu/rsvp>

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

*Office of Equity and Diversity (OED) / Title IX* - (213) 740-5086

<http://equity.usc.edu> , <http://titleix.usc.edu>

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

*Bias Assessment Response and Support* - (213) 740-2421

<http://studentaffairs.usc.edu/bias-incident-report-statement/>

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

*The Office of Disability Services and Programs* - (213) 740-0776

<http://dsp.usc.edu>

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

*USC Support and Advocacy* - (213) 821-4710

<http://studentaffairs.usc.edu/ssa>

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.