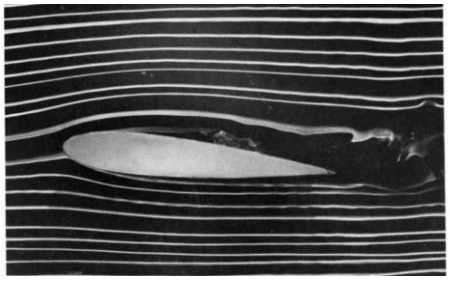
USC Viterbi

AME 309: Dynamics of Fluids

Units: 4
Term: Spring 2025 (Jan 13th – May 2nd)

Sections	28749R (Morning)	Section 29005R (Evening)
Time	Mon/Wed 10:00 – 11:50 am	Tue/Thu 5:00 – 6:50 pm
Location	SOS B46	SOS B4
Instructor	Dr. Mitul Luhar	Dr. Saakar Byahut
Office	OHE 500K	OHE 500N
Office Hours	Thu: 8.30-10.30am	Wed: 2.30-4.30pm
Contact Info	luhar@usc.edu	byahut@usc.edu
	Piazza preferred over email	
TAs	Idan Eizenberg	Jen Ping (JP) Chu
Office Hours	Mon: Noon-2.00pm Friday TBD	Tue: 2.00-4.00pm
Location	VHE 202	VHE 202
Contact Info	eizenber@usc.edu	jenpingc@usc.edu



Flow over an airfoil at an angle of attack.
© Peter Bradshaw.

Course Description

This course aims to provide junior-level aerospace and mechanical engineering students with an in-depth introduction to fluid dynamics. Topics covered will include fluid statics; conservation of mass, momentum, and energy (in both differential and integral forms); laminar and turbulent flows; potential (ideal) flows; compressible flows; as well as several applications thereof.

Recommended Preparation: AME 201, MATH 245, Intro to Computer Programming

Learning Objectives and Outcomes

By the end of this course, you should be able to:

- Explain the concept of fluids as a continuum media
- Use three different analytical approaches to solve fluids problems:
  - Dimensional analysis
  - Control volume (integral) balances of mass, momentum, and energy
  - Differential equations governing fluid flow
- Apply problem-solving strategies in engineering applications of fluid dynamics, including fluid systems in motion and in static equilibrium
- Identify the most appropriate methodology for solving engineering problems

Textbook

There will be no required textbook for this class. All course notes will be provided in electronic format. However, ***A. Smits, A Physical Introduction to Fluid Mechanics: Second Edition, Princeton University*** is recommended. This textbook is available for free at: http://www.efluids.com/efluids/books/efluids_books.htm.
Readings will be suggested from the book to supplement course notes. Other good resources:

- *B.R. Munson, D. F. Young, and T. H. Okiishi, Fundamentals of Fluid Mechanics, Wiley*
- *R. L. Panton, Incompressible Flow, Wiley*

- *F. M. White, Fluid Mechanics, McGraw-Hill*
- *M. Van Dyke, An Album of Fluid Motion, Parabolic Press (a beautiful book – check it out in the library or during the instructors office hours!)*

There is a series of 39 videos developed by the National Committee for Fluid Mechanics Films (NCFMF) that I would highly recommend for anyone interested in the subject: http://web.mit.edu/hml/ncfmf.html.

Grading

30% Homework | 40% In-classes Quizzes | 30% Final
An extra 5% will be added to the final grades of

- The top 3 student answerers on Piazza, and
- The top 3 entries of the Gallery of Fluid Motion competition (see below)

Piazza

This course will use Piazza for all class discussions. Please refrain from emailing questions related to assignments, midterms, etc., and instead use Piazza. The instructor, the TA, and even you can answer questions as they arise, thus providing an efficient means for communication. If you have issues accessing the Piazza, contact team@piazza.com directly.

Exams

There will be in-class quizzes and a comprehensive final exam. Please note the final exam date on your calendar now. All exams will be open notes unless stated otherwise.

Software

Matlab: https://software.usc.edu/matlab/
MS Office (Word, Excel): https://software.usc.edu/microsoft-office/
These programs are also available in all USC computer labs. Install before class begins.

Gallery of Fluid Motion

We will be running a *Gallery of Fluid Motion* competition!

Students are encouraged to capture images of fluid flow as they go about their day-to-day activities (milk in coffee, cloud formations, waves while surfing etc.) and post them in the designated area on the course management platform, together with a brief description. You may also submit results from numerical simulations. All entries must be original. The students who provide the top 3 entries (as judged by your peers) will receive 5% towards their grade.

Course Schedule

	Topics/Daily Activities	Textbook Readings (Smits)
Week 1 01/13	M: Introduction, Continuum Hypothesis, Applications W: Fluid Statics I	Ch. 1 Ch. 2.1-2.11
Week 2 01/20	M: *Martin Luther King's Birthday (no class)* W: Fluid Statics II	
Week 3 01/27	M: Kinematics W: Control Volume Analysis	Ch. 3.1, 4.1 Ch. 3.1
Week 4 02/03	M: Conservation of Mass W: Conservation of Momentum I	Ch. 3.2-3.4 Ch. 3.5-3.7
Week 5 02/10	M: Conservation of Momentum II W: Conservation of Energy	 Ch. 3.8
Week 6 02/17	M: *President's Day (no class)* W: Bernoulli's Equation	 Ch. 4.2-4.3
Week 7 02/24	M: Differential Equations for Fluid Flow W: Vorticity and Irrotationality	Ch. 5 Ch. 6.1
Week 8 03/03	M: Stream function, Velocity Potential W: Potential Flow Solutions I	Ch. 6.2-6.5 Ch. 6.6-6.11
Week 9 03/10	M: Potential Flow Solutions II W: Dimensional Analysis I	 Ch. 7
Week 10 03/17	*Spring Recess (no class)*	
Week 11 03/24	M: Dimensional Analysis II W: Pipe, Channel, and Duct Flows	Ch. 7 Ch. 8.1-8.7
Week 12 03/31	M: Minor Losses, System of Pipes W: Laminar Boundary Layers I	Ch. 8.8-8.11 Ch. 9.1-9.3
Week 13 04/07	M: Laminar Boundary Layers II W: Separation and Transition	 Ch. 9.4
Week 14 04/14	M: Turbulent Boundary Layers and External Flows W: Jets and Wakes	Ch. 9.4 Ch. 9.5-9.8
Week 15 04/21	M: Compressible Flow: Isentropic Flow, Acoustics W: Normal Shockwaves, Nozzle Flow	Ch. 11.1-11.4 Ch. 11.5-11.7
Week 16 04/28	M: Oblique Shocks and Prandtl Meyer Expansions W: Review & Finals Prep	Ch 11.8-11.11
Final	**Mon/Wed Section: Monday, May 12, 8am-10am** Tue/Thu Section: Thursday, May 8, 4:30pm-6:30pm	

Description and Assessment of Assignments

There will be a total of 8 **Homework** assignments. **All assignments are due on Fridays as indicated on the assignment sheet before midnight PT and are to be submitted to GradeScope using the templates provided.** Homework will not be accepted late for unexcused reasons. Please do not attempt to complete your assignment the night before it is due because most problem sets require more than one evening worth of work. Absences or late work for medical reasons must be justified with some verifiable evidence.

To receive credit for your work, all homework and exam problems must be presented in a clear, organized manner. Solutions must show evidence of work; "magic" answers will not be accepted. Partial credit may be given if the solution is presented in a logical fashion.

Students may work together on the homework by helping each other to discuss the problems, review the lectures, set up the problems, etc. **However, when you sit down to write a computer program or solve the homework problems, each student must do that individually.** You may also discuss each other's computer programs but **under no circumstances should you copy anyone's work**. **DO NOT SHARE OR EMAIL ANYTHING**; this goes for all courses at USC. **Failure to comply with this requirement will result in an F for the course.** All students should read and understand the **Academic Conduct** section at the end of this document.

There are office hours throughout the week to help you with the course material; this time is best utilized when students come prepared with an attempt at a solution, thus allowing us to help you through your thought process.

There are no makeup assignments or makeup exams. The lowest homework grade will be dropped from your total score; use this to your advantage if you have an upcoming schedule conflict. There are three exams; the grades from two midterms will be weighted unequally. Everything else will count towards the final grade.

Homework Solutions – Rules and Tips

Technical communication is an extremely important skill required of all engineers. If you cannot present your work well to your boss or co-workers, do not expect a raise! Likewise, if you cannot present your technical work well in this class, you will not get a good grade on your assignments. Thus, all homework **must** be presented in a professional manner. Follow the guidelines below:

1. All homework must be submitted through GradeScope and organized into the format specified in the templates provided. Emailed submissions will not be accepted. Ensure your name is printed on your assignments.
2. Make sure mistakes are clearly erased or carefully crossed out so that anyone can read and follow your work without difficulty. If the grader cannot follow your logic or your work is messy, the homework will be returned to you ungraded and a score of zero recorded.
3. It is necessary that you present your work neatly, logically and professionally. To receive full credit on homework and exam problems **all** the following **must** be shown:
   a) Write down all given **data** at the beginning of the problem solution.
   b) Include a **free hand sketch** of the problem whenever possible.
   c) State any **assumptions** used in the problem.
   d) Write the equations to be used in **symbolic form**. Indicate where you obtained the equations and verify that the assumptions embedded within the equations are consistent with the problem you are attempting to solve. Manipulate the equations in **symbolic form** to obtain the desired form **before** substituting in the numerical values (see example problems 4.3 and 4.4 in your book). **No exceptions!**
   e) **Algebraic steps** are an important part of your work and should be shown. Again, no exceptions.
   f) Work through the **Units** in your calculations and show conversion of the units as needed. Be sure to give BOTH THE NUMERICAL VALUE AND THE UNITS in your answer. Why? Because $4 \neq 4\ \mathrm{m/s}$.
   g) Round off the final numbers and report only **Significant Digits** consistent with the accuracy of the data (*i.e.*, if the data are given to 3 significant digits, DO NOT present an answer with

8 significant digits). If some of the data have only one digit given, *e.g.* angle of attack $\alpha = 8$ degrees, you should assume that two digits are implied (*i.e.*, $\alpha = 8.0°$). In this case, your answer should contain only two significant digits although three significant digits will be accepted. Generally, you should have three significant digits in your answer unless you can justify more or less based upon the given data.

4. Remember that the most important aspect of homework and exam solutions (typically 80-90% of the grade for the problem) is **the method** and not the correct answer. Thus, indicate how the solution was obtained by showing each step in the solution and where the data were acquired.

5. Place a box around your answer to clearly indicate your final solution.

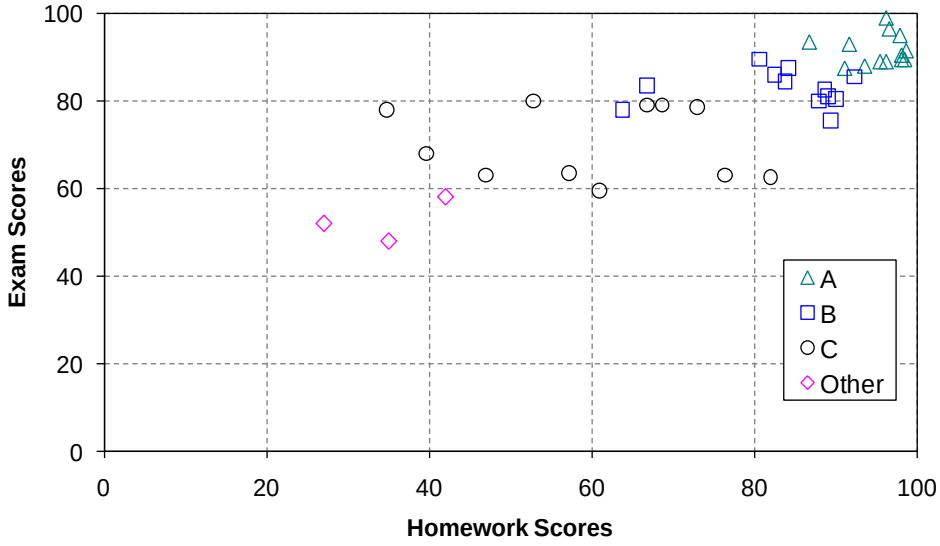


Figure 1. Correlation between Homework and Exam scores

Figure 1 is provided to show the relationship between the homework scores (normalized to 100 points) and the grades on the exams. This data is from a previous semester but the trend is consistent year after year. Note, there is a strong correlation between how well students do on their homework and their exams; do not think that the homework is inconsequential. If you are having trouble, seek help either by seeing the instructor, the teaching assistants or get additional tutoring (Viterbi Academic Resource Center). Secondly, data over the past several year's shows that about one third of the students in the class earn an A, one third earn a B and the remaining third earn a C or lower. Lastly, looking at the individual homework scores (not shown), the lower scores were primarily due to students not submitting several of their assignments; it was not because they did poorly on all of their assignments. **Hence, be sure that you complete, understand the concepts within and turn in ALL of your homework if you want an A or B in the course.**

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. Familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* https://scampus.usc.edu/b/11-00-behavior-violating-university-standards-and-appropriate-sanctions/, and **view the guidelines in Appendix A at the end of this document**. 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.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu or to

the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

Support Systems

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.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
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) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
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 Campus Support and Intervention - (213) 821-4710
campussupport.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.

Tutoring is available for this course through https://viterbiundergrad.usc.edu/academics/. A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://dsp.usc.edu/ provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* http://emergency.usc.edu will provide safety and other updates, including ways in which instruction will be continued by means of teleconferencing and other technology.

Appendix A: Academic Dishonesty Sanction Guidelines

Violation	USC - Recommended Sanction for Undergraduates*	AME - Recommended Sanction for Undergraduates and Graduates
Copying answers from other students on any course work.**	F for course.	First offense: **F** on assignment. Second offense: **F** for course.
One person allowing another to cheat from his/her exam or assignment.	F for course for both persons.	If assignment: First offense: **F** on assignment. Second offense: **F** for course. If exam: **F** for course.
Possessing or using material during exam (crib sheets, notes, books, etc.) which is not expressly permitted by the instructor.	F for course.	First offense: **F** on exam. Second offense: **F** for course.
Continuing to write after exam has ended.	F for course.	**F** on exam
Taking exam from room and later claiming that the instructor lost it.	F for course and recommendation for further disciplinary action (possible suspension).	**F** for course
Changing answers after exam has been returned.	F for course and recommendation for further disciplinary action (possible suspension).	**F** for course
Fraudulent possession of exam prior to administration.	F for course and recommendation for suspension.	**F** for course
Obtaining a copy of an exam or answer key prior to administration.	Suspension or expulsion from the university; F for course.	**F** for course
Having someone else complete course work for oneself.	Suspension or expulsion from the university for both students; F for course.	**F** for course
Plagiarism — Submitting other's work as one's own or giving an improper citation.	F for course.	First offense: **F** on assignment. Second offense: **F** for course.
Submission of purchased term papers or papers done by others.	F for course and recommendation for further disciplinary action (possible suspension).	**F** for course
Submission of the same assignment to more than one instructor, where no previous approval has been given.	F for both courses.	**F** for both courses
Unauthorized collaboration on an assignment.	F for the course for both students.	First offense: **F** on assignment. Second offense: **F** for course.
Falsification of information in admission applications (including supporting documentation).	Revocation of university admission without opportunity to reapply.	Revocation of university admission without opportunity to reapply.
Documentary falsification (e.g., petitions and supporting materials; medical documentation.)	Suspension or expulsion from the university; F for course when related to a specific course.	Suspension or expulsion from the university; **F** for course when related to a specific course.
Plagiarism in a graduate thesis or dissertation.	Expulsion from the university when discovered prior to graduation; revocation of degree when discovered subsequent to graduation.***	Expulsion from the university when discovered prior to graduation; revocation of degree when discovered subsequent to graduation.***

*Assuming first offense
**Exam, quiz, tests, assignments or other course work.
***Applies to graduate students