

# Syllabus

CHE 443: Viscous Flow

Fall 2021

CHE 443 explores the fundamental principles of fluid mechanics as applied to chemical engineering and chemical processing operations.

*Note: All times are Pacific Time; PDT prior to November 7 and PST after November 7.*

## Lectures

TTh, 12:00 – 1:50 pm, VPD 105

## Discussion Sections

Thursdays, 3:00 – 3:50 pm, CPA 256

Fridays, 4:00 – 4:50 pm, GFS 104

**Note:** Please attend the discussion section you have registered for, as space is limited.

## Instructor

Noah Malmstadt

Office: RTH 504

Mobile Phone: 626-318-1754

Email: [malmstad@usc.edu](mailto:malmstad@usc.edu)

Office Hours: Tuesdays 3:00 – 4:00 pm; Thursdays 4:00 – 5:00 pm or by appointment

## Teaching Assistant

Ricki Chairil

Office: RTH 521 (Meeting in the workspace in the hallway outside of room 512)

Email: [chairil@usc.edu](mailto:chairil@usc.edu)

Office Hours: Mondays 4:00 – 5:00 pm

## Prerequisites

One of either CHE 350 or MATH 245.

## Text

*Introduction to Chemical Engineering Fluid Dynamics* by William M. Deen, 2016, ISBN 978-1-107-12377-9

## Communication resources

Slack workspace: [che443.slack.com](https://che443.slack.com)

Piazza resources page: <https://piazza.com/usc/fall2021/che443/resources>

## Grading

Grades will be based on weekly homework assignments, two midterm examinations, and a final examination.

The proportions of the final grade determined by each of these elements will be as follows:

Homework: 10%

Midterms: 25% each

Final: 40%

For homework, each assignment will receive 0, 1, or 2 points. A score of zero points corresponds to an inadequate effort or missing assignment, a score of 1 point corresponds to a good effort that displays some understanding of the material, and a score of 2 points corresponds to an excellent effort that demonstrates and communicates a mastery of the material. Note that **communication** is a key element of this scoring system. If you have mastered the material, you should be able to clearly and unambiguously communicate a solution of the problem in a manner that is obvious to the graders. It will be difficult for us to assign 2 points to a homework assignment in which we must intuit, interpret, and make assumptions about your meaning.

Exams will be take-home with a self-administered time limit. They will be due 24 hours after being distributed, either physically or as a scanned / photographed file via Blackboard. Exams will be graded according to a

rubric that will be made available following the administration of the exam. Midterm exams will be worth 50 points each, the final exam will be worth 80 points.

Final grades will be calculated as follows: Total points will be added and transformed into percentages; the arithmetic mean of the percentage scores will be determined. If the highest score in the class is ten or more percentage points higher than this mean, the mean score will receive a B, ten percentage points above the mean will receive an A, ten percentage points below the mean will receive a C, twenty percentage points below the mean will receive a D, etc. If the highest score in the class is less than ten percentage points above the mean, the highest score will receive an A, ten percentage points below the highest score will receive a B, ten percentage points below that will receive a C, etc.

### **Collaboration Policy**

Students are encouraged to discuss and work together on homework assignments, but the work each student hands in must be their own. It is not acceptable to merely copy another student's effort; each student must be capable of fully understanding and describing everything they have written in the submitted homework assignment. To ensure that this is the case, it is recommended that when working in a group (group sizes of five or fewer are recommended), students plan their approach to a problem making notes on scratch paper or a blackboard. The work that each student submits, however, should be written independently without referencing these notes. If you have any doubts regarding whether a certain instance of collaboration is acceptable at any point in the semester, ask the instructor for clarification.

Work on exams will be completely independent.

### **Homework Due Dates**

Homework assignments will be available at 12 pm each Tuesday, and they will be due in the at 2 pm the next Tuesday. Homework will be posted on Slack, Piazza, and Blackboard and can be turned in as a photograph or scan on Blackboard. There will be no homework due on exam weeks.

### **Lecture and Reading Schedule**

This schedule is subject to change, with notice.

#### ***Part 1: Fluid Phenomenology***

- Week 1: Definition and properties of fluids. Scaling, dimensionless groups, and dimensional analysis.  
*Chapter 1*
- Week 2: Pipe flow. Friction factor, cylindrical and noncylindrical pipes, wall roughness.  
*Chapter 2*
- Week 3: Flow around particles: drag and terminal velocity. Flow through porous media.  
*Chapter 3*

#### ***Part 2: Describing Forces and Motion in Fluids***

- Week 4: Statics. Describing pressure, body forces, and surfaces. Review of scalar fields.  
*Chapter 4*
- Week 5: Kinematics. Fluid velocity. Review of vector fields.  
*Chapter 5*
- Week 6: Stress and momentum. Review of tensors.  
*Chapter 6*

#### ***Part 3: Microscopic Analysis of Fluid Mechanics***

- Week 7: Introduction to microscopic analysis. Unidirectional flow. Symmetry.  
*Chapter 7*
- Week 8: Introduction to viscous flow. Lubrication approximation and creeping flow.  
*Sections 8.1-8.3*
- Week 9: Pseudosteady flow and approximate solutions.  
*Sections 8.4-8.5*
- Week 10: Laminar flow with inertia. Boundary layers.  
*Chapter 9*
- Week 11: Flow considerations for microfluidics. Forces on particles and cells in microflows.  
*To be distributed*
- Week 12: Turbulence.  
*Chapter 10*

Week 13: Introduction to finite element modeling of the equations of flow.  
*To be distributed*

#### **Part 4: Macroscopic Analysis of Fluid Mechanics**

Week 14: Macroscopic mass, momentum, and energy balances  
*Chapter 11*

Week 15: Pipe flow, compressible flows, pumps.  
*Chapter 12*

#### **Special Dates**

Thurs. Sept. 30: Exam 1 distributed  
Thurs. Oct. 14: Fall Recess, no class  
Thurs. Oct. 28: Exam 2 distributed  
Thurs. Nov. 25: Thanksgiving Recess, no class  
Thurs. Dec. 2: Final CHE 443 class meeting  
Tues. Dec. 14: Final Exam due, 1:00 pm

#### **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 Section 11, *Behavior Violating University Standards*:  
<https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/>

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 Equality and Diversity* (<http://equity.usc.edu>) or to the *Department of Public Safety*:  
<http://adminopsnet.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 (<https://sarc.usc.edu>) describes reporting options and other resources.

#### **Support systems**

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://sait.usc.edu/academicsupport/centerprograms/dsp/home\\_index.html](http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html)  
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 BlackBoard, teleconferencing, and other technology.