

ME 542: Advanced Fluid Mechanics

MW 2:30-4:15 EPC 206

Instructor: Sheryl Grace

Office: ENG 407

Email: sgrace@bu.edu

LfA information: The room has been approved for 18 students in person. This means that the class roster can fit into the room and all can attend the in-person lectures. Students arriving in person must wear a mask. There will be no eating or drinking allowed in the classroom as this requires removal/movement of the mask.

The lectures will be synchronously zoomed for those not able to attend in person. If a student misses a class for any reason the lectures will be available on this blackboard site for review.

COVID 19 & BU Community Health Expectations:

Masks are required and face coverings must be worn over the mouth and nose at all times when in public spaces on campus, including classrooms. Students should be prepared to show proof that they are compliant with health attestations and testing in order to attend class. All students are expected to follow all university guidelines with respect to daily symptom checks, testing, social distancing, and mask wearing when they leave their dorm or home. For a detailed description of official BU policies regarding COVID, please visit: <http://www.bu.edu/dos/policies/lifebook/covid-19-policies-for-students/>

Required Textbook: Panton, Ronald L. Incompressible Flow, 4th edition, John Wiley and Sons, Inc.

Supplemental Textbooks:

Batchelor, G.K. An Introduction to Fluid Dynamics, Cambridge University Press.

Kundu, P.K, Cohen, I. M., Dowling, D. R., Fluid Mechanics, Associated Press.

Fox, R W., McDonald, A. T., and Mitchell, J. W., Introduction to Fluid Mechanics, Wiley.

Kreyszig, Erwin. Advanced Engineering Mathematics, Wiley (or any textbook that covers vector calculus, linear equations, and partial differential equations)

Goals: The main goals of this course are to teach students differential and dimensional analysis techniques such that one can analyze incompressible viscous and inviscid flow. Students will be introduced to conventional applied mathematics techniques to solve the Navier-Stokes equations, which is a set of nonlinear partial differential equations that establish the relationship between stresses and fluid motion spatially. Students will utilize Matlab to plot analytical solutions for select flow scenarios and compare with numerical solutions. The computational tools will be leveraged to explore and visualize fluid motion in various geometries and to acquire a deeper understanding of the physics governing the fluid motion. The course will supply the background preparation for more specialized courses on computational fluid mechanics, compressible and/or viscous flow, and aeroacoustics/aerodynamics.

Order of topics (subject to change):

1. Kinematics (Chapter 4), Vector Algebra/Calculus, and Index Notation (Chapter 3)
2. Basic Laws (Chapter 5)
3. Navier Stokes Equations and Basic Solutions (Chapters, 6, 7, 11)
4. Dimensional Analysis (Chapter 8)
5. Viscous Flow Solutions (Chapter 11)
6. Vorticity Dynamics (Chapter 13)
7. Streamlines and Velocity Potential (Chapter 12)
8. Low Reynolds Number Flow (Chapter 21)
9. High Reynolds Number Flow (Chapter 16)
10. Ideal (Potential) Flow (Chapter 18)
11. Boundary Layers (Chapter 20)

Assignments: The focus of the class is to explore various approaches for deriving and solving equations of motion describing the flow of incompressible fluid through or around structures. Students will improve understanding and gain mastery of the various mathematical approaches through problem solving and computational modeling. Assignments will be posted on Gradescope available through the course website. Assignments will be submitted via Gradescope unless otherwise noted.

Homework, which will be assigned in class and noted on the course web page is due at the beginning of the designated class period (unless otherwise noted.) All homework will be graded and returned. The top of the first page of the homework should have: your name and the course number. Every page should have the problem number on the top right corner. There should be no frayed edges and multiple pages must be stapled. You should briefly restate the problem (some even make a photo copy and tape the problem statement to the page). Give a sketch if helpful. List the basic assumptions. Give all necessary analysis. If asked to plot something, you must create a computer generated graph with appropriate axis labels and legend. Place a box around the final answer. Correct units should accompany all numerical answers. **Any answer that is not of the correct order of magnitude, with no accompanying explanation, can be given no points, even if the method used to do the problem is correct.** Homework solutions will be accessible after the assignment is due.

Grading: Final grades will be based on student participation in class and completion of assignments (combination of end of homework problems and computer simulations) and performance on exams.

General course information :

Due to the LfA model, exams will probably be oral and administered via zoom. This is still being reviewed.

Honesty policy: Adherence to the Student Academic Code of Conduct is expected (<https://www.bu.edu/academics/policies/academic-conduct-code/>). I encourage you to freely discuss the homework amongst one another as you formulate your solutions individually. *Your* written work should represent *your* understanding of the problem.

In practice, this means that copying (in whole or in part) another student's homework, exam, computer program, or paper is not permitted. If you choose to discuss your work with a colleague, it should be a discussion in which one teaches another or both work to a mutual understanding. As a counter-example, it is not acceptable to give a friend your homework five minutes before class so that your friend can copy your work. I also consider it unacceptable to copy work from a student who was in the class a previous year. In your written reports, be careful to correctly use quotation marks for words that did not originate with you. Also, be sure to properly cite all sources you used. As is done in the scientific literature, you should *briefly* acknowledge in writing any significant discussion or interactions you had regarding the work you submit. As a general principle, I do not accept the justification that you were not sure of my intentions. If you feel you may be in an ethical gray area, then you should consult with me *before* acting.

Inclusion: I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Accommodations for Students with Documented Disabilities: If you are a student with a disability or believe you might have a disability that requires accommodations, requests for accommodations must be made in a timely fashion to Disability & Access Services, 25 Buick St, Suite 300, Boston, MA 02215; 617-353-3658 (Voice/TTY). Students seeking academic accommodations must submit appropriate medical documentation and comply with the established policies and procedures <http://www.bu.edu/disability/accommodations/>