ME 542: Advanced Fluid Mechanics
MW 2:30-4:15 PSY B41
Instructor: Dr. Tyrone M. Porter
Office: ENG 319
Office Hour: By appointment
Email: tmp@bu.edu

Required Textbook/Course website:
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.
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 implemented by COMSOL. 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)

Lectures will be based on reading material supplemented by vignettes on the history and evolution of fluid mechanics, the contributions of historical pioneers in the field, and the classical equations that serve as the foundation for the field.

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.

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