ME 640: Fundamentals of Fluid Mechanics, Fall 2019

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Office Hours: TBD.

Classroom: TBD

Homework: Due in class, one week after assignment

Grades: Tentative.

One midterm examination	35% of course grade
Final examination	50% of course grade
Homework	15% of course grade

Course Outline:[1]

1. Mathematical preliminaries (Panton Chapter 3)
   (a) Theorems of Stokes and Gauss
   (b) Transport theorem
   (c) Vector and subscript notation
2. Kinematics of fluid motion (Panton 4; Batchelor 2.3)
   (a) The motion of a material line element
   (b) The deformation of a small fluid sphere
3. Conservation of mass (Panton 5; Batchelor 2.2)
   (a) Derivation of continuity equation in differential form
   (b) Streamfunctions for compressible and imcompressible flow
4. Momentum equation (Panton 5 and 6; Batchelor 3.1, 3.2, 3.3)
   (a) Momentum equation for a material particle with unknown surface forces
   (b) Derivation of the pressure and deviatoric stress tensor
   (c) Newtonian relationship between stress and strain rate
   (d) The Navier-Stokes equations for compressible and incompressible fluids
5. Exact solutions of the Navier-Stokes equations (Panton 7 and 11; Batchelor 4)
   (a) The suddenly started plate
   (b) The decay of an ideal vortex
   (c) Flow along an inclined plane
6. Vorticity (Panton 13; Batchelor 5)
   (a) Derivation of the vorticity equation
   (b) The circulation theorem for a viscous compressible fluid motion
   (c) Approximations of flows as irrotational

[1] Chapters in Panton's and Batchelor's books where each topic can be found are listed here. However, these chapters cover more material than is covered in class. Students are only responsible for the material covered in class.

7. The energy equations (Panton 5; Batchelor 3)
   (a) The mechanical energy equation
   (b) The first law of thermodynamics for a Newtonian fluid
8. Irrotational motion (Panton 18 (first sections); Batchelor 6 (first sections))
   (a) Bernoulli's equations
   (b) Steady, two-dimensional irrotational flows about simple bodies

Suggested textbooks:

Incompressible Flow, by R. F. Panton, Second Edition, John Wiley and Sons, New York, 1996. Homework problems will be assigned from this textbook.

An Introduction to Fluid Dynamics, by G. K. Batchelor, Cambridge University Press, 1967.

Books on Reserve at the Engineering Library:

An Introduction to Fluid Dynamics, by G. K. Batchelor, Cambridge University Press, 1967.

Mathematical Methods for Physicists, by G. Arfken and H. J. Weber.

Foundations of Solid Mechanics, by Y. C. Fung, Prentice-Hall, 1965.

Homework and Projects:

A number of homework problems may require use of Matlab or equivalent software.