Spring 2018

MATH 605-600: Mathematical Fluid Dynamics

Instructor: Prabir Daripa
Office: Blocker 629D
Class Room: Blocker 624 (NOT in Blocker 202 as it shows on Howdy)
Class Time: MW 5:45 pm - 7:00 pm
Office Hours: By appointment and/or 2:00-3:00 pm
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homepage of this handout: `http://www.math.tamu.edu/~daripa/courses/m605/spring18/math605-fdh.pdf`

Description: This is an introductory course on fluid mechanics for graduate students in mathematics, engineering, and physics. The goal in this course is to systematically introduce a variety of equations of fluid dynamics from first principle followed by various mathematical analysis involving laminar and turbulent flows. Some applied mathematical tools may be introduced as often as required to make the course fundamentally as self-contained as possible for a semester course. Computational aspects will be covered to the extent possible depending on the time available.

Audience: This course can be taken by graduate students from a variety of disciplines including mathematics, almost all engineering departments, and physics. Some seniors meeting the following pre-requisites may be allowed to take this course **only** at the approval of the instructor.

Prerequisite: Basic knowledge of methods of linear algebra & vector analysis at the level of MATH 601/MATH 311 and MATH 304/MATH 323, Ordinary differential equations at the level of MATH 308, and some classical techniques for solving PDEs at the level of MATH 412 or MATH 602. Some background knowledge of complex analysis is a definite plus but not required. Alternatively, approval of the instructor.

Textbooks (Recommended):

1. Some (may be all ?) lecture notes (some may be handwritten) of Prabir Daripa (instructor of this course) will be provided as often as possible.
2. A Mathematical Introduction to Fluid Mechanics by A. Chorin and J. Marsden, Springer-Verlag, Fourth Edition. Third edition is available for free download at `https://link.springer.com/book/10.1007%2F978-1-4612-0883-9`
3. Elementary Fluid Dynamics by David Acheson, Oxford University Press, 2000.

Other References:

1. Viscous Flow by H. Ockendon and J. R. Ockendon, Cambridge University Press, 1995.
2. A Modern Introduction to the Mathematical Theory of Water Waves, by R. S. Johnson, Cambridge Univ. Press, 1997.
3. Applied Analysis of the Navier-Stokes Equations, by C. Doering and J. Gibbon, Cambridge University Press, 1995.
4. Turbulent Flows, by S.B. Pope, Cambidge University Press, 2000.
5. Navier-Stokes Equations and Turbulence, C. Foias, O. Manley, R. Rosa, and R. Temam, Cambridge University Press, Cambridge, 2001.
6. Vorticity and Incompressible Flow, A. Majda and A. Bertozzi, Cambridge University Press, 2002.
7. Fluid Mechanics by Landau and Lifshitz, 2nd Edition. Pergamon Press, 1959.
8. An Introduction to Fluid Dynamics by G.K. Batchelor, Cambridge Univ. Press, 1967.

Grading Policy: Your grade for the course will be based on project assignments. Please note the projects in my handout broadly include any test I give and any homework I assign. A mid term and/or final counts as a project since at times I give take home exam. Your letter grade for the semester will be A, B, C, or D, for averages of minimum 90%, 80%, 70%, or 60%, respectively.

Cheating: I take this very seriously, and will prosecute any case that I think I can prove. Scholastic dishonesty procedures will be rigorously enforced.

Identification: You must have your ID with you at all exams and quizzes.

Attendance: Attendance is required and rolls may be taken. Please come to the class on time and do not leave early.

Disabilities: The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.

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http://www.tamu.edu/aggiehonor

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If you have any questions regarding plagiarism, please consult issue of the Texas A&M University Student Rules, under section "Scholastic Dishonesty".

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Tentative Course Outline. All topics below may not be covered.

1. Part 0: A Brief Review of Some Mathematical Techniques
2. Part I: Flow Map, Strain, Stress, Kinematics, and All That
   - Flow map and some related preliminaries
   - Strain, Stress, Constitutive equations and All That
3. Part II: Basic Equations of Fluid Dynamics
   - The equation of mass conservation
   - The equation of motion: Euler and Navier-Stokes' equations
   - The equation for energy conservation
   - Equations for special cases: Isentropic fluid flow, potential flow etc.
   - Dimensionless parameters and scaling of these equations
   - Introduction to non-Newtonian models
4. Part III: Potential Flows
   - Incompressible potential flow
   - Point vortex dynamics on planar and spherical surfaces
   - Compressible potential flow
5. Part IV Viscous Flows
   - Slightly viscous flows: Flows at high Reynolds number
   - Boundary layer theory and Prandtl's equation
   - Application of Prandtl's equation
   - Slow viscous flows: Flows at low Reynold's number
   - Stokes flow, Lubrication theory etc.
   - Introduction to porous media flows
6. Part V: Water Waves (Tentative ?)
   - Introduction
   - Linear and nonlinear problems
   - Weakly nonlinear dispersive waves
   - Slow modulation of dispersive waves
7. Part VI: Compressible Flows
   - Equations of compressible flows
   - Conservation laws
   - Theory of shock waves
   - Gas Dynamics: transonic and supersonic flows
8. Part VII: Instability and Turbulence (time permitting!)
   - Introduction to Instability (a flavor of Math 672)
   - Introduction to Turbulence (a flavor of Special topics course I want to offer in the future)