1.63J/2.21J Fluid Dynamics Spring 2010

http://web.mit.edu/1.63/www/

- Instructor in Charge

  Professor T.R. Akylas; Room 3-362, x3-5356, trakylas@mit.edu
  Office hours: M,W 11am –12 noon in Room 3-362 and by appointment

- Guest Lecturer

  Professor Thomas Peacock; Room 1-310D, x8-0736, tomp@mit.edu

- TA

  Yeunwoo Cho; Room 3-355, x3-5420, ywcho@mit.edu

- Homework

  There will be about 6 problem sets; typically a new problem set will be handed out every other week and you will have two weeks to work on it

- Exams

  There will be a mid-term quiz and a final quiz but no final exam. Both quizzes will be take-home

- Grading

  The homework, mid-term and final will count equally (1/3 of the grade) towards the final grade

- Textbook

  The subject will be based on the material presented in the lectures. There is no required textbook. A set of Lecture Notes prepared by Professor C.C. Mei is available in the subject website. A list of books placed on reserve in Barker Library and other references is provided on a separate sheet

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Outline

I. Introduction

Organization, scope of subject. Review of basic principles: flow kinematics, strain and vorticity; mass, momentum and energy conservation; Navier–Stokes equations; vorticity dynamics; scaling and approximations; Rayleigh problem

II. Creeping flows

Lubrication approximation for thin fluid layer; gravitational spreading; biolocomotion. Stokes flow past a sphere, Stokeslet; slender bodies, G.I. Taylor problem. Oseen's equations

III. Boundary-layer theory

Boundary-layer equations; method for finding similarity solutions; integral methods and unsteady boundary layers; oscillatory boundary layers, streaming

IV. Dispersion in shear flows

Taylor dispersion of passive solvent; effective diffusivity

V. Flows in porous media

Darcy's law; Saffman–Taylor instability

VI. Rotating and stratified flows

Centrifugal and Coriolis forces; Taylor–Proudman theorem, Taylor columns; inertial waves. Buoyancy frequency; internal waves

Module I: Introduction to hydrodynamic stability (6 lectures)

Kelvin–Helmholtz instability; capillary instability of liquid jet; absolute vs. convective instability; stability of nearly-parallel flows; combined effects of shear and stratification, Miles–Howard theorem; centrifugal and other instabilities; nonlinear effects

Module II: Experimental techniques (6 lectures by Prof. T. Peacock, Guest lecturer)

Measuring fundamental fluid properties: density, viscosity, temperature; velocity field measurements: laser Doppler anemometry, particle image velocimetry; density/temperature/concentration field measurements: laser induced fluorescence, synthetic schlieren; wave tanks and density stratifications, the double bucket method

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References

- On reserve in Barker Library:

P.K. Kundu & I.M. Cohen, *Fluid Dynamics* (3^{rd} ed.), Elsevier, 2004.

L.G. Leal, *Advanced Transport Phenomena*, Cambridge U.P., 2007.

G.K. Batchelor, *An Introduction to Fluid Dynamics*, Cambridge U.P., 1967.

- Additional references:

M.J. Lighthill, *An Informal Introduction to Theoretical Fluid Mechanics*, Oxford, 1986.

I.G. Currie, *Fundamental Mechanics of Fluids*, McGraw-Hill, 1974.

D.J. Tritton, *Physical Fluid Dynamics*, Van Nostrand, 1977.

C.-S. Yih, *Fluid Mechanics*, West River, 1979.

L.D. Landau & E.M. Lifshitz, *Fluid Mechanics*, Pergamon Press, 1975.

F.M. White, *Viscous Fluid Flow*, McGraw-Hill, 1974.

H. Schlichting, *Boundary-Layer Theory*, McGraw-Hill, 1968.

L. Rosenhead (ed.), *Laminar Boundary Layers*, Oxford U.P., 1963.

H. Ockendon & J. R. Ockendon, *Viscous Flow*, Cambridge, U.P., 1995.

F.K. Moore (ed.), *Theory of Laminar Flows*, Vol. 4, High Speed Aerodynamics and Jet Propulsion, Princeton U.P., 1964.

M. Van Dyke, *Perturbation Methods in Fluid Mechanics*, Parabolic Press, 1975.

J. Happel & H. Brenner, *Low Reynolds Number Hydrodynamics*, Prentice-Hall, 1965.

P.G. Drazin & W.H. Reid, *Hydrodynamic Stability*, Cambridge U.P., 1982.