Math 654 Introduction to Fluid Dynamics Fall 2008

Instructor: Robert Krasny, 4830 East Hall, 763-3505, krasny@umich.edu

Time and Location: TuTh 10-11:30am, 1060 East Hall

Office Hours: Tu 3-4pm, W 11am-1pm

Course Website: www.math.lsa.umich.edu/∼krasny/math654.html

Text

"A Mathematical Introduction to Fluid Mechanics", A.J. Chorin & J.E. Marsden, Springer

Math 654 is a mathematically oriented introduction to fluid dynamics for students in math, science, and engineering. The term "fluid" refers to a liquid or a gas - the key property is that a fluid deforms easily in response to an applied force. Fluid motion is described by a set of partial differential equations expressing conservation of mass, momentum, and energy. These are the Navier-Stokes equations for viscous flow and the Euler equations for inviscid flow. The goal in solving these equations is to understand, predict, and control the fluid motion. The subject has extensive applications (e.g. designing the shape of an aircraft wing or an artificial heart valve) and there is also great beauty in many flow visualizations (e.g. clouds, ocean waves, smoke swirls). Math 654 covers basic material on compressible and incompressible flow. If time permits there will be a short introduction to some special topics. The emphasis is on analytical techniques, but I will also discuss relevant experiments and computer simulations. Previous coursework in vector calculus, complex variables, and differential equations will be helpful. There will be several homework assignments.

Outline

1. basics: derivation of the Euler and Navier-Stokes equations, compressible and incompressible flow, stream function, potential function, flow map, vorticity, Biot-Savart law, circulation, Kelvin's theorem, point vortices, potential flow past a cylinder, Bernoulli principle, viscous flow past a flat plate, lift and drag, Prandtl boundary layer equations

2. short introduction to some of the following: vortex sheet motion, hydrodynamic stability, 1D gas dynamics

Other References

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

"Fluid Mechanics", L.D. Landau & E.M. Lifshitz, Pergamon

"Supersonic Flow and Shock Waves", R. Courant & K.O. Friedrichs, Springer

"Introduction to Mathematical Fluid Dynamics", R.E. Meyer, Dover

"Hyperbolic Systems of Conservation Laws and the Mathematical Theory of Shock Waves", P.D. Lax, SIAM

"An Album of Fluid Motion", M. Van Dyke, Parabolic Press

"Multimedia Fluid Mechanics", G.M. Homsy, Cambridge University Press

"Fundamentals of Hydro- and Aeromechanics", L. Prandtl & O. G. Tietjens, Dover