

Math 655 - Winter 2004

Topics in Fluid Dynamics: Hydrodynamic Stability

Instructor

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Time/Location

class: TuTh, 10-11:30am, 4096 East Hall

office hours: TuTh 11:30am-12:30pm and by appointment or drop-in, 4830 East Hall

Website

www.math.lsa.umich.edu/~krasny/math655.html

Fluid flow is governed by the Navier-Stokes equations, a set of nonlinear partial differential equations expressing the conservation of mass, momentum, and energy. These equations contain a nondimensional parameter, the Reynolds number, which measures the ratio between inertial and viscous effects in a specific flow. Experiments show that if the Reynolds number is sufficiently small, the flow is laminar, but if the Reynolds number is larger than a certain critical value, the flow undergoes a transition to turbulence. The goal of hydrodynamic stability theory is to explain the details of this transition. This course is an introduction to the subject, dealing with analytical results and how they relate to experiments and computations. Thermal and centrifugal instability will be discussed but the main emphasis is on parallel shear flow, including mixing layers, jets, wakes, and boundary layers. The course will cover classical linear and nonlinear stability theory. Some key topics are: bifurcations, Kelvin-Helmholtz instability, Rayleigh equation, Orr-Sommerfeld equation, critical layer, absolute and convective instability, global modes, transient growth.

Text

Introduction to Hydrodynamic Stability, P. G. Drazin, Cambridge University Press

References

Hydrodynamic Stability, P. G. Drazin & W. H. Reid, Cambridge University Press

Hydrodynamic and Hydromagnetic Stability, S. Chandrasekhar, Dover

Stability and Transition in Shear Flows, P. J. Schmid & D. S. Henningson, Springer

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

Prerequisites

It is assumed that students have previously taken an introductory course in fluid dynamics (e.g. Aero 522, Math 654, or Mech 520). Students lacking this prerequisite are welcome, but they should acquire some background by reading the first two chapters in the Chorin-Marsden text or the lecture notes for Math 654.

Course Requirements

There will be several homework assignments.