Hydro Dynamic Stability:
(Stability of Fluid Flows)

Instructor: Don Slinn

Class: MWF – 11:45 – 12:35

Office: Weil 575 I

Office Hours: MWF - 3:00 pm
TR - 9:30 am

Class Website: www.coastal.ufl.edu/~slinn/classes.html

Lecture 1

First Assignment:

Name, credit/audit

Department

Describe background in fluids and applied mathematics

Degree you are seeking

Thesis topic and advisor

Subjects of interest related to stability

Prerequisites:
- Grad level courses in Fluid Mechanics and Applied Mathematics
- Familiarity with Fourier and LaPlace Transforms and Sturm Liouville Theory

Grading:
1-2 problems per week
Tests: midterm/ final
**Course Objectives:**
1. Develop understanding of flow stability. (When, how, and why flows are unstable)
2. Develop capabilities
   a. Determine whether a particular flow is unstable
   b. Predict growth rates of instabilities and other properties of transition (wavelength, structures, resonance).
   c. Use understanding in a research environment.
3. Interest people in working in these areas.

**Two approaches possible:**
1. Broad brush
   a. Not going into any problem deeply.
   b. Touching on main instability problems
   c. More useful to students
2. More in depth
   a. Requires more mathematical background
   b. Perturbation theory
   c. Gives tools for solving general problems

*We will cover both approaches.*

Need some programming language ability like Matlab or Fortran.

**Importance of Stability**
1. Technologically Important
   Potentially critical in design to know if laminar or turbulent.
   i.e. chemical reaction
   Heat transfer
   Laminar flow control – wing’s
   Estimate drag – sea vessels or airplanes
   Try to keep the B. L. laminar
2. Research – Active Area
   Used in many disciplines and uses many techniques
   Good problems in Applied Math.
   Much experimental work going on
   Now Numerical Techniques too
   (Direct numerical simulations)
3. Key topic in Fluid Mechanics
   Especially true for turbulence
   a. Turbulent flow is by definition unstable.
   b. Turbulent flows – although random and chaotic, they are characterized by having large scale structures related to local instabilities in flow.
   c. Turbulence control – possible to manipulate a turbulent flow, delay or hasten transition.
Recommend you get a copy of Van Dyke’s book “An Album of Fluid Motion”
Parabolic Press - $25.00, from amazon.com

A turbulent mixing layer occurs in nature and technological problems.

See pages 101 & 102

Structures are related to flow instability.

Kelvin – Helmholtz instability

Structures also occur in Boundary Layers.

Emphasize importance of visualization in learning about transition.

Books:
1. Intro to Hydrodynamic Stability, 2002, P. G. Drazin – will follow 60% of time in class.

Missing some recent topics in non-linear systems.

References:
Drazin & Reid. 1981. $47.00, Hydrodynamic Stability.


Very good for linear analysis and work up to that time, very readable.

Dover edition, $15.00

Concise and mathematical. Well written, and very useful. Asymptotic expansions – Coastal Library has a copy.
Betchov & Criminale – 1967
Emphasis on Numerical Solutions, Boundary layers and free shear flows.

Joseph – 1967
Set of 2 books. Very mathematical, energetics approach, optimization method.

Many Annual Reviews of Special Topics.
Handout – post PDF on web.
Handout – List of review article from A.R. of F.M.

**General Course Outline**

1. Introduction
2. Classical Problems – Kelvin & Helmholtz, Rayleigh (work done before 1900).
5. Nearly parallel shear flows boundary layer and other shear flows.
6. Special Topics – Compressible effects