GG 711: Theoretical Fluid Mechanics
Fall 2015
Instructor: Janet Becker (janetbec@hawaii.edu)

General Information:

- Time: 9:00am – 10:15am, Tuesday & Thursday
- Place: POST 702
- Official Grading Policy:
  1. Homework: 50%
  2. Exams (take home)/Projects: 50%
- References:
  1. Advanced Mathematical Methods for Scientists and Engineers by Bender and Orzag (BO)
  2. Hydrodynamic Stability by Drazin and Reid
- Additional References:
  1. Lectures on Geophysical Fluid Dynamics by Rick Salmon
  2. Perturbation Methods by E.J. Hinch
- Instructor’s Office Hours: tba

Comments: I have taught this course in two ways: (1) as an advanced mathematics course in asymptotic and perturbative analysis with Bender and Orzag as the primary reference and (2) as a fluids course where advanced mathematical techniques are used to solve problems of interest in the earth and ocean sciences, and engineering. The topics covered in Fall of 2015 will draw from these two courses and will be modified depending upon the interests/needs of the enrolled students.

Course Outline

- Preliminaries
  1. Review of ordinary differential equations (BO, chapter 1)
  2. Review of exact solutions of partial differential equations
- Regular perturbation theory (BO, Chapter 7)
  1. Flow past a circular cylinder in small shear
  2. Nonlinear surface gravity waves: Stokes’ expansion
- **Differential Equations (BO, Chapter 3)**
  1. Local behavior at irregular singular points
  2. Asymptotic definitions

- **Integration (BO, chapter 6)**
  1. Approximate evaluation of integrals
  2. Method of stationary phase and steepest descent
  3. Cauchy-Poisson problem

- **Singular perturbation theory, matched asymptotic expansions, and boundary layer theory (BO, chapters 7, 9)**
  1. Roots of algebraic equations
  2. Viscous flow past a body at high Reynolds number
  3. Boundary layers in theoretical models of the general ocean circulation

- **WKB theory (BO, chapter 10)**
  1. Long waves near a caustic

- **Multiple-scale analysis (BO, chapter 11)**
  1. Resonance and secular behavior in perturbation expansions
  2. Resonant interaction theory

- **Instability**
  1. Thermal instability: The Benard problem (method of normal modes)
  2. Convection in a porous medium
  3. Kelvin-Helmholtz Instability