Math 551: Peturbation Methods in Applied Mathematics: Jan-April 2013

Synopsis: This is a course in modern techniques in applied mathematics, focusing on singular perturbation methods for partial differential equations. The material provides valuable skills and resources complementary to scientific computations, mathematical modeling in applications, analysis of PDE's and dynamical systems. The general concepts and methods are illustrated and developed for a wide variety of specific problems arising in math biology, reaction-diffusion systems, fluid mechanics, and materials science. Some problems related to purer aspects of PDE theory are also discussed.

Topics Covered:

- 1. Strong localized perturbation theory; Localization problems for eigenvalues, diffusion, mean first passage time, fluid flow, coarsening problems in materials science.
- 2. Pattern Formation Problems: Turing stability analysis, amplitude and envelope equations, dynamics of fronts and interfaces in PDE, with applications to Math Biology.
- 3. Singular perturbations and boundary layers for PDE's.
- 4. Singularities for PDE's; edge and corner singularities, blow-up and focusing behavior, self-similarity.
- 5. Homogenization methods; Micro- vs. Macro-scale, Wave propagation on rough boundaries, diffusion in layered media.
- 6. WKB for partial differential equations; high frequency wave propagation, eigenvalue asymptotics.
- 7. Steepest descent methods, Stokes phenomena, and exponential asymptotics, with applications to free surface flows etc.. (as time permits)

Requirements: There will be 6 homework assignements. A final project (20-25 pages), based on readings of a current research topic, will be due in April. There is no final exam. The grading is 60% homework and 40% project.

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