AME 626: Singular Perturbation Methods, Spring 2019

Instructor: S.S. Sadhal
Class Meeting: MW 08:30-09:50 am, ZHS 360

Syllabus

This course is meant for acquiring analytical experience in dealing with a class of problems where a small or large parameter can be identified for suitable asymptotic expansion. The course will begin with basic problems with linear and nonlinear algebraic equations, followed by treatment of integrals, and development towards solving ordinary and partial differential equations. A large part of the course deals with problems in fluid mechanics

Prerequisite: AME 526

Topics:

1. Overview of asymptotic methods.
   1.1 Identification of a small parameter in physical problems.
   1.2 Asymptotic sequences, and expansions.
   1.3 Application to linear and nonlinear algebraic equations.

2. Expansions of integrals
   2.1 Generalized Fourier integral
   2.2 Method of steepest descent

3. Regular perturbation methods
   3.1 Simple expansion for ODEs with a small parameter
   3.2 Large-time expansions with Laplace transform for PDEs

4. Singular perturbation methods
   4.1 Failure of regular perturbation
   4.2 Effect of a small parameter on boundary conditions
   4.3 ODEs with boundary-layer type effects
   4.4 Classical fluid mechanics problems with PDEs. Matched Asymptotics.
      4.4.1 Flow past a sphere with Re <<1. Oseen expansion
      4.4.2 Sphere problems with heat/mass transfer for Pe<<1
      4.4.3 Boundary layers for Re>>1
      4.4.4 Problems involving drops with large radial flow.
      4.4.5 Oscillatory bodies in fluids. High-frequency motion. Application to acoustics.
      4.4.6 Double boundary layer problems in confined regions.
   4.5 Method of multiple time scales

Reference Books:

1. *Perturbation Methods in Fluid Mechanics* by Milton Van Dyke. Used copies still available.
2. *Perturbation Methods* by Ali H. Nayfeh, Wiley
3. *Perturbation Methods* by E. John Hinch, Cambridge