Fall 2001

CE527/CH527/ME527: Advanced Fluid Mechanics

Course Outline

This course provides the student with a background in the physical aspects of fluid mechanics. The emphasis is on physical concepts and the posing of problems. The simplification of the equations using carefully stated assumptions, which retain the essential physics of each problem, is stressed. The student taking this course should be taking or have taken CH561: Chemical Engineering Analysis, or a first course in partial differential equations. The following topics will be covered.

1. Elementary concepts in tensor analysis, material and spatial coordinates, Reynolds transport theorem

2. The equation of continuity, kinematics and the rate of deformation and vorticity tensors, the stress tensor, Euler's law, constitutive equations, Navier-Stokes equation, and the physical basis of boundary conditions

3. Steady unidirectional flow and some exact solutions

4. Unsteady one-dimensional flow – Rayleigh problem, flow near an oscillating plate, unsteady flow between parallel plates and through a straight circular tube

5. Motion due to wind shear and the Ekman solution

6. Some general properties of Stokes flow, fundamental solution of Stokes's equation, Stokes and Lagrange streamfunctions, Two-dimensional flow near a corner; Invariant representation of solutions using vector harmonics: examples of Stokes flow induced by a rotating sphere, Stokes flow over rigid and fluid spheres, and Stokes flow due to a point force; Whitehead's paradox

7. Potential flow theory, introduction to boundary layer theory, Prandtl's boundary layer equations, boundary layer on a flat plate, exact and approximate methods of solution, Falkner-Skan flows, flow over blunt bodies and boundary layer separation

8. The significance of the Reynolds number, turbulence, time-averaging, and Reynolds stresses, simple turbulence models

9. Lubrication theory