ME 634 Introduction to Turbulence Spring 2004

Course Outline

I. Introduction

  A. Importance of fluid flow, prevalence of turbulence
  B. Descriptions of turbulence
  C. History of study of turbulence
  D. Definitions, mathematical tools, basic concepts

II. Statistical Analysis and Modeling of Turbulence

  A. Why a statistical approach?—basic notions
  B. Derivation of Reynolds-averaged Navier–Stokes (RANS) equations
  C. Discussion of lack of time dependence
  D. Vortex stretching and Reynolds stresses
  E. General difficulties with RANS—independent of specific models
  F. Description and comparison of various RANS models
    1. mixing length theory, van Driest model
    2. eddy viscosity transport
    3. $k-\varepsilon$ models
    4. second-order closures
    5. PDF models (if time permits)
  G. Kolmogorov's K41 theory and consequences

III. The Navier–Stokes Equations as a Dynamical System

  A. Discussion of general concepts from dynamical systems and their relation to turbulence
  B. Direct numerical simulation (DNS)
  C. Large-eddy simulation (LES)
    1. basic formulation
    2. advantages/disadvantages (compared with DNS and RANS)
    3. detached-eddy simulation (DES)
  D. Subgrid-scale (SGS) models
    1. Smagorinsky model
    2. dynamic models
    3. synthetic-velocity models

Grading

Written summaries of reading assignments	15%
Homework problems (4 or 5 of varying weight)	40%
Term project	45%

Required Texts

H. Tennekes and J. L. Lumley, *A First Course in Turbulence*, MIT Press, Cambridge, MA, 1972.
U. Frisch, *TURBULENCE, the Legacy of A. N. Kolmogorov*, Cambridge University Press, 1995.

Office Hours

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