Course Outline
AME 599…Fall 2014

Required Text: ***Turbulence Modeling for CFD,***
Third Edition, David C. Wilcox
Earlier editions of the text are inappropriate for this course. There have been significant changes in nomenclature, material included and homework problems.

Class web site: http://www.dcwindustries.com/599

1. INTRODUCTION (Weeks 1-2)
    * Course Overview
    * The ideal turbulence model
    * Cartesian tensor analysis
    * Perturbation methods

2. PHYSICS OF TURBULENCE (Week 3)
    * Physics of turbulence
    * Kolmogorov theory
    * The law of the wall and the power-law controversy
    * History of turbulence modeling

3. THE CLOSURE PROBLEM (Week 4)
    * Reynolds averaging
    * Reynolds-averaged equations
    * The Reynolds stress equation
    * Length scales and their behavior
    * Equations vs. unknowns
    * The scales of turbulence
    * Two-point statistics

4. ALGEBRAIC MODELS (Weeks 5-6)

    * Molecular transport of momentum
    * The mixing length hypothesis
    * How molecules and eddies are different
    * Free shear flows
    * Cebeci-Smith and Baldwin-Lomax models
    * Channel/pipe flow
    * Attached boundary layers
    * Separated flows
    * The half-equation model
    * Range of applicability

5. TURBULENCE ENERGY EQUATION MODELS (Weeks 6-9)

- The turbulence energy equation
- One-equation models
- Two-equation models/generic
- k-omega and k-epsilon models
- Closure coefficients
- Free shear flows
- The role of cross diffusion
- Solution sensitivity to freestream conditions
- Surface boundary conditions
- Surface roughness and surface mass transfer
- Channel/pipe flow
- Perturbation analysis of the boundary layer
- Attached boundary layers
- Low-Reynolds-number corrections
- Transition prediction
- Separated flows
- The stress-limiter concept
- Range of applicability

6. EFFECTS OF COMPRESSIBILITY (Weeks 9-10)

- Favre-averaging
- Favre-averaged equations
- Compressible-flow closure approximations
- Compressible mixing layer
- Compressible law of the wall
- Shock induced separation
- More on the role of the stress limiter
- The reattachment-point heat-transfer anomaly

7. BEYOND THE BOUSSINESQ APPROXIMATION (Week 11)

- Nonlinear constitutive relations
- Algebraic Stress Models
- Why the stress-limiter works so well
- Stress-transport models
- Pressure-strain correlation modeling
- LRR and Wilcox Stress-omega models
- Free shear flows
- Channel/pipe flow

- Attached boundary layers
- Streamline curvature
- Rotating channel flow
- Unsteady boundary layers
- Separated flows
- Range of Applicability

8. NUMERICAL CONSIDERATIONS (Week 12)

- Multiple time scales and stiffness
- Near-wall solution accuracy
- Turbulent/nonturbulent interfaces
- Parabolic marching methods
- Elementary time-marching methods
- Block-implicit methods
- Iteration and grid convergence

9. NEW HORIZONS (Weeks 13-15)
- Direct Numerical Simulation
- Large Eddy Simulation
- Detached Eddy Simulation
- Chaos
- Student Project Reports
- Commercially available computer programs