AAE 626: Turbulence and Turbulence Modeling

Credit Hours	3
Offered	Spring (in odd years)
Pre-requisites	AAE 511 or ME 509
Co-requisites	None
Instructional Method	3 hours of lecture per week
Required	No, Aerodynamics elective

1. Course Description

Physical description of turbulence. Reynolds averaged equations. Scaling of basic turbulent flows. Homogeneous turbulence, spectra and two-point correlations. Hierarchy of turbulence models, including zero-, one-, and two-equation models, Reynolds stress models, large eddy simulations, and direct numerical simulations. Additional topics, such as compressibility effects on turbulence and probability density function methods, as time allows.

2. Instructor Information

Prof. Gregory A. Blaisdell
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3. Topics Covered

- Physical description of turbulence, vortex dynamics
- Reynolds averaged Navier-Stokes (RANS) equations
- Scaling of free shear flows and wall bounded flows

- Spectra and two-point correlations
- Hierarchy of turbulence closures
- Algebraic turbulence models
- One-equation and two-equation turbulence models
- Compressible turbulent flows
- Algebraic stress and Reynolds stress models
- Probability density function (PDF) methods for turbulent combustion (overview only)
- Direct numerical simulation (DNS), large eddy simulation (LES), hybrid RANS/LES approaches

4. Intended Learning Outcomes

On completing this course, the student shall be able to:

- Understand the sensitivity of chaotic dynamical systems to initial conditions
- Understand how vortex interactions create larger and smaller length scales in a turbulent flow
- Derive the governing equation for a specified turbulent statistic
- Derive the scaling of various quantities in turbulent free shear flows
- Compute spectra and two-point correlations from time series data
- Classify turbulence models within a hierarchy of models
- Understand the assumptions and limitations of turbulence model formulations
- Understand what various turbulence simulation methods are and what their advantages and limitations are
- Select a topic for further research on turbulence, find relevant references, carry out a study and report on the results

5. Assessment Method

Six homework assignments during the first half of the course, one midterm exam, individual project, including oral presentation and written report.

6. Relation to ABET Outcomes

	Program Learning Outcomes	Included?
1.	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	Yes
2.	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	No
3.	An ability to communicate effectively with a range of audiences.	Yes
4.	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	No
5.	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	No
6.	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	Yes
7.	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	Yes