

AE 6080 Syllabus

Dynamics of Turbulence AE 6080, Sections A and Q, 3 Credits

Fall 2026

Instructor Information

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General Course Information

Description

Turbulence research and the role of direct numerical simulations. Vorticity dynamics and the study of extreme events. Kolmogorov similarity hypotheses: scaling and intermittency. Fourier-spectral representation and energy transfer. Turbulent mixing, passive scalars and active scalars Turbulent dispersion, fluid particles and inertial particles. Second-order Reynolds stress modeling. Probability density function (PDF) methods. Large-eddy simulations and subgrid scale modeling. Brief discussion of compressible turbulence.

Course Learning Outcomes

Develop knowledge and perspective in state-of-the-art turbulence research, especially those bearing upon fundamental scaling behaviors and intermittency at high Reynolds number.

Understand the dynamics of turbulence from a spectral transfer perspective.

Understand the mechanics of turbulent mixing of passive and active scalars over a range of Schmidt numbers.

Obtain a fundamental understanding of important turbulence modeling approaches including Reynolds stress modeling, probability density function methods, and subgrid scale modeling coupled with large eddy simulation.

Required Course Materials

Turbulent Flows, S.B. Pope (2000), published by Cambridge University Press; A First Course in Turbulence, H. Tennekes and J.L Lumley (1972); MIT Press.

Grading Policy

Mid-term 30%; Final 45%, Presentation 25%.

Overall grade cutoffs will depend somewhat on the score distribution, but the A/B line will likely fall between 50 to 55 points out of 75 for both exams combined.

Description of Graded Components

Both exams will be given as take-home: 24 hours for Mid-term, 48 hours for final exam. Each student will be asked to give a short (8 to 10 mins) presentation on a chosen topic in the last week of the class.

Course Policies

Attendance and/or Participation

Attendance (in person for those in Section A) is highly encouraged. Not attending class will not help you learn better, and a low attendance rate may have a detrimental effect on the learning atmosphere in the classroom. All students are expected to participate activity in the Final Presentations component of the course.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Please review Georgia Tech's Honor Code and the student Code of Conduct.

Accommodations for Students With Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Pre-Requisites

AE 6012 or equivalent (please discuss with instructor).

Policy on AI use

Use of AI for work in this course, including exams and the final presentation, is explicitly NOT allowed.

Course objectives:

This is a *second-level* course on turbulence, building on the introductory material presented in AE 6012. The emphasis is on fundamental physical understanding, and on the use of this knowledge to test theories and develop improved turbulence models. Students are encouraged to explore the literature on current research developments, including large-scale numerical computations enabled by rapid advances in high performance computing.

Lecture Topics:

The plan is to spend (on average) about 1-1.5 weeks on each topic below.

1. Introduction, and review of AE 6012
2. Turbulence research and the role of direct numerical simulations
3. Vorticity dynamics and the study of extreme events
4. Kolmogorov similarity hypotheses: scaling and intermittency
5. Fourier-spectral representation: Fourier modes and energy transfer
6. Turbulent mixing: passive scalars and active scalars
7. Turbulent dispersion: fluid particles and inertial particles
8. Second-order Reynolds stress modeling
9. Probability density function (PDF) methods
10. Large-eddy simulations and subgrid scale modeling
11. Compressible turbulence
12. Class presentations

Grading:

No homework assignments will be collected, but exercises will be suggested and solutions will be made available. Course grades will be determined by Mid-Term Exam (30%), Final Exam (45%) and a 10-min individual class presentation (25%). Both exams will be given as take-home, for 24 and 48 hours respectively.