MAE 741: Fundamentals of Turbulence (3 credits)

Lecture TR 12:30pm-1:50pm
Center for Science and Technology 3-212

Course Description

Qualitative description, main parameters and scaling variables; similarity analysis of mixing layers, jet boundary layers, pipe flows; extension to transport and mixing with emphasis on K-E models.

Audience: This course is intended for students interested in expanding their knowledge in fluid dynamics.

Prerequisites

MAE 643 – Fluid Dynamics

Instructor

Kasey Laurent
Link Hall 241
klaurent@syr.edu
Office Hours: W 1:00pm-3:00pm or by appointment

Course Materials

Textbooks: This course will utilize multiple textbooks. Below is a list of textbooks students may find useful

Batchelor, G. K. (1953). *The theory of homogeneous turbulence*. Cambridge university press.
Davidson, P. A. (2015). *Turbulence: an introduction for scientists and engineers*. Oxford university press.
Frisch, U., & Kolmogorov, A.N. (1995). *Turbulence: the legacy of AN Kolmogorov*. Cambridge university press.
Pope, S.B. (2000). *Turbulent flows*. Cambridge university press.
Tennekes, H., & Lumley, J.L. (1972). *A first course in turbulence*. MIT press.

Course Usage of Blackboard: Course materials and assignments will be posted on Blackboard. All assignments will be turned in on Blackboard.

Learning Objectives

As a result of participating in this course, you will be able to:

1. Understand the origins and significance of turbulence in natural and engineered systems
2. Apply analytical approaches to characterize and quantify turbulence
3. Explain the distinction between Kolmogorov's 1941 hypotheses and intermittency in turbulence

Course Grading

Grade Distribution:

Homework	20%
Presentation	20%
Final Report	60%

Grading Scale:

A	93-100%
A-	90-92%
B+	87-89%

B	83-86%
B-	80-82%
C+	77-79%

C	73-76%
C-	70-72%
F	<70%

Homework

Problems will be posted on Blackboard at least one week before the due date and should be submitted on Blackboard before the due date. Homework will be graded and returned one week after submission. You are allotted 2 late homework assignments which must be submitted before grades are assigned (i.e. you get a one week extension). Any additional late assignments will not be accepted outside of a medical emergency.

Presentation

Each student will select one (or multiple) paper(s) related to a special topic in turbulence. Paper choice should be approved by the instructor before spring break. Students will critically analyze the paper's content and present the findings to the class in a 15-minute presentation. Presentations will occur in the last few weeks of class. Additional details for the presentation can be found in the document titled ‘PresentationInfo.pdf” on Blackboard.

Final Report

For this report, you will be analyzing data from a wind tunnel experiment and relating the findings to the predictions made by the Kolmogorov theory. The report will be completed in LaTex. Students are welcome to submit a draft of the report up until the last class in March for feedback on content and/or structure (this is optional). Additional details for the report can be found in the document titled "CourseReportInfo.pdf" on Blackboard.

Attendance & Absences

Attendance in classes is expected in all courses at Syracuse University. Students are expected to arrive on campus in time to attend the first meeting of all classes for which they are registered. Students who do not attend classes starting with the first scheduled meeting may be academically withdrawn as not making progress toward degree by failure to attend. Instructors set course-specific policies for absences from scheduled class meetings in their syllabi.

It is a federal requirement that students who do not attend or cease to attend a class to be reported at the time of determination by the faculty. Faculty should use "ESPR" and "MSPR" in Orange Success to alert the Office of the Registrar and the Office of Financial Aid. A grade of NA is posted to any student for whom the Never Attended flag is raised in Orange SUccess. More information regarding Orange SUccess can be found here, at http://orangesuccess.syr.edu/getting-started-2/.

Students should also review the University's religious observance policy and make the required arrangements at the beginning of each semester.

Syracuse University Policies

Syracuse University has a variety of other policies designed to guarantee that students live and study in a community respectful of their needs and those of fellow students. Some of the most important of these concern:

Diversity and Disability: There may be aspects of the instruction or design of this course that result in barriers to your inclusion and full participation in this course. I invite any student to contact me to discuss strategies and/or accommodations (academic adjustments) that may be essential to your success and to collaborate with the Center for Disability Resources (CDR) in this process.

If you would like to discuss disability-accommodations or register with CDR, please call (315) 443-4498 or email disabilityresources@syr.edu

Religious Observances Notification and Policy: Students are given an opportunity to make up and examination, study, or work requirements that may be missed due to a religious observance, provided they notify their instructors no later than the academic drop

deadline. For observances occurring before the drop deadline, notification is required at least two academic days in advance. Students may enter their observances in MySlice under Student Services/Enrollment/My Religious Observances/Add a Notification.

Orange SUccess: Orange SUccess is the platform used to help students succeed by providing timely feedback on academic progress. More information can be found here: https://experience.syracuse.edu/soar/academic-support/orange-success

Academic Integrity Policy: Syracuse University's Academic Integrity Policy reflects the high value that we, as a university community, place on honesty in academic work. The policy defines our expectations for academic honesty and holds students accountable for the integrity of all work they submit. Students should understand that it is their responsibility to learn about course-specific expectations, as well as about university-wide academic integrity expectations. The policy governs appropriate citation and use of sources, the integrity of work submitted in exams and assignments, and the veracity of signatures on attendance sheets and other verification of participation in class activities. The policy also prohibits students from submitting the same work in more than one class without receiving written authorization in advance from both instructors. Under the policy, students found in violation are subject to grade sanctions determined by the course instructor and non-grade sanctions determined by the School or College where the course is offered as described in the Violation and Sanction Classification Rubric. SU students are required to read an online summary of the University's academic integrity expectations and provide an electronic signature agreeing to abide by them twice a year during pre-term check-in on MySlice.

Course Schedule (subject to change)

Jan 16	**What is Turbulence? Historical Perspectives**
Jan 18	**Navier-Stokes Equations and Turbulence**
Jan 23	**Characteristics of Turbulent Flows**
Jan 25	**Reynolds-Averaged Navier-Stokes (RANS) Equations**
Jan 30	**Reynolds-Averaged Navier-Stokes (RANS) Equations** HW1 due
Feb 1	**Closure Problem and Turbulence Models**
Feb 6	**Probability Density Functions (PDFs) and Moments**
Feb 8	**Turbulent Energy Spectra**
Feb 13	**Two-Point Correlations and Autocorrelations** HW2 due
Feb 15	**Reynolds Stresses and Production Terms**
Feb 20	**Turbulence Kinetic Energy**
Feb 22	**Intermittency and Scaling Laws**
Feb 27	**Introduction to Fourier Analysis** HW3 due
Feb 29	**Energy Spectra and Wave Number Space**
Mar 5	**Taylor's Hypothesis**
Mar 7	**Energy Spectra (cont.)** Paper selection due
Mar 12	*Spring Break*
Mar 14	*Spring Break*
Mar 19	**Kolmogorov's Theory**

Mar 21	**Spectral Models for Turbulence** HW4 due
Mar 26	**Spectral Analysis of Real Data**
Mar 28	**Lagrangian Particle Tracking** First draft of final report due (optional)
Apr 2	**Trajectory Analysis in Turbulent Flows**
Apr 4	**Eulerian vs. Lagrangian Approaches** HW5 due
Apr 9	**Fundamentals of Experimental Design**
Apr 11	**Data Acquisition and Analysis**
Apr 16	**Flow Visualization Techniques**
Apr 18	**Student presentations**
Apr 23	**Student presentations**
Apr 25	**Student presentations** Final report due