ENME483/656
Physics of Turbulent Flow
Spring 2020

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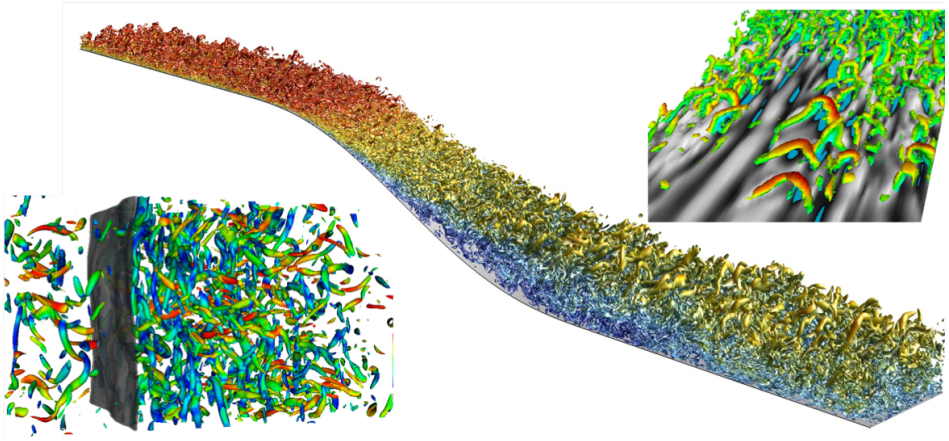

Instructor

Johan Larsson
jola@umd.edu; office: EGR3149; office hours: Thu 1230-1400.

Course objectives

Turbulent fluid flow is everywhere in engineering, including in the flow around airplanes, cars, and ships; the flow around wind or hydro power turbines; the flow in internal combustion and gas turbine engines; the flow in the atmosphere; and many other cases.

The course will introduce the notion of turbulence and why it is so important in a wide range of engineering disciplines. The course will cover turbulence in a general way with a fundamental focus, but with specific appeals to boundary layer flows (airfoils, wind turbines, fans, ships, atmospheric boundary layer, etc) as a very important class of turbulent flows.

Specific topics:

- What is turbulence? Why is it important?
- Statistical treatment of turbulence; governing equations for the mean flow and the turbulence.
- Channel and pipe flow; the log-law; production, transport and dissipation of turbulence.
- Boundary layers in external flows including airfoils.
- Turbulence modeling.

Prerequisites

Students are assumed to have taken an introductory course in fluid mechanics (e.g., ENME331).

Textbooks

Recommended texts:

- *Turbulent flows*, S. B. Pope (probably the best introductory text on the matter; includes introductions to the relevant statistics and tensor algebra).
- *Statistical theory and modeling for turbulent flows*, P. A. Durbin and B. A. Pettersson-Reif (a very good book, but starts from a slightly higher level).
- *Turbulent flow: analysis, measurement and prediction*, P. S. Bernard and J. M. Wallace.

Course format and Evaluation

Assignments will require both pen-and-paper problem solving and rudimentary coding (in Matlab, Python, or similar) to process realistic turbulence data sets.

Collaboration and internet resources

Collaboration is (of course) not allowed on exams, but is allowed on homework problems with the following conditions: each student must complete their own work and can't simply copy someone else's solution, and students that collaborate must write clearly at the top of the affected problems whom they collaborated with.

Internet resources that explain concepts (like Wikipedia and some Youtube videos) can be excellent learning aides – they explain the same thing in different words which may help students' understanding. These types of internet resources are absolutely allowed. However, internet resources that provide solutions to problems are not allowed and are considered cheating.

Topics and tentative schedule

1/28: course info; what is turbulence?; averaging and the Reynolds decomposition.
1/30: Cartesian tensors; the Navier-Stokes equations; channel flow and intro to homework.
Homework 1: channel flow, averages and variances.

2/4: averages of derivates; evolution equations for the mean velocity and the turbulence kinetic energy.
2/6: production, dissipation, transport in channel flow.
Homework 2: Reynolds stress equations.

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2/13: a

2/18: a
2/20: a

2/25: a
2/27: a

3/3: a
3/5: a

3/10: a
3/12: a

Spring break

3/24: a
3/26: a

3/31: a
4/2: a

4/7: a
4/9: a

4/14: a
4/16: a

4/21: a
4/23: a

4/28: a
4/30: a

5/5: a
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5/12: a