ENME489M
Advanced fluid mechanics with applications
Spring 2023

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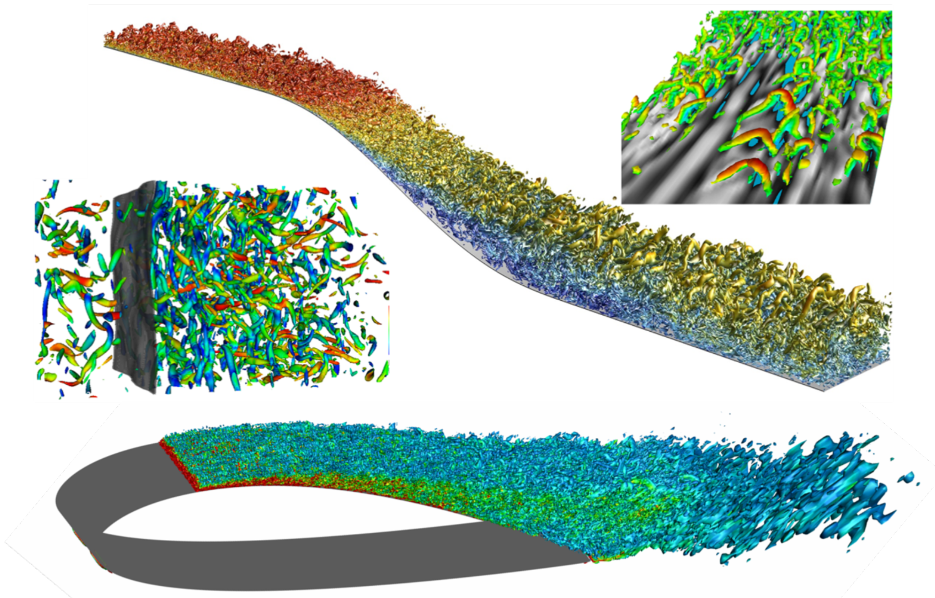

Instructor

Johan Larsson
jola@umd.edu

Course objectives

The course will provide an introduction to the fluid mechanics of flows at high Reynolds numbers, which is important in many applications including the flow around airplanes, cars and ships; the flow around wind or hydro power turbines; the flow in internal combustion and gas turbine engines; atmospheric flows; and many other cases. These types of flows are characterized by an inviscid external flow coupled with viscous and generally turbulent flow in thin boundary layers. The course will provide an introduction to both aspects and will also include a more applied component where students will use CFD software to analyze applied flows in mini-projects.

Topics covered

- Laminar boundary layers
- Statistical treatment of turbulence; governing equations for the mean flow and the turbulence.
- Turbulent boundary layers; the log-law; production, transport and dissipation of turbulence.
- Turbulence modeling.
- Vorticity, stream functions, velocity potentials.
- Inviscid external flow; potential flow; circulation.
- Lift, drag and moments of airfoils; drag polars.
- Separated flows.
- Order-of-magnitude reasoning to simplify equations.

Learning outcomes

Learn the basic fluid mechanics of external flows at high Reynolds numbers. Learn to interpret the partial differential equations in fluid mechanics, and make the connection between the math and observed flow patterns. Gain a basic understanding of turbulence, including its statistical treatment and how it modifies the transport processes. Gain an understanding of potential flows, including introductory airfoil theory. Learn to use a software package for computing these types of flows using turbulence models.

Prerequisites

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

Students should also have a working knowledge of some programming language, e.g., Matlab, Python, or similar. Students need *not* be expert programmers – but they do need a willingness to take on challenging programming tasks (with help from the instructor and peers in the class, of course).

Course format

The material will be covered during two lectures of 75 mins each per week.

There will be weekly homework, consisting of a written portion (deriving equations, etc) and a computational portion where students use Matlab, Python, or similar to process realistic data sets and solve simple equations. Students will also have to download and learn to use a freely available CFD software package.

Evaluation

The homework will be graded on the basis of completion, not correctness. Two or three exams (that may be take-home exams) will be given and graded on the basis of correctness. The final grade is a combination of the homework/project credit (20%) and the exam scores (80%).

Academic integrity and collaboration

Collaboration is encouraged in this class. Having said that, every student must complete their own homework by themselves (e.g., write their own computer code, produce their own plots, derive their own equations, etc). In other words, students are allowed (and encouraged!) to work together when figuring things out, and to ask each other questions etc, but must make sure that they do the homework themselves without copying.

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.

The exams must be completed without any collaboration.

Textbooks

Text book: *Fundamentals of aerodynamics*, J. D. Anderson.