SYLLABUS
SPRING 2022/23

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AE 534 VISCOUS FLOW

Instructor: Dr. Emre Kara (Room Z04)
Lecture: **Online:** 13.30-14.15 Wednesday (GAUZEM)
After April starts – Possibly Hybrid or In Class: 13:30 – 16:05 Wednesday – Z04

Course Webpage: http://www1.gantep.edu.tr/~emrekara/index.php/ae534/

Course Prerequisites:
The course will assume a general familiarity with thermodynamics, heat transfer, fluid mechanics, aerodynamics and vector calculus, on the level of a first graduate fluids course. The student will encounter some numerical/differential applications such as Cartesian tensor notation, theorems for vector calculus, Stokes theorem, thermodynamics relations, heat transfer, Reynolds transport theorem, derivation of the full compressible viscous Newtonian equations (conservation of mass, momentum, energy), vorticity equations, complementary error functions, ODE's, elliptic equations versus parabolic equations etc. so that they should be aware of how to apply them before start of the lecture.

Course Objectives:
- To understand the continuum mechanical derivation of the Navier-Stokes equations and the appropriate boundary conditions.
- To understand the boundary layer theory in the introductory level.
- To apply the equations to various fluid problems giving a mathematical description of the flow, and to solve the industrial problems.

Course Outcomes:
After successful completion of this course, the students should be able to:

- CO1: Apply the basic laws of fluids to the incompressible and compressible viscous flow fields.
- CO2: Calculate the properties of laminar boundary layers.
- CO3: Establish the laminar and thermal boundary layer equations.

Description:
Momentum and thermal transport in wall boundary-layer and free shear flows, solutions to the Navier-Stokes equations for heat conducting laminar and turbulent shear flows; similarity concepts; thermal boundary layers in ducts and high-speed aerodynamic boundary layers.

Lecture notes
You can find "in-class notes" from http://acoustics.ae.illinois.edu/classes/AE412-Fall-2020.html
Thanks to Professor D. J. Bodony of Illinois University for allowing us to use his lecture notes.

Recommended Textbooks
- Viscous Fluid Flow, F. M. White, 3rd edition or newer.
- Incompressible Flow, R. L. Panton, 4th Ed., John Wiley & Sons, Inc.
- Fluid Mechanics, P. K. Kundu et al., 5th Ed., Elsevier Inc.
- Fundamentals of Heat and Mass Transfer, T. L. Bergman and A. S. Lavine, 8th Ed., John Wiley & Sons, Inc
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- Van Dyke, An Album of Fluid Motion
- Schlichting, Boundary Layer Theory
- J.D. Anderson Jr.'s book, Fundamentals of Aerodynamics (Viscous Flow Section), 6th Edition, 2017 or newer.
- You can find related textbooks also from our university library.

TENTATIVE SCHEDULE

Week 1:	**Introduction**
Week 2:	States of matter / Continuum approximation Tensors / Surface forces
Week 3:	The stress tensor Kinematics and Governing equations / Steady- incompressible Navier-Stokes equations
Week 4:	Tensorial forms & Examples Integral boundary layer equations & approximations and Boundary layer concept
Week 5:	Differential forms / Incompressible form of the energy equation Non-dimensionlization & Energy equation / Incompressible limit
Week 6:	Low Mach, convection-dominated flow / Differential boundary layer equations Exact solutions / Unsteady Couette flow
Week 7:	Self-similarity and Stokes' first problem, other exact solution examples
Week 8:	**April 19th 2023, Wednesday 13:30 MIDTERM-1 (Date can change regarding uncertain earthquake conditions)**
Week 9:	Blasius solution of boundary layer equations
Week 10:	Convective heat transfer / Falkner-Skan boundary layers Thwaites-Pohlhausen vs Blasius solution
Week 11:	Inviscid-Viscous model / "Thin-layer" equations Free-shear flows
Week 12:	Plane, laminar jet / Buoyant flows / **MIDTERM-2 (TAKE-HOME PROJECT. Submit at the start of the next lecture: Week 13, May 24th 2023 lecture)**
Week 13:	Free convection & atmospheric boundary layers Stability (concept)
Week 14:	Linearization / modal superposition Kelvin-Helmholtz waves
Week 15:	Lecture Review

Exams

There will be two midterms and one final. First midterm will be open **lecture notes**, there will be numerical problems and conceptual parts. Second midterm will be **take-home** type project (details will be shared at the end of lecture on Week-12). Final will be a **multiple choice** exam.

Course Grade

The grading will be based on a weighing of

- **30** % on the midterm-1,
- **30** % on the midterm-2 (project),
- **40** % on the final.

Policies:

- Regular and punctual attendance (at least 70%) and participation are expected.
- Computers and cell phones must be turned off during lectures, no texting, chatting etc.
- Absence from tests must be explained with medical certificates or other valid reasons beyond your control and planning.