SYLLABUS
SPRING 2021/22

AE 534 VISCOUS FLOW

Instructor: Dr. Emre Kara (Room Z04)

Lecture Hours: 14:25 – 17:00 Friday - A02

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 (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, trapezoidal rule, 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.
- 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 flow fields.
- CO2: Calculate the properties of laminar boundary layers.
- CO3: Establish the laminar and thermal boundary layer equations.
- CO4: Get a first step towards transition to turbulence solutions (after this lecture, AE509 Turbulent Boundary Layer lecture can be recommended)

Textbook

- F. M. White's book, Viscous Fluid Flow, 3rd edition or newer.

Recommended Books

- H. Schlichting's book, Boundary Layer Theory, 7th edition, 1979 or newer.
- 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 (Primary source of the lecture is 4th edition of Viscous Fluid Flow Textbook and the subchapters that are not shown in the schedule below are not omitted but can be given as reading assignments by the instructor.)

Week 1:	**Introduction**
Week 2:	**Chapter 1 – Preliminary Concepts: (1 week)** Some Examples of Viscous-Flow Phenomena Boundary Conditions for Viscous-Flow Problems
Week 3:	**Chapter 2 - Fundamental Equations of Compressible Viscous Flow: (2 weeks)** Introduction Classification of the Fundamental Equations Conservation of Mass: The Equation of Continuity Conservation of Momentum: The Navier–Stokes Equations The Energy Equation (First Law of Thermodynamics)
Week 4:	Dimensionless Parameters in Viscous Flow Vorticity Considerations in Incompressible Viscous Flow Two-Dimensional Considerations: The Stream Function Non-Inertial Coordinate Systems Control-Volume Formulations
Week 5:	**MIDTERM regarding chapters 1-2**
Week 6:	**Chapter 3 - Solutions of the Newtonian Viscous-Flow Equations: (3 weeks)** Introduction And Classification of Solutions Couette Flows Due to Moving Surfaces Poiseuille Flow Through Ducts
Week 7:	Unsteady Duct Flows Unsteady Flows with Moving Boundaries Asymptotic Suction Flows
Week 8:	Similarity Solutions Low Reynolds Number: Linearized Creeping Motion
Week 9:	**Chapter 4 - Laminar Boundary Layers: (4 weeks)** Introduction Laminar-Boundary-Layer Equations
Week 10:	Similarity Solutions for Steady Two-Dimensional Flow
Week 11:	Free-Shear Flows Approximate Integral Methods Thermal-Boundary-Layer Calculations
Week 12:	Three-Dimensional Laminar Boundary Layers Unsteady Boundary Layers: Separation Anxiety
Week 13:	**Chapter 5 - The Stability of Laminar Flows: (2 weeks)** Introduction: The Concept of Small-Disturbance Stability Linearized Stability of Parallel Viscous Flows Parametric Effects in the Linear Stability Theory
Week 14:	Transition to Turbulence

Exams

There will be one midterm and one final examination. Exams will be multiple-choice, there will be numerical problems and conceptual parts. The midterm will be from Chapters 1-2 and the final will be from Chapters 3-4-5.

Course Grade

The grading will be based on a weighting of **40** % on the midterm-1 and **60** % on the final exam. Grades will be given with respect to the following table:

Puan	Ders notu	Katsayı
90-100	AA	4.0
85-89	BA	3.5
80-84	BB	3.0
75-79	CB	2.5
70-74	CC	2.0
60-69	DC	1.5
50-59	DD	1.0
40-49	FD	0.5
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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.