**ME 527/CE527 ADVANCED FLUID MECHANICS**

**FALL 2019**

**INSTRUCTOR:** Goodarz Ahmadi, Room 267 CAMP (268-2322)

Office Hours: Monday and Wednesday 12:30 - 3:30 pm

**TEXT:** None. Lectures notes are available on the web.

**TA:** Athukorala Chethani (CAMP 292) Office hours: Friday 3:00-5:00pm

**COURSE WEB SITE:** <https://webspace.clarkson.edu/projects/fluidflow/public_html/courses/me527/index.html>

**Recommended Book:**  Incompressible Flow, by R.L. Panton, 4th ed. John Wiley (2013)

# Course Objectives

1. To provide a fundamental understanding of fluid flows in laminar regime.
2. To provide a fundamental understanding of boundary layer flow.
3. To familiarize the students with the computational modeling of fluid flows.
4. To familiarize the students with the industrial applications of fluid flows.

**Course Learning Outcomes**

**Objective 1:**

* Students will be able to formulate and solve fluid flows under laminar regime.

**Objective 2:**

* Students will be able to use perturbation and asymptotic methods and analyze boundary layer flows.

**Objective 3:**

* Students will become familiar with the fundamentals of computational fluid mechanics.
* Students will demonstrate using the ANSYS-Fluent Code for solving laminar flows.
* Students will become familiar with using the CFD code for solving turbulent flows.

**Objective 4:**

* Students will become familiar with the stability of fluid motion.
* Students will become familiar with the basics of turbulent flows.
* Students will become familiar with industrial application of fluid flows.

**COURSE OUTLINE**

1. **REVIEW OF ENGINEERING MATHEMATICS**

• Review of differential equations

• Review Partial Differential Equations

• Indicial notation

**II. CONTINUUM FLUID MECHANICS**

• Kinematics

• Conservation Laws

• Review of Continuum Thermodynamics

• Constitutive Equations

1. **THE NAVIER‑STOKE EQUATION**

• Exact Solutions

• Viscous Flows

**IV. LOW REYNOLDS NUMBER FLOWS**

• Creeping Flows

• Lubrication Theory

• Squeeze Film

• Flow around a Sphere

1. **COMPUTATIONAL FLUID MECHANICS**

- Finite Difference and Finite Volume Methods

- Introduction to CFD

- ANSYS-Fluent Code

**VI. ASYMPTOTIC METHODS**

• Perturbation Theory

• Singular Perturbation Theory

• Matched Asymptotic Expansion

**VII. BOUNDARY LAYER THEORY**

• Boundary Layer Theory

• Self-Similar Solutions

• Integral methods

• Jets and Wake Flows

**VIII. STABILITY OF FLUID MOTION**

• Theory of Small Perturbation

• The Orr‑Sommerfeld Equation

• Nonlinear Stability Theory

**IX. TURBULENT FLOWS**

• Reynolds Equation and Turbulence Stresses

• Energy Equation

• Phenomenological Theories

• Turbulent Pipe Flows

• Jet Flows and Wake Flows

**X. TURBULENCE MODELING**

• Algebraic Models

• One‑Equation Models

• Two‑Equation Models

• Stress Transport Models

**EVALUATION METHOD**

 Midterm (November 1, 2019, CAMP 268, 4:00-5:30 pm) 25%

Final Exam (Final Exam week) 35%

Projects 30%

Homework 10%

**REFERENCES**

1. J. Y. Tu, K. Inthavong, and G. Ahmadi, “Computational Fluid and Particle Dynamics in the Human Respiratory System,” Springer, New York (2013).

<https://www.springer.com/gp/book/9789400744875>

1. F. White, Viscous Flow, McGraw‑Hill (1974).

<https://www.amazon.com/Viscous-Fluid-MCGRAW-MECHANICAL-ENGINEERING/dp/0072402318>

1. Happel and H. Brenner, Low Reynolds Number Hydrodynamics, Martinus Nijhoff (1983)

<https://www.springer.com/gp/book/9789024728770>

1. H. Schlichting, Boundary Layer Theory, McGraw Hill (1979).

[https://link.springer.com/book/10.1007%2F978-3-662-52919-5](https://link.springer.com/book/10.1007/978-3-662-52919-5)

1. J.O. Hinze, Turbulence, McGraw Hill (1975).

<https://www.amazon.com/Turbulence-McGraw-Hill-mechanical-engineering-Hinze/dp/0070290377>

1. H. Tennekes and J.L. Lumley, A First Course in Turbulence, MIT Press (1981).

<https://mitpress.mit.edu/books/first-course-turbulence>