**ME 527 ADVANCED FLUID MECHANICS**

**FALL 2018**

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

Office Hours: Tuesday and Thursday 12:30 - 3:30 pm

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

**TA:** Babak Nasr (CAMP 292) Office hours: F 1:00-3:00pm

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

**Textbook:**  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 in laminar flows.

**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 FLUENT Code for setting up and solving laminar flows.
* Students will become familiar with using CFD code for solving turbulent flows.

**Objective 4:**

* Students will become familiar with the stability of fluid motion.
* Students will become familiar with the 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

- 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 (October 26,2018, 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).
2. F. White, Viscous Flow, McGraw‑Hill (1974).
3. Happel and H. Brenner, Low Reynolds Number Hydrodynamics, Martinus Nijhoff (1983)
4. H. Schlichting, Boundary Layer Theory, McGraw Hill (1979).
5. J.O. Hinze, Turbulence, McGraw Hill (1975).
6. H. Tennekes and J.L. Lumley, A First Course in Turbulence, MIT Press (1981).