ME326 - INTERMEDIATE FLUID MECHANICS
Spring 2024

Instructor: Goodarz Ahmadi, Room 267 CAMP (315-268-2322)
gahmadi@clarkson.edu https://clarkson.zoom.us/j/761986404)
Office Hours: Monday and Wednesday 12:30 - 3:30 pm

Text: Fluid Mechanics, Fundamentals and Applications, 3/e or 4/e,
by Cengel and Cimbala (ISBN-978-0-07-338032-2)

TA: Abbas Khanmohamdi, khanmoa@clarkson.edu
Office Hours: Friday 1:00-2:30 pm CAMP 275
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Course Site: http://webspace.clarkson.edu/projects/fluidflow/courses/me326/index.html
https://sites.clarkson.edu/gahmadi/courses/me326/

Prerequisites: ES330, ES340, MA232
Class Time: TT11:00-12:55 pm. Lectures are captured and posted on Moodle
Computer Lab, F 4:00-5:30, CAMP 163/172
(CAMP 177 for Lectures on ANSYS-FLUENT)

Course Description
A continuation of ES 330. Topics include: deformation and stress in fluids; basic conservation laws; kinematics of fluid flow; theory of potential flow; introduction to compressible flows; isentropic flows and shock waves; compressible flows with friction and heat transfer; Navier-Stokes equation and theory of viscous flow; low Reynolds number flows with applications to hydrodynamic lubrication; laminar boundary layer theory and von Karman momentum integral method; introduction to computational fluid dynamics; applications of fluid mechanics to engineering problems including turbomachinery. Introduction to design concepts.

Delivery Method
The course is offered in-person in the class and labs, as well as online (synchronous). The lectures will be captured by Echo 360, and are made available in Moodle to students.

Course Web Site:
http://webspace.clarkson.edu/projects/fluidflow/courses/me326/index.html
https://sites.clarkson.edu/gahmadi/courses/me-326-intermediate-fluid-mechanics/

Course Objectives

1. Students to learn the fundamentals of viscous incompressible flows.
2. Students to learn the basics of non-viscous potential flows.
3. Students to learn the fundamentals of computational fluid mechanics.
4. Students to learn the fundamentals of compressible flows.

Course Learning Outcomes

Objective 1 a) Students will be able to formulate and solve incompressible laminar parallel flows in Cartesian and polar coordinates. (1)[1]
b) Students will be able to analyze boundary layer flows over a flat plate. (1)
c) Students will be able to evaluate drag forces in laminar and turbulent flows for different immersed bodies. (1)

Objective 2 a) Students will be able to use the stream and potential functions and solve elementary potential flows. (1)
b) Students will be able to analyze simple potential flows by the superposition method. (1)

Objective 3 a) Students will use the basic computational fluid mechanics. (1)
b) Students will demonstrate using the ANSYS-FLUENT Code for solving two-dimensional laminar and turbulent flows. (1, 6)

Objective 4 a) Students will be able to analyze 1-D isentropic compressible flows. (1)
b) Students will be able to analyze 1-D flows with shock waves. (1)
c) Students will be able to analyze 1-D compressible flows with friction. (1)

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[1] Numbers in parentheses refer to the course outcomes consistent with ABET Criterion 3.

COURSE OUTLINE

Course Schedule & Graded Activities

Dates	Text Section	Learning Materials/Topics	Activities
Week 1 Jan. 11-12	4.1	• Applications Fluid Mechanics • Review of ES330	----
Week 2 Jan. 15-19	9.1,2,4	• Review of Differential Equations • Conservation Laws • Viscous Flow	Homework-1 4.19, 9.28, 30, 31, 34, 36, 38 Due date: Jan. 25 (Thursday)
Week 3 Jan. 24-26	9.4,5,6	• Viscous Flows • Naiver-Stokes Equation • Viscous Parallel Flows	Homework-2 9.86, 87, 89, 91, 95 Due date: Feb. 1 (Thursday)
Week 4 Jan. 29-Feb. 2	9.6	• Exact Solutions, • Approximate Solutions • CFD	Homework-3 9. 96, 101, 102, 103, 104 Due date: Feb. 8 (Thursday)
Week 5 Feb. 5-9	10.6	• Boundary layer Flows • CFD, ANSYS-Fluent Code	Homework-4 10.99, 100, 102, 114, 115, 116 Due date: Feb. 20 (Tuesday)
Week 6 Feb. 12-16	10.6, 11.1-4	• Boundary layer Flows • Drag Force • CFD, ANSYS-Fluent Code	Homework-5 11.51,65,99,106 Due date: Mar. 5 (Tuesday)
Week 7 Feb. 19-21	11.1-4	• Drag Force • Immersed Bodies	----
Feb. 22-23		**February Break**	
Week 8 Feb. 26- Mar. 1	9.3, 10.2-4	• Stream Function • Inviscid Flows	Homework-6 10.56,59, 60, 66, 71 Due date: Mar. 7 (Thursday)

Mar. 1 Friday	**4:00-5:15**	**Exam 1, CAMP 177**	**Exam 1, March 1, CAMP 177**
Week 9 Mar. 4-8	10.5	• Inviscid Irrotational Flows	Homework-7 Assigned Problems are posted. Due date: Mar. 14 (Thursday) Project 1 due date: March 7
Week 10 Mar. 11-15	12.1-3	• Acoustic Waves • Isentropic Flow	Homework-8 12.7, 9, 25, 26, 27 Due date: Mar. 26 (Tuesday)
Week11 Mar. 18-22		**Spring Break**	
Week 12 Mar 25-29	12.3	• Isentropic flow	Homework-9 12.38, 40, 45, 48, 50 Due date: Apr. 4 (Thursday)
Mar. 29 Friday	**4:00-5:15**	**Exam 2, CAMP 177**	**Exam 2, March 29, CAMP 177**
Week 13 Apr. 1-5	12.4	• Normal Shocks • Nozzles and Diffusers	Homework-10 12.62, 63, 65, 66, 69, 70 Due date: Apr. 11 (Thursday)
Week 14 Apr. 8-12	12.5,6	• Flows with heat transfer • Flows with friction	Homework-11 12.87, 88, 93, 95 Due date: Apr. 18 (Thursday) Project 2 due date: April 11
Weeks 15 Apr. 15-19	12.6	• Flows with friction	Homework-12 12.105,106,107,109,114 Due date: Apr. 23 (Tuesday)
Week 16 Apr. 22-26		• Review	Bonus project due date: Apr. 23
Final Exam week		**Final Exam**	**Final Exam**

Evaluation Methods

1. Homework and quizzes 10%
2. Exam-1 25% **Friday, March 1, CAMP 177, 178 (4:00-5:15)**
3. Exam-2 20% **Friday, March 29, CAMP 177, 178 (4:00-5:15)**
4. Final Exam 30% **Final Week**
5. Projects 15%

Exam Policy

Hourly exams will be closed book and closed notes. A formula sheet will be provided for the hourly exams. The final exam will be open book. The students are permitted to bring their textbooks to the final exam. Notes and homework solutions are not allowed.

Grading

Grade Ranges

Graduate Letter Grades

Course Average	Grade	Quality Points
97+	A+	4.0
93-96	A	4.0
90-92	A-	3.667
87-89	B+	3.334
83-86	B	3.0
80-82	B-	2.667
77-79	C+	2.334
73-76	C	2.0
70-72	C-	1.7
67-69	D+	1.3
63-66	D	1
60-62	D-	0.7
<60	F	0

Course Policies

Etiquette Expectations & Learner Interaction

Educational institutions promote the advancement of knowledge through positive and constructive debate--both inside and outside the classroom. Please visit and follow: Netiquette and Electronic Learner Interaction Guidelines.

Institutional Policies

Institutional Policies & Regulations

Academic Integrity

Students are expected to abide by the standards of academic honesty, as described in the Clarkson Regulations. The work or words of others must be properly cited. Please refer to Clarkson Library's Guide to Plagiarism and Citing Sources.

Students with Disabilities Policy

Clarkson University welcomes inquiries and applications from individuals who have disabilities. Information relating to disabling conditions is not a determining factor in admission decisions. The University strives to make all facilities and programs accessible to students with disabilities by providing appropriate academic adjustments and other appropriate modifications (accommodations) as necessary. Timely notification of any need for accommodations due to a disability is encouraged so that the Office of Accommodative Services (OAS) may provide for students in an efficient manner.

For more information or other appropriate campus referrals, contact:

Director of Accommodative Services
Clarkson University
PO Box 5645
Potsdam, NY 13699-5635
Phone: 315-268-7643
Fax: 315-268-2400

Email: oas@clarkson.edu
Office of Accessibility Services Website

Instructor Participation

During this course, as your instructor, you can expect me to

- Respond to emails and voicemails within 1 day
- Grade activities and assessments within 3 days
- Be an active participant on the discussion board

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
2. F. White, Viscous Flow, McGraw-Hill (1974). https://www.amazon.com/Viscous-Fluid-MCGRAW-MECHANICAL-ENGINEERING/dp/0072402318
3. H. Schlichting, Boundary Layer Theory, McGraw Hill (1979). https://link.springer.com/book/10.1007%2F978-3-662-52919-5