Carleton University | Faculty of Engineering and Design

Fluid Mechanics I (MAAE2300) Winter 2022

Course Description: Fluid Mechanics is one of the most interesting and widely applicable subject areas in all of engineering. Familiar examples and applications include diverse topics such as aerodynamics (e.g., flight, lift, and drag); weather; biology (circulation, breathing, etc.); transportation (combustion, vehicle design); water transport; hydroelectric power, wind-turbines, pollutant dispersion, along with numerous other fascinating and important areas, such as sap flow in maple trees. In this course, we will first introduce basic concepts of fluids and fluid mechanics. We will consider fluids at rest and in motion and we will develop powerful governing equations using the control volume approach. We will give particular attention to developing useful forms of linear momentum and energy equations to study fundamental and practical applications of fluid mechanics in engineering problems. Laboratory experiments will also provide “hands-on" examples and experience to complement the lecture material.

Prerequisites: This is a **DEMANDING** course, and you should dedicate **at least 9 h/week (3 h lectures, 3 h reading and preparation, 3 h labs & problem analysis sessions)** to it. You should have passed MATH 1005 (Differential Equations and Infinite Series for Engineering Students), MATH 1104 (Linear Algebra for Engineering and Computer Science Students), ECOR 1101 (Mechanics I).

Graduate Attributes: Knowledge Base: Develop sufficient engineering knowledge and competency in the principles that underpin fluid mechanics [40%]; Problem Analysis: Develop appropriate knowledge and skills to identify, formulate, analyze, and solve engineering fluid mechanics problems to reach substantiated conclusions [40%]; Investigation: Use of experiments, analyze and interpret experimental data to achieve valid conclusions [20%].

Lectures and Instructors:

Section D
Dr. Karen Taylor
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Tue-Thu, 11.35-12.55

Section E
Dr. Kristen Schell
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Mon-Wed, 14.35-15.55

Section F
Dr. Reza Kholghy
RezaKholghy@cunet.carleton.ca
Wed-Fri, 13.05-14.25
Course Coordinator

Lectures will be delivered synchronously using Zoom (links are available through Brightspace page for each section) and their recordings will be available. If health conditions allow, students can also attend the lectures in person.

Grading: This course has **two optional online midterms that can only improve your final mark**. This means that if your performance improves from the first midterm to the second one and the final exam, only your best performance is used to calculate your final mark. Missing a midterm will move its weight to your final exam. If you receive 80% and above in one midterm, you will receive a 0.5 (half a letter grade) bonus in your final letter grade in the course. If you receive 75% and above per midterm test or in the average of the two tests, you will receive a 1.0 (full letter grade) bonus in your final letter grade in the course. You MUST submit all three lab reports on the Brightspace page of your lab session within 7 days of performing each experiment to pass the course. Late submissions will be marked with 15% penalty per day. Lab reports are individual work and students must not share solutions with each other. Lab reports will be submitted electronically as a PDF file with the posted template and must be typed or written with stylus using a tablet or in a blank letter paper (8.5 * 11 inches) and scanned. 30% of their mark is dedicated to the style and organization of the writing. Pass is 50% in the final exam and an overall 50%.

Item	Weight	Option	Date	Content
Midterm I	15%	Optional	Feb 12th	up to & including Week 5
Midterm II	20%	Optional	March 26th	up to & including Week 9
Lab 1	5%	mandatory	Due Feb 26th	Flow Through a Venturi
Lab 2	5%	mandatory	Due March 19th	Jet Pump
Lab 3	5%	mandatory	Due April 2nd	Uncertainty in Fluid Flow Measurements
Final Examination	50%	mandatory	TBA	All lectures and Labs

Lecture Topics:

Week #	Content	Text chapter	PA session
Week 1 10/01 to 14/01	**Introduction:** Concept of Fluid; Fluid Properties, Units & Dimensions & Their conversion, Compressibility; Normal/Tangential Stress; Continuum Approximation; Significant Digits; Density; Viscosity and No Slip Condition; Surface Tension, Speed of Sound	#1	
Week 2 17/01 to 21/01	**Fluid Statics:** Pressure at a Point; Basic Equation for a Pressure Field, Pressure Variation in a Fluid at Rest for Incompressible and Compressible Fluids; Pressure Measurements and Manometry, Absolute vs Gauge Pressure; Hydraulic Machinery, The Atmosphere, Change of Pressure with Altitude;	#2.1 to 2.7	W1
Week 3 24/01 to 28/01	**Rigid Body Motion**: Linear and Angular, Fluid Undergoing Constant Linear, or Angular Acceleration	#2.12	W2
Week 4 31/01 to 04/02	**Fluid Dynamics:** Bernoulli's Equation, Idealized Fluid Flow; Pressure Changes; Stagnation Pressure, Applications of Bernoulli's Equation, Measurement of Flow Rate: Inlet, Venturi, Orifice Meter, Stagnation Tube	#3	W3
Week 5 07/02 to 11/02	**Fluid Kinematics:** The Velocity field, Eulerian and Lagrangian Flow Description, Streamline; Streakline and Pathlines; Acceleration and the Material Derivative, Control Volume and System Representative,	#4.1 to 4.3	W4
Week 6 14/02 to 18/02	**Reynold's Transport Theorem – Mass**, Mass Conservation; Steady Flow; Applications: Multiple Inlets/Outlets; Accumulation of Fluid	#4.4 & #5.1	W5
Winter Break 22/02 to 25/02	**Reading Week**		W6 Lab I demo
Week 7 28/02 to 04/03	**Reynold's Transport Theorem: Linear Momentum**, Linear Momentum to Analyze Forces on Fluids: Internal and External, Conservation of Momentum	#5.2.1 to 5.2.2	W7
Week 8 07/03 to 11/03	**Reynolds Transport Theorem: Energy**, Head; Static Head; Dynamic Head; Elevation, Head; Pump/Turbine Head; Head Loss	#5.3 & 5.4	W8 Lab II demo
Week 9 14/03 to 18/03	**Viscous Flow & Moody Charts**, Reynolds Number; Viscous Effects; Flow Regimes; Minor Losses: Bends, Valves, Expansions/Contractions	#8	W9
Week 10 21/03 to 25/03	**Reynolds Transport Theorem: Angular Momentum**, Angular Momentum for a Control Volume; Angular Velocity; Acceleration; Coriolis Acceleration, Applications of Angular Momentum, Devices, and effects of Fluids Undergoing Rotation; Pumps and Fans	#5.2.3 & 5.2.3	W10 Lab III demo
Week 11 28/03 to 01/04	**Forces on Submerged Surfaces**, Forces on Plane and Curved Surfaces; Centre of Pressure	#2.8 to 2.10	W11
Week 12 04/04 to 08/04	**Submerged Bodies**, Buoyancy & Archimedes Principle; Floating Stability & Meta-Centre	#2.11	W12
Week 13 11/04 to 14/04	**Open Channel Flow** (tentative)	#10	W13

Textbook: P. M. Gerhart, A. L. Gerhart, J. I. Hochstein, Munson, Young and Okiishi's Fundamentals of Fluid Mechanics, 9th Ed, 2020 (ISBN 978-1119598114).

Additional References:

F. M. White, Fluid Mechanics", 8th Ed., McGraw Hill, 2016 (ISBN 978-9385965494).

Yunus A. Cengel, John M. Cimbala, Fluid Mechanics: Fundamentals and Applications", Student Ed., McGraw Hill, 2017 (ISBN 978-1260152067).

David A. Chin, Fuid Mechanics for Engineers, 1st Ed, Pearson, 2016 (ISBN 978-0133803129).

C.T. Crowe, D.F. Elger, and J.A. Roberson, Engineering Fluid Mechanics", 9th Ed., John Wiley & Sons, 2008 (ISBN 978-0470259771).

R.W. Fox, A.T. McDonald, and P.J. Pritchard, Introduction to Fluid Mechanics", 7th Ed., John Wiley & Sons, 2008 (ISBN 978-0471742996).

Teaching Assistants:
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Academic accommodation: You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:
Pregnancy or religious obligation: Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see Student-Guide-to-Academic-Accommodation.
Academic accommodations for students with disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally scheduled exam (if applicable).

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/equity/sexual-assault-support-services

Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Write to me with any requests for academic accommodation during

the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf

Academic integrity:

***Plagiarism*:** The University Academic Integrity Policy defines plagiarism as "*presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own."* This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, artworks, laboratory reports, **research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet** and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another's data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own; and
- failing to acknowledge sources through the use of proper citations when using another's work and/or failing to use quotations marks.

Plagiarism is a serious offence that cannot be resolved directly by the course's instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of "F" for the course.

***Intellectual Property*:** Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors and students, are copy protected and remain the intellectual property of their respective author(s). All course materials, including PowerPoint presentations, outlines, and other materials, are also protected by copyright and remain the intellectual property of their respective author(s). Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not permitted to reproduce or distribute lecture notes and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s).

Winter 2022 Pandemic Measures: All members of the Carleton community are required to follow COVID-19 prevention measures and all mandatory public health requirements (e.g. wearing a mask, physical distancing, hand hygiene, respiratory and cough etiquette) and mandatory self-screening prior to coming to campus daily. If you feel ill or exhibit COVID-19 symptoms while on campus or in class, please leave campus immediately, self-isolate, and complete the mandatory symptom reporting tool. For purposes of contact tracing, attendance will be recorded in all classes and labs. Participants can check in using posted QR codes through the cuScreen platform where provided. Students who do not have a smartphone will be required to complete a paper process as indicated on the COVID-19 website.

All members of the Carleton community are required to follow guidelines regarding safe movement and seating on campus (e.g. directional arrows, designated entrances and exits, designated seats that maintain physical distancing). To avoid congestion, allow all previous occupants to fully vacate a classroom before entering. No food or drinks are permitted in any classrooms or labs.

For the most recent information about Carleton's COVID-19 response and required measures, please see the University's COVID-19 webpage and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca

Please note that failure to comply with University policies and mandatory public health requirements, and endangering the safety of others are considered misconduct under the Student Rights and

Responsibilities Policy. Failure to comply with Carleton's COVID-19 procedures may lead to supplementary action involving Campus Safety and/or Student Affairs.

E-Proctoring: Please note that tests and examinations in this course will use a remote proctoring service provided by Scheduling and Examination Services. You can find more information at https://carleton.ca/ses/e-proctoring/.

The minimum computing requirements for this service are as follows:
Hardware: Desktop, or Laptop
OS: Windows 10, Mac OS 10.14, Linux Ubuntu 18.04
Internet Browser: Google Chrome, Mozilla Firefox, Apple Safari, or Microsoft Edge
Internet Connection (High-Speed Internet Connection Recommended)
Webcam (HD resolution recommended)

Note: Tablets, Chromebooks and Smartphones are not supported at this time. Windows-based tablets are not supported at this time.