Department of Mechanical & Aerospace Engineering

Carleton UNIVERSITY
Canada's Capital University

# MAAE 2300: Fluid Mechanics I

**(SECTIONS B, C, D and F WINTER 2016)**

## COURSE OUTLINE

### Instructors

| | Section B | Section C |
|---|---|---|
| | Dr, John Gaydos | Dr. Fred Nitzsche |
| Office | 2194 ME | 6214D VSIM |
| Phone | 613 520 2600 ext. 8282 | 613 520 2600 ext. 5660 |
| E-mail | John_Gaydos@carleton.ca | Fred_Nitzsche@carleton.ca |
| Office Hrs. | To be Announced Later | To be Announced Later |

| | Section D | Section F |
|---|---|---|
| | Dr. Vinh Q. Tang | Mr. Thor Jodoin |
| Office | 2186 ME | 3041 MC |
| Phone | | |
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| Office Hrs. | By Appointment | By Appointment |

### Teaching Assistants

To be announced later.

### 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. In this course, we will first introduce basic concepts of fluids and fluid mechanics. We will consider fluids at rest and in motion and, using the control volume approach, we will develop powerful governing equations. We will give particular attention to developing useful forms of linear momentum and energy equations to study fundamental and practical applications of fluids mechanics in engineering problems. Laboratory experiments will also provide "hands-on" examples and experience to complement the lecture material.

## Prerequisites

MATH1005: Differential Equations and Infinite Series for Engineering Students
MATH1104: Linear Algebra for Engineering and Computer Science Students
ECOR 1101: Mechanics I

## Course Materials

Manual: MAAE 2300 Course Manual with problem sets (to be downloaded from course website on cuLearn as the MAAE2300_CourseManual.pdf document)

## Recommended Texts

There are several good texts on undergraduate fluid mechanics. Although we believe it is essential to have and to use a text when learning fluid mechanics, the choice of preferred texts is somewhat personal. We have selected three good and widely-used texts for recommendation to you. Any one of these texts or an earlier edition will be valuable as you begin to learn about the exciting and widely applicable area of fluid mechanics.

F.M. White, Fluid Mechanics, 7th Ed., McGraw-Hill, 2010 (ISBN 978-0077422414).

- A thorough and generally rigourous undergraduate text. The mathematical approach makes it an excellent reference to hold onto and to use throughout your studies and beyond. A standard text in engineering schools throughout the world. However, some students find it difficult at first as an introductory text.

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

- An introductory text aimed at both 2nd and 3rd year students. Coverage and explanations of introductory concepts and material is generally very good and examples tend to focus on problem solving. Although, it may not be as useful as White as a long term reference, it might be better as a first introduction to fluid mechanics.

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

- Another widely used introductory text. The content is similar to that of White, and there is an emphasis on problem solving in the text.

## Grading

The final grade for the course will be derived as follows

| | |
|---|---|
| One Mid-term test: | 20% |
| Final examination: | 65% |
| Laboratory experiments: | 15% |

The final examination is for evaluation purposes only and answer booklets will not be returned to the students. **You must pass the final exam to pass the course.**

Please note that successful completion of laboratory work is an important requirement of professionally accredited engineering programs. **Failure to submit any laboratory report or to receive an overall passing grade for the reports will result in a grade of FND (failure no deferred) for the course.**

## Course Schedule

### Lectures

| | | | |
|---|---|---|---|
| **Section B (Gaydos)** | Wed. & Fri. | 14:35 to 15:55 | 3275 ME |
| **Section C (Nitzsche)** | Wed. & Fri. | 11:35 to 12:55 | 416 SA |
| **Section D (Tang)** | Tue. & Thu. | 11:35 to 12:55 | 3380 ME |
| **Section F (Jodoin)** | Mon. & Wed. | 10:05 to 11:25 | 3275 ME |

### Lab Experiments / Problem Sessions with TAs

| | | | |
|---|---|---|---|
| Section L01 | Mon. | 14:35 to 17:25 | 3174 ME |
| Section L02 | Thu. | 14:35 to 17:25 | 3190 ME |
| Section L03 | Fri. | 08:35 to 11:25 | 3190 ME |
| Section L04 | Fri. | 11:35 to 14:25 | 3174 ME |
| Section L05 | Wed. | 08:35 to 11:25 | 3356 ME |
| Section L06 | Mon. | 11:35 to 14:25 | 3190ME |
| Section L07 | Thu. | 11:35 to 14:25 | 3174 ME |
| Section L08 | Fri. | 14:35 to 17:25 | 3174 ME |
| Section L09 | Wed. | 14:35 to 17:25 | 3174 ME |
| Section L10 | Tue. | 14:35 to 17:25 | 4494 ME |
| Section L11 | Tue. | 08:35 to 11:25 | 3174 ME |
| Section L12 | Thu. | 08:35 to 11:25 | 3190 ME |

***Please note***: *All laboratory work will take place in Mackenzie Building as outlined in the course manual. Laboratory group sign-up and schedule will be posted on cuLearn after the first class have occurred. Because of equipment access and space restrictions, you can only sign-up for laboratory in the section in which you are registered. However, you are free (and encouraged) to attend any and all of the tutorial sessions listed above.*

### Midterm Exam

Due to the lack of availability of suitable rooms during the term, there will be no traditional mid-term exam. Instead, there will be a 24-hour take-home test assignment. This assignment will be posted to cuLearn at 16:00 on Wed~~Thu~~. Feb. 15~~6~~, 2017.

## Course Website

Additional course material, laboratory sign-up sheets, problems, and term grades will be posted using cuLearn.

## Laboratory Experiments

All students will be required to perform three laboratory experiments, as described in the course manual. The experiments will be conducted near the middle of the term. The precise scheduling of the laboratory sessions will be announced in lectures. The late start to the laboratory exercises is to enable most of the theory needed in the laboratory to have been covered in lectures. Students will be required to personally submit their laboratory reports to the large drop box outside the Mechanical and Aerospace Engineering Office (3135 Mackenzie Bldg.) or to the Teaching Assistant (TA) responsible for that lab, one week after performing the laboratory exercise. Students **must include the name of the TA, names of their lab partners, and date the experiment was performed on the cover sheet**. See the section on Laboratory Exercises in the course manual for details on laboratory report preparation.

**Students who have successfully completed the laboratory work during a previous registration in the course may NOT request an exemption from the laboratory work.**

## Problem Sessions with TAs

The mid-term and final examinations will be problem oriented. Problem solving proficiency will be essential in order to succeed in the course. We will focus on developing problem solving skills in the problem sessions that are listed above. However, the range of possible problems in fluid mechanics is enormous. Possible problems cannot be categorized into a few "standard" types. Adaptability is essential and it is therefore extremely important to develop a sound understanding of the subject matter. To develop the necessary understanding and proficiency at solving problems it is essential to do a substantial number of problems and to do them relatively independently. Problems are provided for this purpose in the course manual. During the term, students are expected to complete all suggested problems. To assist you as much as possible, weekly sessions with the TAs have been arranged to help you as you work through these problems. All students are expected to attend the sessions. A few selected example problems will also be solved in detail.

## Brief Outline of Lectures

| Week | Relevant Book Section (White, 6th ed.) | Topic |
|---|---|---|
| 1 | 1.1-1.9 | **Introduction.** Applications of fluid mechanics. Definitions: fluid, continuum concept, no-slip condition. Fluid properties. Units and dimensions. |
| 2 | 2.1-2.4, | Pressure and shear stress. Pressure distribution in a fluid in a gravitational field. Examples. |
| 3 | 2.9, 2.10 | The atmosphere. Pressure measurement: mercury barometer, manometers. Effect of acceleration on the pressure distribution in a fluid: examples. |
| 4 | 1.11, 3.1-3.3 | **Fluid dynamics.** Streamlines and streamtubes. Steady flow. One-dimensional flow. Control volume approach. Continuity equation. |
| 5 | 3.4 | Linear momentum equation for a control volume. |
| 6 | 3.4 | Application of linear momentum to steady flows. |
| 7 | 3.6, 3.7 | Euler and Bernoulli equations. Bernoulli equation as an energy equation. Dynamic and total pressure. Applications of Bernoulli: measurement of flow rate (bellmouth inlet, venturi, orifice meter). |
| 8 | 3.5 | Angular momentum equation for a control volume. Application to steady flows. |
| 9 | 3.6, 6.1-6.4 | Steady-flow energy equation (SFEE). Effects of friction: losses. Concept of hydraulic head. Pump or turbine power; efficiency. |
| 10 | 6.6-6.9 | Viscous flow: laminar versus turbulent flow. Pipe flow analysis: Moody chart. "Minor" losses. Flow over immersed bodies: boundary layers, separation, drag. |
| 11 | 2.5 | **Fluid statics.** Forces on plane submerged surfaces. Centre of pressure. Examples. Forces on curved submerged surfaces. |
| 12 | 2.6-2.8 | Stresses in pipes and vessels due to internal pressure. Forces on submerged bodies: buoyancy. Stability of submerged and floating bodies: centre of buoyancy, metacentre. |
| 13 | | Review |

## Accommodations

You may need special arrangements to meet your academic obligations during the term because of disability, pregnancy or religious obligations. Please review the course outline promptly and 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.

Students with disabilities requiring academic accommodations in this course must register with the Paul Menton Centre for Students with Disabilities for a formal evaluation of disability-related needs. Registered PMC students are required to contact the Centre, 613-520-6608, every term to ensure that course instructors receive your Letter of Accommodation, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you require accommodation for your formally scheduled exam(s) in this course, please submit your request for accommodation to PMC. See the Paul Menton Centre website https://carleton.ca/pmc/ for additional information.

You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://carleton.ca/equity/accommodation