Western Engineering

Department of Chemical & Biochemical Engineering

CBE 2221 – Fluid Flow

Course Outline – 2025-2026

Course Description

To introduce chemical engineering students to the basics of momentum transfer and fluid flow; their application to the solution of engineering problems. Topics include: conservation of mass, momentum and energy, flow of fluids, measurement of fluid flow, laminar and turbulent flow, compressible and incompressible flow, pumps, nozzles, flow meters, turbines.

Prerequisites

Applied Mathematics 1413

Contact hours

3 lecture hours, 3 tutorial/lab hour per week.

Instructor

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Undergraduate coordinator

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Required textbook

Fluid Mechanics: Fundamentals and Applications (4th edition). Y. A. Çengel & J. M. Cimbala. McGraw Hill, 2018. This textbook costs $161.23 and students are welcome to use second-hand or earlier editions.

Course content

1. Properties of fluids (Ch 1-1 to 1-8, Ch 2-1 to 2-3)
2. Forces on fluids (pressure and viscous forces; hydrostatics; Ch 2-6, 2-7, Ch 3)
3. Fluid kinematics (velocity and acceleration fields; flow visualization; Ch 4)
4. Conservation laws (control volume analysis; mass, momentum, and energy conservation; Ch 5, Ch 6-1 to 6-4)
5. Dimensional analysis (dimensionless numbers; correlations; Ch 7)
6. Viscous flow in pipes (viscous friction and minor losses; Ch 8-1 to 8-7)
7. External flows (lift and drag forces; Ch 11)

Evaluation

The final mark will be calculated as follows:

Assessment	Focus		Weight
	Topics	PSets	
Labs (in SEB 2036)			
Lab 1			2.5%
Lab 2*			2.5%
Lab 3			2.5%
Lab 4			2.5%
Tests†,‡			
Test 1 (Jan 23, 3:35-4:20pm)	Flow descriptions, fluid kinematics	0, 1, 2	17%
Test 2 (Feb 6, 3:35-4:20 pm)	Pressure forces, manometry, hydrostatics	3, 4	17%
Test 3 (Feb 27, 3:35-4:20pm)	Viscous forces, surface tension	5, 6	17%
Test 4 (Mar 13, 3:35-4:20pm)	Mass & momentum balances	7, 8	17%
Final exam§			
Exam Part A ("Test 5")	Energy, Bernoulli, dimensional analysis	9, 10	0%†
Exam Part B ("Test 6")	Pipe flow, pumps	11, 12	22%

* Designated assessment: supporting documentation is always required to receive academic consideration for Lab 2 in this course.

† Your best 4 out of 5 test grades on Tests 1-5 will each count equally toward the 68% of the final grade allotted for these tests (i.e., your lowest test score between Tests 1-5 will be dropped).

‡ The scheduled location of Tests 1-4 is Natural Sciences Centre 1 (NSC1).

§ The exam consists of two parts (A and B) and will take place during the final exam period. Part A is also termed "Test 5" and Part B is termed "Test 6."

Course schedule

Week	Assessments	Sections
Week 1 (Jan 5 - 9)	–	–
Week 2 (Jan 12 - 16)	Lab 0¶	ALL
Week 3 (Jan 19 - 23)	Lab 1 TEST 1	003-006 ALL
Week 4 (Jan 26 - 30)	Lab 1	007-010
Week 5 (Feb 2 - 6)	Lab 2 TEST 2	003-006 ALL
Week 6 (Feb 9 - 13)	Lab 2	007-010
READING WEEK (Feb 16 - 20)	–	–
Week 7 (Feb 23 - 27)	TEST 3	ALL
Week 8 (Mar 2 - 6)	–	–
Week 9 (Mar 9 - 13)	Lab 3 TEST 4	003-006 ALL
Week 10 (Mar 16 - 20)	Lab 3	007-010
Week 11 (Mar 23 - 27)	Lab 4	003-006
Week 12 (Mar 30 - Apr 3)	Lab 4	007-010
Week 13 (Apr 6 - 9)	–	–
Exam period	FINAL EXAM	ALL

¶ Lab 0 is a mandatory laboratory safety orientation but does not include an evaluation.

Learning Objectives

At the end of this course, students should be able to:

- Describe fluid flows in terms of pressure, velocity, and acceleration fields.
- Calculate hydrostatic forces and moments on submerged bodies.
- Apply control volume analysis to estimate flow rates, forces, and power in fluid systems.
- Identify flow conditions where the Bernoulli equation can be applied to simplify analysis.
- Formulate tractable fluid flow models based on dimensional analysis and engineering intuition.
- Employ experimental correlations to estimate forces and flow rates involving complicated geometries.
- Complete design calculations for systems of pipes and turbomachinery.
- Conduct basic investigations to understand complicated fluid flow systems.
  - *Note: this learning objective aligns with and is selected for the assessment of the graduate attribute "investigation" (IN3 & IN4, LEVEL: Introduced): an ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.*
  - *Note: this learning objective aligns with and is selected for the assessment of the graduate attribute "individual and team work" (ITW1 - ITW3, LEVEL: Introduced): An ability to work effectively as a member and leader in teams preferably in a multidisciplinary setting.*
- Draw on their fundamental knowledge of fluid mechanics and experience with relevant flows to understand and explain unfamiliar fluid flow behavior.
  - *Note: this learning objective aligns with and is selected for the assessment of the graduate attribute "communication skills" (CS2, LEVEL: Introduced): An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.*

Expectations / keys to success

- Solve problem sets the week they are assigned.
  - Attempt problems independently first.
  - Review in-class examples and tutorial problems then discuss with classmates if you get stuck.
  - Bring your work to office hours or email a photo of your work to the instructor for further guidance.
- Attend all lectures and tutorials and take notes.
  - Arrive to class on time.
  - Routinely review class notes.
  - Ask questions during class, at office hours, or by email.
  - In the rare case that you miss class, get the notes from a classmate and study the material that you missed. Note that lecture slides are intended to be visual aids but are not a complete set of notes.
- Complete all work on time.

Course delivery

- This course is planned for in-person delivery.
- Each week, students will attend 3 hours of lectures and a 1 hour tutorial. Tutorial and lecture slots may be switched from week to week without notice. In addition, students will participate in in-person labs during 4 of the weeks.
- Lecture slides will be posted on the OWL website, but most of the lecture notes will be written on the board in class.
- Problem sets will be posted for practice but will not be collected.
- Students are responsible for all material covered in the course including lectures, tutorials, problem sets, labs, and assigned readings.

Other Course Policies

The following course-specific policies will be strictly enforced throughout the course:

Emergency Contingency Plans

- Course policies, class delivery method, and the number/format of assessments may change at any time in response to difficulties that emerge as a result of pandemics or other emergencies.
- If circumstances prevent in-person instruction from continuing as planned, some or all of the remaining course content will be delivered entirely online, synchronously (i.e., at the times indicated in the timetable) and/or asynchronously (e.g., posted on OWL for students to view at their convenience). Any remaining assessments will also be conducted online at the discretion of the course instructor.

Classes

- Attendance at all lectures, tutorials, and lab sessions is mandatory.

Labs

- Every student is required to attend labs for the full duration and contribute their fair share to the group submission. No credit will be given if a student fails to attend the full lab or adequately contribute.
- You are required to have WHMIS certification to attend labs in this course. You will be required to submit proof of certification prior to Lab 0 and to attend Lab 0, which is a mandatory laboratory safety orientation.
- You are required to wear appropriate lab attire to participate in the labs. This includes safety glasses, lab coat, long pants, and closed-toed shoes.
- Students who arrive late for the lab session, do not have appropriate attire (e.g., safety glasses and lab coat), or have not provided proof of WHMIS certification, will not be permitted to participate in the lab and will receive a grade of zero on the assessment.
- If you have an excused absence during 1 or 2 labs, the weight will be re-distributed to the tests and the exam. Missing more than 2 labs for any reason, excused or otherwise, will result in a grade of zero for those labs.
- Communicating with people outside of the class about the labs or seeking help on labs from tutors not associated with the course is prohibited.

- No credit will be given for late lab report submissions.

Tests & Exam

- There will be four tests during the term and a final exam during the examination period.
- The exam consists of two parts (A and B). Part A is also termed "Test 5" and Part B is termed "Test 6."
- Your best 4 out of 5 test grades on Tests 1-5 will each count equally toward the 68% of the final grade allotted for these tests (i.e., your lowest test score between Tests 1-5 will be dropped).
- The tests and exam will be closed book.
- Tests are 45 min long and the exam is 2 h long.
- If you are unable to write a test for medical or compassionate reasons, you must provide the appropriate documentation. Failure to provide adequate documentation will result in a mark of zero.
- The first of Tests 1-5 for which you have an excused absence (e.g., submit an undocumented absence notification or receive academic consideration) will count as the one that is dropped and you will not write a make up test. If you have excused absences from more than one of Tests 1-4, you will write make up tests for all but the first one that you missed. Make up tests will be scheduled for near the end of the term. It is likely that Make Up Tests 2-4 will be held back-to-back on the same day. Students who miss a make up test for any reason, excused or otherwise, will receive a grade of zero on the test.
- If you receive academic consideration to write the special exam (i.e., make up exam) after writing Tests 1-4 or the corresponding make up tests, you will only write Part B ("Test 6") during the special exam and the test duration will be 75 min rather than 2 h. You will not write Part A ("Test 5") and this will be the test dropped from your test score calculation.
- Tests and exams will be rescheduled if a university closure affects their planned time. Furthermore, if circumstances require, test dates/times or location may be changed by the instructor with advanced notice.
- If you are eligible to write a supplemental exam, note that because of the nature of supplemental exams, it will be a 3 h exam covering all material from the course.
- To all tests and exams in this course, you are responsible for bringing a non-programmable scientific calculator (with the memory cleared), a 15-30 cm ruler with mm increments, and a writing implement.
- In the event of emergency changes to course delivery, the tests and exam may need to be administered online. By enrolling in this course, you are consenting to the use of online proctoring software and acknowledge that you will be required to provide personal information (including some biometric data) and that the session will be recorded.

Absences from Final Examinations

- If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the university to a make up Final Exam).
- You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation" (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period).

Use of artificial intelligence (AI) tools

- Any use of artificial intelligence (AI; e.g., ChatGPT) to produce course work that is submitted for grading is considered cheating and/or plagiarism and is not permitted. This applies to work including, but not limited to, assignment solutions, projects, and tests/exam problem solutions.

Units

SI units will be the primary units used in lectures and tutorials. Students are expected to be able to solve problems formulated in English/British units by first converting all parameters into SI units.

Repeating All Components of the Course

In accordance with Senate and Faculty Policy, students who have failed an Engineering course (i.e. <50%) must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years.

Use of English

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Cheating

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning (see Scholastic Offence Policy in the Western Academic Calendar).

Plagiarism

Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

The University of Western Ontario has software for plagiarism checking. Students may be required to submit their work in electronic form for plagiarism checking.

Sickness and Other Problems

Students should immediately consult with the instructor or Associate Chair (Undergraduate) if they have problems that could affect their performance in the course. The student should seek advice from the Instructor or Associate Chair (Undergraduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Undergraduate) immediately (or

as soon as possible thereafter) will have a negative effect on any appeal.

Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions provided by the Faculty of Engineering. You should understand that academic relief will not be granted automatically on request. You must demonstrate to the Undergraduate Services Office that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments.

For further information, please consult the University's medical illness policy at:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf.

The Student Medical Certificate is available at:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

Accessibility

Please contact the course instructor if you require material in an alternative format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education (formerly SSD) at 661-2111 x 82147 for any specific questions regarding an accommodation.

Notices

Students are required to check their Western email and OWL course site announcements every day.

Consultation

Students are encouraged to ask questions during and after class. Office hours will be arranged for students to see the instructor. Other individual consultation can be arranged by appointment with the instructor.

Email policy

Students wishing to communicate with the instructor by email should include "CBE 2221" at the start of the subject line. Email responses should not be expected in less than 2 business days.

Accreditation (AU) Breakdown

Engineering Science = 70 %
Engineering Design = 30 %

Graduate Attribute Assessment for Accreditation by the Canadian Engineering Accreditation Board

Graduate Attribute	Indicator	Assessment tool	Assessment Level
Investigation	IN2: Demonstrate ability to conduct an investigation successfully.	Labs 1-4. Students follow instructions to complete lab exercises and analyze data. Their ability to conduct the investigation is evaluated by observation during the experiments and through a written report submitted at the end.	I: Introduced
Investigation	IN3: Demonstrate ability to analyze and interpret data to reach valid conclusions.	Labs 1-4. Students analyze experimental data they have collected. This includes graphing, calculations, and written interpretations of findings. Their analysis and ability to reach valid conclusions is evaluated through a written report submitted at the end of the lab.	I: Introduced
Individual and team work	ITW2: Demonstrates ability to contribute to team goals.	Labs 1-4. Team dynamics are observed and evaluated while students complete labs in groups of 3-4.	I: Introduced
Communication skills	CS3: Demonstrate ability to articulate ideas in writing using appropriate technical language, and effective graphical tools.	Labs 1-4. Students submit written reports at the end of each lab. Communications skills are evaluated based on their writing, presentation of calculations, and graphs.	I: Introduced