

CEE 2224 – Engineering Fluid Mechanics – Course Outline 2024/25

This course introduces the basic fundamentals of fluid mechanics, and how they are applied to topics that are likely to be of interest to civil engineers. The general objectives of the course are for students to become able to identify, formulate and solve basic fluid mechanics problems related to:

- fluid statics,
- buoyancy and stability,
- the conservation of mass, momentum and energy in fluid flow problems,
- dimensional analysis,
- viscous flow in enclosed conduits,
- pipe networks,
- external flows, including boundary layers, and
- open channel flows.

Land Acknowledgment:

Western University recognizes that its campus is situated on First Nations territory. The Great Lakes woodland region of Turtle Island has been home to many Nations over centuries and at different times, including the Anishinaabek, Haudenosaunee, Lunaapéewak and Huron-Wendat peoples. The three local First Nations communities in closest proximity to Western are:

- Chippewas of the Thames First Nation;
- Oneida Nation of the Thames; and
- Munsee-Delaware Nation.

For some time, the Dish with One Spoon Covenant Wampum served as an agreement between the Haudenosaunee and Anishinaabek for sharing hunting territory, thus ensuring the viability of this land into the future. After contact, Treaty-making between the Anishinaabek and Britain took place. In the London area, there are several Treaties including the Treaty 6 London Township, Treaty 7 Sombra Township and Treaty 21 Longwoods.

Today, London and the region are home to a diverse Indigenous population including First Nations, Métis and Inuit people. By recognizing Indigenous peoples' historic and present relationships to the land and London, Ontario, Western makes explicit Indigenous peoples' ongoing presence and their rights to self-determination. Please visit: <https://indigenous.uwo.ca/>

Calendar Copy:

Basic concepts of fluid mechanics: fluid statics; continuity, momentum and energy equations; vortex flow; flow of real fluids and boundary layers; dimensional analysis. These principles are applied to pipe and open channel flows: steady pipe flows, uniform and gradually-varied flow in open channels; sluice gates, weirs and hydraulic jumps, unsteady flows.

Prerequisites:

ES 1022A/B/Y, Physics 1401A/B or the former Physics 1026

Antirequisites:

None

Corequisites:

NMM 2270A/B

Note: It is the student's responsibility to ensure that all Prerequisite and Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the student's responsibility to ensure that they have not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

Contact Hours:

3 lecture hours/week.

Lectures will be delivered in-person, and are organized by major learning topics. Depending on the material to be covered, each major learning topic may take a number of weeks to complete.

2 tutorial hours/week.

A 2-hour tutorial session will be delivered each week during the scheduled tutorial hours. On completion of each major learning topic a graded *MasteringEngineering* quiz will be given at the start of the following week's tutorial session, and must be submitted by the end of the tutorial session. In weeks that an end of learning topic quiz is not given, tutorials may be used to complete examples from the course notes being covered that week, or to give additional examples.

Instructor:

Dr. Craig Miller, P.Eng.; SEB 2084

E-mail: cmiller@eng.uwo.ca

Office hours: by appointment

Textbook:

Fluid Mechanics (3rd edition), packaged with *MasteringEngineering*, by R.C. Hibbeler, Pearson, 2022. Purchase of the text with *MasteringEngineering* is required (hard copy or ebook).

Other References:

Weekly homework assignments, and end of major learning topic quizzes will be delivered using *MasteringEngineering*. Midterm and final examinations may also be delivered using *MasteringEngineering*.

Units:

Both SI and FPS unit systems may be used in lectures, laboratories, tutorials and examinations.

Specific Learning Objectives:

By the end of each term, the student will be able to:

Fall Term:**1) Fluid Properties [KB2, KB3]**

- a) describe units in both SI and US Customary systems
- b) define mass, weight and volume
- c) describe elasticity and compressibility as applied to a fluid
- d) define absolute, gauge and differential pressure
- e) describe vapour pressure, cavitation and viscosity

- 2) Fluid Statics [KB2, KB3]
 - a) calculate pressure at a point applying Pascal's Law
 - b) calculate pressure in compressible and incompressible static fluids
 - c) describe the effects of compressibility on specific weight and pressure
 - d) calculate the forces on vertical, inclined and curved submerged surfaces
 - e) calculate pressures in constantly accelerated fluids
- 3) Buoyancy and Stability [KB2, KB3]
 - a) apply Archimedes Principle
 - b) define and calculate buoyancy and stability of bodies in/on fluids
- 4) Introduction to Fluid Flow [KB2, KB3]
 - a) describe the properties and types of fluid flows
 - b) apply the principles of flow analysis to steady incompressible flows
 - c) apply the ideal steady flow equations (continuity, momentum and energy)
 - d) describe how ideal steady flow assumptions relate to real fluid flows
- 5) Dimensional Analysis [KB2, KB3]
 - a) apply dimensional analysis techniques
 - b) define dynamic similarity

Winter Term:

- 1) Pipe Networks [KB4]
 - a) manipulate the solution for the flow rate and velocity distribution between two flat plates (i.e., Hagen-Poiseuille flow) for different boundary conditions and applications
 - b) identify and apply assumptions and boundary conditions in conjunction with the energy (Bernoulli), continuity, and momentum equations to solve pipe flow problems
 - c) identify and calculate frictional losses using the Darcy-Weisbach equation and the Moody diagram
 - d) identify and calculate separation (minor) losses
 - e) calculate flow rates and losses in "simple pipes", pipes in series and parallel, in branching pipe networks and in three reservoir problems
 - f) use the Hardy-Cross method for solving pipe network problems
- 2) Boundary Layers and External Flows [KB4]
 - a) describe the velocity profiles in laminar and turbulent boundary layers
 - b) estimate friction drag
 - c) estimate pressure drag for various external flows
- 3) Open Channel Flows [KB4]
 - a) identify assumptions and boundary conditions necessary to solve open channel problems
 - b) apply the energy (Bernoulli), continuity, and momentum equations to open channel problems in uniform flow, gradually varied flow and rapidly varied flow
 - c) calculate the optimum shape of cross-section for uniform open channel flow
 - d) apply the Manning equation for flow resistance
 - e) recognize and calculate critical flow conditions
 - f) understand the use of, and make calculations related to, various flow control devices such as sluice gates and weirs
 - g) sketch and calculate water surface profiles in gradually varied open channel flows
 - h) predict the existence of hydraulic jumps and other rapidly varying flow conditions
 - i) calculate gradually varied flows with the standard-step method

The instructor may expand or revise material presented in the course as appropriate.

General Learning Objectives:

E=Evaluate, T=Teach, I=Introduce; (I) = Introduction, (D) = Developing, (A) = Advanced level

Knowledge Base	E (D)	Engineering Tools		Impact on Society	
Problem Analysis	T (D)	Team Work	T (D)	Ethics and Equity	
Investigation	E (D)	Communication		Economics and Project Management	
Design		Professionalism		Life-Long Learning	

Accreditation Units:

Natural Science: 30%, Engineering Science: 70%

Evaluation:

The final course grade will be determined as follows:

<i>MasteringEngineering</i> homework assignments (Fall term):	7.5%
<i>MasteringEngineering</i> homework assignments (Winter term):	7.5%
<i>MasteringEngineering</i> end of module quizzes (Fall term):	12.5%
<i>MasteringEngineering</i> end of module quizzes (Winter term):	12.5%
Midterm (December) exam:	30.0%
Final exam:	30.0%
Total:	<u>100%</u>

- Notes: (a) **Students must obtain a passing average when the marks of the midterm and final examinations are averaged to pass this course.** Students who fail to meet this requirement will be assigned the aggregate mark, as determined above, or 48%, whichever is less.
- (b) **Students who have failed this course previously 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.

1. Examinations:

Three-hour midterm and final examinations will be held during the regular December and April examination periods respectively. These examinations may be either delivered online using *MasteringEngineering* or written in-person.

2. Quizzes

Four 90-minute *MasteringEngineering* end of module quizzes will be given each term, during the tutorial session in the week immediately following the end of lectures on that topic. Students must be physically present in the tutorial room at the time that the quiz is written. Students who are not physically present in the tutorial room at the time that the quiz is written will be given a mark of zero for the quiz, irrespective of whether they have completed it or not. **Academic consideration will not be given for these quizzes without appropriate documentation.**

3. Weekly Homework Assignments:

Weekly homework assignments will be given using *MasteringEngineering*. Assignments are to be submitted prior to the due date on *MasteringEngineering*. To receive full marks for a question, all parts of the question must be completed. Questions with uncompleted parts will receive a mark of zero for the entire question, irrespective of how many parts have been completed before the due date. Extensions are to be negotiated with the course instructor, not the teaching assistants.

4. Participation:

Participation will be assessed based on class attendance, participation in lectures and tutorials and completion of short in-class assessments.

I. Missed/Late Accommodation Policy:

1. Students missing a test/assignment/lab or examination you will report the absence by submitting Academic Consideration Request form through [STUDENT ABSENCE PORTAL](#).
2. Documentation must be provided as soon as possible.

II. Exam Accommodation:

1. If you are unable to write a final examination, report your absence using the Academic Consideration Request Form through [STUDENT ABSENCE PORTAL](#).
2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.
3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department and the Associate Dean and in order to apply you must submit an the Academic Consideration Request Form through [STUDENT ABSENCE PORTAL](#). PLEASE NOTE: It is the student's responsibility to check the date, time and location of the Special Examination.

III. Late Assignments:

1. Students must advise the course instructor if they are having difficulty completing an assignment on time (prior to the due date of the assignment).
2. Students should be prepared to submit the Academic Consideration Request Form and provide documentation if requested to do so by the course instructor (see reverse side for information on documentation).
3. If granted an extension, a revised due date should be established with the course instructor. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. This course has 11 homework assignments each term, with only 8/11 assignments each term counted towards your final grade. Academic consideration will not be granted for missed assignments. If students miss 3/11 assignments in a term, the remaining 8 assignments will be used in the calculation of the final grade. If students miss more than 3 assignments, they will receive a grade of zero on each missed assignment for that term. Should students submit their assignment after the deadline, a late penalty of 10% per day will be subtracted from the assessed grade.
5. If you have a long-term academic consideration or an accommodation for disability that allows greater flexibility than provided here, please reach out to your instructor at least one week prior to the posted deadline.
6. Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.

Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).

IV. Medical Accommodation:

1. Requests for Academic Consideration Request Form through [STUDENT ABSENCE PORTAL](#).

2. Requests for academic consideration must include the following components:
 - a. Self-attestation signed by the student (*This is only accepted for the first/one absence*)
 - b. Medical note
 - c. Indication of the course(s) and assessment(s) affected by the request
 - d. Supporting documentation as relevant
3. Requests without supporting documentation are limited to one per term per course.
4. **Students must request academic consideration as soon as possible and no later than 48 hours after the missed assessment.**
5. Once the request and supporting documents have been received and reviewed, appropriate academic consideration, if granted, shall be determined by the instructor in consultation with the academic advisor, in a manner consistent with the course outline. Academic consideration may include extension of deadlines, waiver of attendance requirements for classes/labs/tutorials, or re-weighting of course requirements. Some forms of academic consideration, such as arranging Special Examinations, assigning a grade of Incomplete, or granting late withdrawals without academic penalty, may only be granted by the Academic Advising office of the Faculty of Engineering.

V. Religious Accommodation:

When scheduling unavoidably conflicts with religious holidays, which (a) require an absence from the University or (b) prohibit or require certain activities (i.e., activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), no student will be penalized for absence because of religious reasons, and alternative means will be sought for satisfying the academic requirements involved. If a suitable arrangement cannot be worked out between the student and instructor involved, they should consult the appropriate Department Chair and, if necessary, the student's Dean.

It is the responsibility of such students to inform themselves concerning the work done in classes from which they are absent and to take appropriate action.

VI. Academic Integrity:

In the Faculty of Engineering, we encourage students to create a culture of honesty, trust, fairness, respect, responsibility, and courage, befitting the professional degree you are pursuing.

Please visit [Academic Integrity Western Engineering](#) for more information

VII. Academic Offences:

Plagiarism means using another's work without giving credit. The university has rules against plagiarism and other scholastic offences. Western Engineering has a zero-tolerance policy on plagiarism. The minimum penalty is zero on the course work and a repeat offence will earn you zero on the course. A third offence may lead to expulsion from the university.

[Scholastic Discipline for Undergraduate Students & Cheating, Plagiarism and Unauthorized Collaboration: What Students Need to Know](#)

Students must write their reports, 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. University policy states that cheating, including plagiarism, 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.

All required papers may be subject to submission for textual similarity review to commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (<http://www.turnitin.com>). Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

VIII. Faculty of Engineering AI Policy:

The use of generative Artificial intelligence (GenAI) tools won't be discouraged in the Faculty of Engineering. As we pride ourselves on building the future we can't hide from the use of GenAI tools to contribute to the understanding of the course materials. However, the use of GenAI tools in any assignment or contribution during the course will have to be disclosed, as a resource.

GenAI tools use won't be permitted in any type of examination or other assessments where the faculty have prohibited their use. If use of GenAI tools is detected by the instructor in these instances, academic offences penalties might be imposed against the student.

IX. Use of English Policy:

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work except for 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.

X. Accessibility:

Western is committed to achieving barrier free accessibility for persons with disabilities studying, visiting and working at Western. As part of this commitment, there are a variety of services, groups and committees on campus devoted to promoting accessibility and to ensuring that individuals have equitable access to services and facilities. To help provide the best experience to all members of the campus community, please visit the [Accessibility Western University](#) for information on accessibility-related resources available at Western.

Students with disabilities may arrange for academic accommodation at Western. For a more detailed explanation, please visit [Academic Support & Engagement -Academic Accommodation](#).

XI. Inclusivity, Diversity, and Respect:

The Faculty of Engineering at Western University is committed to creating equitable and inclusive learning environments that value diverse perspectives and experiences. We recognize that university courses often marginalize students based on social identity characteristics such as, but not limited to, Indigeneity, race, ethnicity, nationality, ability, gender identity, gender expression, sexuality, age, language, religion, and socioeconomic status. Understanding this, we strive to facilitate equitable experiences and inclusion within the classroom by respecting and integrating multiple ways of knowing, being, and doing. Please visit the [Office of Equity, Diversity and Inclusion](#).

XII. Health and Well-Being:

- [Health & Wellness Services – Students](#) - Offers appointment-based medical clinic for all registered part-time and full-time students.
- [Mental Health Support](#) - Provides professional and confidential services, free of charge, to students needing assistance to meet their personal, social and academic goals. Services include consultation, referral, groups and workshops, as well as brief, change-oriented psychotherapy.

- [Crisis Support](#) - For immediate assistance, please visit Thames Hall Room 2170 or call 519-661-3030. The crisis clinic operates between 11:00 am - 4:30 pm. For after-hours crisis support, click [here](#).
- [Gender-Based Violence and Survivor Support](#) - Western [is committed to reducing incidents of gender-based and sexual violence](#) and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, [here](#). To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Important Contacts:

Engineering Undergraduate Services	SEB 2097	519-661-2130	engugrad@uwo.ca
Civil & Environmental Engineering	SEB 3005	519-661-2139	civil@uwo.ca
Office of the Registrar/Student Central	WSSB 1120	519-661-2100	

Important Links:

- [WESTERN ACADEMIC CALENDAR](#)
- [ACADEMIC RIGHTS AND RESPONSIBILITIES](#)