Western University - Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 9527 – Computational Wind Engineering
Course Outline – Winter 2024

Objectives: Students will be introduced to: Computational Wind Engineering (CWE)[1] focusing on modelling of air flow (wind) with in the built environment by using Computational Fluid Dynamics (CFD) techniques; the fundamentals and the current state-of-the-art of CWE application to model wind-building interaction; the terms, questions and problems encountered during design of buildings and other structures for wind performance; computational evaluation of parameters useful to assess human comfort to wind effects and to secondary flows caused by tall buildings and other structures; and wind flow modeling over topography.

Topics:

PART I - Fundamentals

1. Introduction to experimental and computational wind engineering (***Week 1***)
2. Introduction to Sharcnet high performance computing (***Week 2***)
3. CFD and flow visualization software training (STAR CCM; OPENFOAM) (***Week 3***)
4. Air flow governing equations (***Week 4***)
5. Turbulence modelling (***Week 5***)
   5.1. Two-equation turbulence models
   5.2. Large eddy simulation
6. Numerical methods (finite volume) (***Week 6***)
7. Geometrical modelling and grid generation (***Week 7***)
8. Boundary conditions (inflow turbulence, roughness effects, wall effects) (***Week 8***)

PART II – CWE Application[2]

9. Wind pressure evaluation for buildings (low- and high-rise buildings) (***Weeks 9***)
10. CFD application for assessing thermal performance of buildings (***Week 10***)
11. Wind environment simulation for pedestrian level wind evaluation and wind-driven ventilation (***Week 11***)
12. Wind flow over topography (***Week 12***)

Notes:

- *There will be no class in **reading week***
- *Reading material (Course notes) will be uploaded on OWL before each lecture.*
- *Office hours (every Wed 1-3 PM)*

---

[1] CWE is the application of computational methods to Wind Engineering problems. Computational fluid dynamics (CFD) based modeling of air flow (wind) and its interaction with buildings constitutes a major part of CWE.

[2] Note that all application topics may not be covered, and new applications may be added according to the interest of the enrolled students.

Instructor:
Girma Bitsuamlak, PhD, P Eng, F CSCE, email: gbitsuam@eng.uwo.ca [3].

Contact Hours:

- Three lecture hours per week – 9:30 AM to 12:30 PM (date TBD),
- Lecture Room: TBD.
- Weekly Office hours: TBD.
- Contact instructor via email (above) or through messages in OWL

Course Materials:
There is no set textbook for the course. There are several textbooks that cover many aspects of the course material and are available through Western Libraries, either physically or online. Including the following book:

Versteeg, H.K. and Malalasekera, W. An introduction to computational fluid dynamics: the finite volume method, 2nd edition, 2007

Prepared class notes will be made available through the course OWL site at http://owl.uwo.ca/, along with other useful reference materials and data for assignments.

Computing:
Assignments will require the processing of computational data using computer data-analysis software such as MATLAB, and students will be assumed to be proficient in the use of the software of their choice (e.g., MATLAB. Excel or C++). Star CCM and OPENFOAM CFD software will be used during the course. Students can opt to use OPENFOAM or Star CCM to carry out their CFD project and assignments. OPENFOAM is an open sources software, License for Star CCM will be made available for registered students.

Units:
SI units will be used in lectures and examinations.

Evaluation:
Student performance will be assessed as follows:

Biweekly Assignments (total of 5) (no collaboration is allowed on assignments)	40%
Individual Project[4] (no collaboration is allowed on the project) (Includes oral presentation and Q&A after the presentation, abstract, Progress and final report submissions)	60%
TOTAL	100%

[3] Please include the course number on the subject line of your email while writing emails to the instructor i.e. **Subject: "CEE 9527"** followed by specific subject for your email

[4] List of projects and wind engineering resources are attached with the course outline. Please notify your choice to the instructor within the first three weeks, submit your abstract by week 4 and your progress report by week 8 and final report week 12. The presentation schedule will be discussed in the class.

Specific Learning Outcomes:

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	20%	• Assignments • Project	• Understanding of advanced concepts and theories • Awareness of important current problems in the field of study • Understanding of computational methodologies to solve related problems
Research & scholarship	20%	• Project	• Ability to conduct critical evaluation of current advancements in computational wind engineering • Ability to conduct coherent and thorough analyses of complex problems using CFD
Application of knowledge	20%	• Assignments • Projects	• Ability to apply knowledge in a rational way to analyze a particular problem • Ability to use coherent approach to analyze a particular engineering system using existing design tools
Professional capacity / autonomy	20%	• Assignments • Projects	• Awareness of academic integrity • Ability to implement CED procedures and practices in coursework • Defends own ideas and conclusions • Integrates reflection into his/her learning process
Communication skills	10%	• Project	• Ability to communicate (both oral and written) ideas, scientific problems, methods, results and conclusions clearly and effectively
Awareness of limits of knowledge	10%	• Project	• Awareness of the need of assumptions in complex scientific analyses and their consequences • Understanding of the difference between theoretical and empirical approaches • Ability to acknowledge numerical/analytical limitation due to complexity of practical problems

Prequisites:
This course is intended for graduate students enrolled in civil and environmental, mechanical engineering, physics, or geography with an interest in modeling wind inthe built- environment. It is expected that students will have basic understanding of fluid mechanics and numerical techniques obtained by taking suitable courses at either the undergraduate or graduate level. Students without a suitable background in fluid mechanics and numerical methods should discuss with the course instructor prior to registering for the course.

Co-requisites: None

Anti-requisites: None

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 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.

Course Content:
The lecture notes and online lecture videos are copyrighted to the instructor and legally protected. Do not post these videos and lecture notes on any other website or online forums. The recording of the live/synchronous sessions of the course without the permission from the instructor is prohibited. The illegal posting and sharing of the copyrighted course content could be subjected to legal actions.

Cheating, Plagiarism/Academic Offences:
Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text 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. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence at the following website: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

All required papers may be subject to submission for textual similarity review to the commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents

in 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).

Conduct:

Students are expected to follow proper etiquette to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

Health/Wellness Services:

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at http://www.health.uwo.ca/.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Faculty of Engineering has a Student Wellness Counsellor. Information on how to schedule an appointment with the counsellor is available at: https://www.eng.uwo.ca/undergraduate/academic-support-and-accommodations/Student-Wellness-Counselling.html

Students who are in emotional/mental distress should refer to Mental Health@Western: http://www.uwo.ca/uwocom/mentalhealth/ for a complete list of options about how to obtain help.

Sickness:

Students should immediately consult with the instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

Students who are not able to meet certain academic responsibilities due to medical, compassionate, or other legitimate reason(s), could request academic consideration. The Graduate Academic Accommodation Policy and Procedure details are available at: https://www.eng.uwo.ca/graduate/current-students/academic-support-and-accommodations/index.htmlStudents

Accessibility:

Western is committed to achieving barrier-free accessibility for all its members, including

graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program. Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW): http://academicsupport.uwo.ca/accessible_education/index.html
AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education for any specific question regarding an accommodation at:
661-2111 x 82147 or
http://academicsupport.uwo.ca/accessible_education/index.html

Additional notes:
Students are responsible for regularly checking their email, and the course OWL site for new announcements related to the course.

List of **individual** course project topics (to be revised after consultation with students)
1. Numerical evaluation of wind loads on solar panel (arrays)
2. Numerical evaluation of wind loads on tall building
3. Numerical evaluation of wind loads on low-rise roofs.
4. Aerodynamic optimization for tall buildings
5. Aerodynamic optimization for low-rise building roofs
6. Aerodynamic optimization for long span bridge sections
7. Pressure equalization simulation for multilayered cladding systems
8. Computational approaches for fluid/structure interaction problems (e.g., traffic sign board, tall buildings, long span section, solar panel, canopies etc.)
9. Numerical evaluation of wind speed-up due to topography
10. Numerical simulation natural ventilation in buildings
11. Numerical modeling of surface roughness
12. Numerical evaluation of tornado loads on buildings
13. Numerical evaluation of downburst loads on buildings
14. Numerical simulation of wind flow over complex terrain
15. Numerical evaluation of wind load on wind energy infrastructure
16. Numerical evaluation of wind loads on porous structures
17. Numerical simulation of wind-driven rain
18. Numerical modeling of pedestrian level wind
19. Numerical modeling snow drift etc.
20. Numerical modeling of droplet dispersion (in relation to Covid 19).

21. Numerical modeling of cough under different ambient wind and obstruction conditions

Wind Engineering Resources:

Journals in Wind Engineering

- Journal of Wind Engineering and Industrial Aerodynamics
- Wind and Structures
- Fluids and Structure
- Wind Energy
- Building and Environment
- Boundary layer meteorology
- Engineering Structures
- Journal of Civil Engineering, CSCE
- Journal of Structural Engineering, ASCE
- Journal of Engineering Mechanics, ASCE
- Journal of Aerospace Engineering, ASCE
- Journal of Bridge Engineering, ASCE
- Natural Hazard Review, ASCE
- Computers and Structures
- Building Energy

Books on Wind Engineering

- *Wind Loading of Structures* by JD Holmes
- *Design of Buildings and Bridges for Wind – A practical Guide for ASCE-7 Standard Users and Designers of Special Structures", John Wiley & Sons, 2006,* by E. Simiu and T. Miyata
- *Wind Effects on Structures: Fundamentals and Applications to Design* by Simiu and Scanlan
- *Wind Engineering: A Handbook for Structural Engineers* by Henry Liu
- *The Designers Guide to Wind Loading of Building Structures. Part 1 Background, Damage Survey, Wind Data and Structural Classification* by NJ Cook
- *The Designers Guide to Wind Loading of Building Structures. Part 2 Static Structures* by NJ Cook
- *Architectural Aerodynamics* by Aynsley, Melbourne and Vickery
- *Wind Effects on Buildings, Volume 1 Design Applications, Volume 2 Statistics and*
- *Meteorology* by TV Lawson
- *Wind Forces in Engineering* by Peter Sachs