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

CEE 3386b – Numerical Modeling for Environmental Engineers – Course Outline 2025/26

In this course students will use of mathematical models to explore physical and chemical processes associated with common environmental engineering problems. Modeling plays an important role in environmental engineering. The general objectives are for the student to become able to:

- Formulate conceptual models for 'real world' environmental problems and identify when problems can be solved numerically.
- Formulate and implement numerical models related to the fate and transport of contaminants in environmental systems.
- Program numerical algorithms and interpret the physical meaning of model results.
- Undertake the different stages of numerical modeling including development, implementation, calibration and validation of models.
- Identify the benefits and limitations of modeling methods in searching for solutions to environmental problems.
- Improve communication skills by documenting model development, implementation, results and interpretation.
- Recognize the need for life-long learning, and advancement of computational skills for solving complex environmental engineering problems.

Calendar Copy:

Principles of model development and solution for environmental systems including river and lake water quality, groundwater flow and contamination, and atmospheric pollution. Application of these principles using a range of numerical techniques, including current commercial software packages, through all stages of the modeling process from conceptualization to calibration and validation.

Prerequisite(s): CEE 2219A/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 during the scheduled lecture hours. Lectures will be organized into learning modules which students should review on a weekly basis. Review of lecture material and self-study should take approximately 3 hours per week.

3 computer lab hours/week

A 3-hour computer lab session will be delivered in-person each week during the scheduled tutorial hours. The computer labs are mandatory as they will provide a practical component to theoretical concepts.

Instructor:

[redacted]

Teaching Assistant:

[redacted]

Textbook:

Prepared class notes that can be downloaded from the course website should be brought to each class.

Other References:

Anderson, M. and Woessner, W., 1992. *Applied Groundwater Modeling*, Elsevier, San Diego.
Holzbecher E., 2007. *Environmental Modeling Using MATLAB,* Springer-Verlag, Berlin.
James, A. (ed), 1993. *An Introduction to Water Quality Modeling*, John Wiley & Sons, New York.
Ramaswami, A., Milford, J., et al., 2005. *Integrated Environmental Modeling, John Wiley & Sons,* New Jersey.
Vreugdenhil, C.B., 1989. *Computational Hydraulics: An Introduction*, Springer-Verlag, New York.
Wood, W.L., 1993. *Introduction to Numerical Methods for Water Resources*, Oxford University Press, Oxford.
Zheng, C., Bennett, G., 2002, *Applied contaminant transport modeling*, John Wiley & Sons, New York.

Computing:

Assignments will require the use of MATLAB and PMWIN 11 (graphical user interface for MODFLOW and MT3DMS). MATLAB is freely available for every student through Western Engineering Web Store (https://webstore.eng.uwo.ca/dashboard), and will also be available on Western computer laboratories. PMWIN 11 is available in the various engineering computers.

Units:

SI units will be used in lectures and examinations.

Specific Learning Objectives [GA Indicator – **bold** denotes evaluated indicator]**:**

1. Introduction. At the end of this section, the student should be able to:

a) Appreciate the usefulness and limitations of modeling in searching for solutions to environmental problems [KB3, LL1]
b) Appreciate the important of all stages of the modeling process including model development, solution, calibration, and validation [KB3]
a) Determine the level of complexity required in a numerical model to meet specific objectives and understand the importance of model conceptualization [KB3]
d) Classify types of models including stochastic vs. deterministic, lumped vs. distributed, steady state vs. transient [KB3]
e) Assess the suitability of a particular level of modeling for specific goals (simple analytical versus complex numerical) [KB3, PA1]

f) Identify types of differential equations and boundary and initial condition requirements [KB3, PA1]

2. Lumped "box" models. At the end of this section, the student should be able to:

a) Apply the law of mass conservation to a control volume to solve simple environmental problems [**KB1**, PA1, **PA2**]
b) Develop and apply finite difference schemes to initial value first order O.D.Es [**KB1**, PA1, **PA2, ET3**]
c) Evaluate the accuracy of finite difference schemes and appreciate sources of error in numerical modeling [PA3]
d) Appreciate the importance of step size for numerical accuracy and stability [PA3]

3. Fate and transport of contaminants. At the end of this section, the student should be able to:

a) Appreciate the mechanisms controlling the fate and transport of contaminants in the environment including diffusion, dispersion, advection, and reaction [KB4]
b) Appreciate the difference and be able to solve contaminant transport problems with a continuous vs. instantaneous source and point vs. non-point source [KB4]
c) Develop finite difference schemes and apply in MATLAB to solve partial differential equations for (i) diffusion, (ii) advection-dispersion, and (iii) advection-dispersion-reaction contamination problems [**KB1**, PA1, **PA2, ET3**]
d) Spatially and temporally discretize target systems, select appropriate boundary and initial conditions and undertake stability and accuracy analyses [**ET3**]
e) Compare numerical results to analytical solutions for contaminant transport problems and appreciate the sources of error [PA3, LL1]

4. Groundwater flow and transport. At the end of this section, the student should be able to:

a) Derive groundwater flow equations for common hydrogeological problems [**KB1**, KB4]
b) Solve the groundwater flow equation using finite difference methods [PA1, **PA2, ET3**]
c) Spatially and temporally discretize target systems, select appropriate boundary and initial conditions and undertake stability and accuracy analyses [ET3]
d) Apply MODFLOW and MT3DMS to solve groundwater flow and transport problems and compare results with numerical solutions implemented in MATLAB [PA1, **PA2, ET2**]
e) Calibrate "real world" groundwater models [**ET2**]
f) Appreciate the advantages and limitations of finite difference methods [PA3]

5. Computing and Professional skills. At the end of the course, the student should be able to:

a) Proficiently program numerical algorithms to solve equation sets [**ET3**]
b) Be familiar with a number of computational software they will encounter in the environmental engineering profession [**ET2,** LL2]
c) Clearly document model development, implementation, results, and interpretations to support collaborative analysis and professional reporting [CS2, ITW1]
d) Review groundwater modelling reports using appropriate tools and clearly explain key findings and limitations [CS3, ITW2]

Instructor may expand or revise on material presented in the course as appropriate.

General Learning Objectives

Knowledge Base	E/A	Use of Engineering Tools	E/D	Impact on Society and the Environment	
Problem Analysis	E/D	Individual and Team Work	T	Ethics and Equity	
Investigation		Communication Skills	T	Economics and Project Management	
Design		Professionalism		Life-Long Learning	I

E=Evaluate, T=Teach, I=Introduce

I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e.g. no review).

Accreditation Units:

Engineering Science = 75% Math = 25%

Evaluation:

The final course mark will be determined as follows:

Participation	10%
Lab assessment	10%
Assignments	20%
Quizzes	20%
Midterm	20%
Modelling Study Analysis	20%
Total	100%

1. Quizzes and Examinations:

Two 50-minute quizzes will be scheduled during the lecture periods.
A two-hour written midterm examination will be held after the Reading Week.

2. Assignments

Assignments will be based on computer laboratories with some theoretical background questions. Assignments are to be done individually. Each assignment will be posted on the Brightspace course website by Monday at 5:00 pm. The computer laboratory for working on the assignments will be on Friday (2:30pm – 5:20pm). You should review the assignment before the computer laboratory and may only ask for assistance on a question you have attempted. Completed assignments are due on the following Wednesday at 5:00 pm.

Late assignments will be assessed a penalty of 10% per day, to a maximum of 3 days, after which they will receive a mark of zero. Extensions are to be negotiated with the course instructor, not the teaching assistant.

Plagiarism on Assignments: Each person must hand in an assignment that contains only their own work. If an assignment is deemed to be similar to another (in the opinion of the TA and the Prof.) this will be taken as a case of plagiarism. In such circumstances, both individuals (e.g., the person providing the answer and the person copying it) will both receive a mark of zero on the entire assignment. For a first offense, both individuals will receive a personal warning and the infraction will be recorded. For a second offense, further action will be taken.

3. Participation

As part of the course mark breakdown, 10% will be allocated to student participation during live classes. Participation is an important component of this course and will be assessed by: (i) attendance at live classes and lab sessions, and (ii) contributing in class.

Use of laptop computers, tablets or smart mobile phones:
Use of laptop computers, tablets or smart mobile phones is expected to be for the purpose of participating in the lecture explicitly. They can be used to fill in the gapped notes, participate in class polls, and to register your attendance. Students using the devices for activities not related to this class may be asked to leave.

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 10 assignments with only 8/10 assignments counted towards your final grade. Academic consideration will not be granted for missed assignments. If students miss 2/10 assignments, the remaining 8 assignments will be used in the calculation of the final grade. If students miss more than 2 assignments, they will receive a grade of zero on each missed assignment.
5. This course employs flexible deadlines for assignments. The assignment deadlines can be found above in the course outline. For each assignment, students are expected to submit the assignment by the deadline listed. Should illness or extenuating circumstances arise, students are permitted to submit their assignment up to 72 hours past the deadline without academic penalty. Should students submit their assessment beyond 72 hours past the deadline, a late penalty of XX% per day will be subtracted from the assessed grade. As flexible deadlines are used in this course,

requests for academic consideration will not be granted. 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

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

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.

VII. 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.

VIII. 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.

IX. 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.

X. 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 assistant, 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