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

CEE 3386a – Numerical Modeling for Environmental Engineers – Course Outline 2023/24

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.

Contact Hours:

3 lecture hours; 3 design lab/tutorial hours

Attendance at the online tutorial/laboratory session is **mandatory**

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 tutorial hours/week

A 3-hour tutorial session will be delivered in-person each week during the scheduled tutorial hours. Tutorials are not mandatory but students seeking assistance with weekly assignments or clarification on lecture material are strongly encouraged to attend.

Instructor:

Dr. Christopher Power, cpower24@uwo.ca, SEB 3039A

Teaching Assistant:

Seyed Ziaedin Miry, smiry@uwo.ca

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.

Computer Laboratory:

There will be nine computer laboratory sessions. These will be held on Tuesdays from 5:30pm – 8:30pm in TEB-454. Two sessions will help to introduce MATLAB and MODFLOW, with the remaining laboratories associated with an assignment.

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, including TEB-454 where all tuttorials will be held.

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]
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]

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 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**]

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

General Learning Objectives

E=Evaluate, T=Teach, I=Introduce

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

Course breakdown:

Engineering Science = 75% = 42.53 AU's; Mathematics = 25% = 14.18 AU's.

Evaluation:

The final course mark will be determined as follows:

Participation	10%
Assignments	20%
Quizzes:	15%
Presentation	15%
Final Examination	40%
Total	100%

1. Quizzes and Examinations:

Two 50 minute quizzes will be scheduled during the lecture periods. These quizzes are tentatively scheduled for Tuesday, October 11 and Tuesday, November 8.

A three-hour written final examination will be held during the regular examination period.

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 OWL course website by Thursday at 5:00pm. The computer laboratory for working on the assignments will be on the following Tuesday (5:30pm – 8:30pm). 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 Friday at 5:00p.m.

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 assistants.

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 from this year (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.

4. Use of English

In accordance with Senate and Faculty Policy, students may be penalised 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 that might include expulsion from the program. If you are caught cheating, there will be no second warning.

For more information on scholastic offenses, please see:
http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf

Attendance:

Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Information regarding iClicker Cloud:

Classroom Polling: We will be using iClicker Cloud, a cloud-based student response software, in class this semester. This will help me understand what you know, give everyone a chance to participate in class, and provide more interaction on concepts and example questions. We will also use this software to keep track of attendance. At the start of every class, you will register your attendance; only after you do this will you be able to answer any poll questions posted.

You are required to bring a device connected to the university Wi-Fi to participate in iClicker Cloud during class, including a smartphone, tablet, laptop or iClicker remote. You will need to create an iClicker Reef Student account to participate in class.

Creating Your iClicker Reef Student Account: Go to iclicker.com/students or download the iClicker Reef Student app for your Apple or Android device to sign up for a Reef account. You should use your university email address and your University ID (e.g., "cpower24" for student cpower24@uwo.ca) in the Student ID field. You can edit your email address, password, or student ID from your account profile. Do not create and use more than one Reef account as you will only receive credit from a single account.

You do not need to purchase anything – iClicker Cloud is fully supported by Western and is free to all its students. Make sure you choose Western University Ontario when signing up.

Add This Course to Your Reef Account
Institution: Western University Ontario
Course: CEE 3386A Numerical Modeling

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.

Accessibility:
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 Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

Conduct:
Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Please turn off your cell phone before coming to a class, tutorial, quiz or exam. On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: http://www.uwo.ca/univsec/board/code.pdf

Sickness and Other Problems:
Students should immediately consult with the Instructor or Department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor or Department Chair regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

Students that 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

For more information concerning medical accommodations, please see:
http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf

Notice:
Students are responsible for regularly checking their email, course website (https://owl.uwo.ca) and notices posted outside the Civil and Environmental Engineering Department Office

Consultation:
Students are encouraged to discuss problems with their teaching assistant and/or the Instructor in tutorial sessions. Office hours will be arranged for the students to see the Instructor and teaching assistants. Other individual consultation can be arranged by appointment with the instructor.

Masking Guidelines:
Students will be expected to wear triple layer, non-medical, paper masks at all times in the classroom as per University policy and public health directives. Students who are unable to wear a mask must seek formal accommodation through Western Accessible Education, and present medical documentation. Students are not permitted to eat or drink while in class to ensure masks stay in place.

Students will be able to eat and drink outside of the classroom during scheduled breaks.

Students unwilling to wear a mask as stipulated by Western policy and public health directives will be referred to the Dean, and such actions will be considered a violation of the student Code of Conduct.

Course Absences due to Daily COVID Screening Questionnaire:
Missed assessments (e.g., presentations, essays, quizzes, tests, midterms, etc.) require formal academic considerations (typically self-reported absences and/or academic counselling).

Methods for dealing with missed work and course content are at the discretion of the instructor(s). Students should be aware that some learning outcomes cannot be easily made up and may need to be completed in a subsequent year. Your instructor will provide you with further information as to how this applies within this course.

Students who demonstrate a pattern of routinely missing coursework due to self-reported COVID symptoms, and therefore do not demonstrate mastery of the learning outcomes of the course, will not receive credit for the course.

Contingency plan for an in-person class pivoting to 100% online learning:
In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online as determined by the course instructor. In the event that online learning is required, a stable internet connection with working microphone and webcam will be required. As has been the case in the past, the decision to pivot to online learning will be made by Western, and not individual instructors or departments (excepting temporary online instruction in the event of instructor illness).