MATH*4050*01 Topics in Mathematics: *Environmental Transport Models*

MATH*6181*01 Topics in Applied Mathematics: *Environmental Transport Models*

*ENGG*6790*03 ST: Mathematical Basics of River Quality Models*

Winter 2023
Department of Mathematics & Statistics
Credit Weight: 0.50
Version 0.01 – January 4, 2023

Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings and academic schedules. Any such changes will be announced via CourseLink and/or class email. All University-wide decisions will be posted on the COVID-19 website

https://www.uoguelph.ca/covid19/

1 Course Details

1.1 Calendar Description

MATH*4050: In this course students will discuss selected topics at an advanced level. It is intended mainly for mathematics students in the 6th to 8th semester. Content will vary from year to year. Sample topics include: probability theory, Fourier analysis, mathematical logic, operator algebras, number theory combinatorics, philosophy of mathematics, fractal geometry, chaos, stochastic differential equations.

MATH*6181: This course provides graduate students, either individually or in groups, with the opportunity to pursue topics in applied mathematics under the guidance of graduate faculty. Course topics will normally be advertised by faculty in the semester prior to their offering. Courses may be offered in any of lecture, reading/seminar, or individual project formats.

ENGG*6970: A course of directed study involving selected readings and analyses in developing knowledge areas of environmental engineering.

1.2 Course Description

This course gives an introduction into mathematical aspects that arise in the modeling of transport phenomena. They will be illustrated in examples drawn from environmental

problems, more specifically the Streeter-Phelps model, which is the most basic river quality model. Extensions of this model will be introduced, leading to increased levels of mathematical complexity. Time permitting also models of open channel hydraulics will be discussed. The mathematical aspects will focus on 1st order semilinear PDEs and singularly perturbed second order two point boundary value problems of ODEs. We will discuss the qualitative and quantitative analysis of these equations. This course will utilise techniques from calculus, and ordinary differential equations, and to lesser extent from linear algebra and real analysis. Graduate students enrolled in MATH*6181 or ENGG*6790 will carry out a programming project.

A good preparation for this course will be, in addition to the formal requirements, some of MATH*2130, MATH*2270, MATH*3100, MATH*3510, or equivalent background, and the overall mathematical maturity that can be expected from a 4th year student. Graduate students enroled in MATH*6181 or ENGG*6790 will also conduct a programming project. Familiarity with suitable scientific software such as R, phyton, julia will be a good preparation for this.

1.3 Timetable

TUE, THU – 8:30-9:50, MacKinnon 238

1.4 Final Exam

Oral examinations will be held in the period April 10-14, or on another mutually agreed upon (by instructor and student) day. A detailed exam schedule will be provided in the last two weeks of classes.

2 Instructional Support

Instructor: Hermann Eberl
Email: heberl@uoguelph.ca
Office Hours: THU 15:30-16:30, MacNaughton 508

For questions on course content and assignments, please visit my office hours. Email is a good tool for inquiries concerning course logistics, etc, but it is not an efficient vehicle to discuss mathematics. Also keep in mind that email is a means of asynchronous communication, i.e. immediate responses should not be expected. I will get to your emails eventually.

3 Learning Resources

3.1 Lecture notes

Students are encouraged to take their own notes during lectures. Lecture notes will be provided via courselink, but often with delay, several days or even a couple of weeks after the material was taught in class.

Written assignments will be an important part of the course that contain practice exercises and a more in depth treatment of some material. Assignments will be posted on courselink. An important resource will be solutions to the assignment that will also be made available on courselink.

The programming projects for graduate students will be discussed individually during the first half of the semester.

3.2 Textbooks

There is no textbook on the market that covers the material of this class. I will occasionally provide information about research papers or pointers to book chapters that support the lectures. These resources will be announced in class and on courselink.

4 Learning Outcomes

1. Numeracy and quantitative skills
2. Critical and logical thinking
3. Application of mathematical knowledge
4. Independent learning of advanced mathematical concepts
5. Mathematical and scientific communication

in addition, for MATH*6181, ENGGG*6790:

6. Use of scientific software to answer a research question

5 Teaching and Learning Activities

Method of instruction

The main thrust of the course follows a traditional lecture model and includes written assignments to practise the material covered in the lectures.

As per academic calendar, students should expect to spend 10-12 hrs/wk for their course work (including lectures).

Lecture Topics (tentative):

1 1D Advection-Reaction Equations

1.1 Derivation

1.2 Solution Theory for the Infinite Domain: Constant Flow Velocity
1.2.1 The transport equation
1.2.2 The transport-reaction equation

1.3 Streeter-Phelps Equations: Formulation and Basic Results

1.4 Theory: Dependence on Parameters; Comparison Theorems

1.5 Parameter Dependence of the Streeter-Phelps-Equation
1.5.1 Upper and Lower Bounds on Solutions Obtained with the Comparison Theorem
1.5.2 Local Sensitivity Analysis

1.6 Nonlinear Modifications of the Streeter-Phelps Equations
1.6.1 1st order BOD decay
1.6.2 BOD decay with Monod kinetics

1.7 Advection-Reaction Equations on a Bounded Domain

1.8 Streeter-Phelps Advection-Reaction Equations on River Networks

2 Advection-Diffusion-Reaction Models

2.1 Modeling: Streeter-Phelps with Diffusion

2.2 Stationary Solutions on Finite River Stretches in the Linear Case

2.3 Comparison Theorem for Advection-Diffusion-Reaction Models

2.4 Advection-Diffusion-Reaction Models on River Networks

Time Permitting

2.5 Travelling waves of the diffusive Braun-Bertheoux Model

3. Models of open channel hydraulics
3.1 The de Saint Venant equations
3.2 The kinematic wave approximation and its weak solutions

The focus in our course is on nonlinear problems. Mathematically, it extends far beyond the application of mathematical methods for linear problems which are sometimes taught in

undergraduate courses. Those methods for nonlinear problems will be introduced in the course, no prior knowledge should be necessary.

6 Assessments

6.1 Marking Schemes & Distributions

Final grades will be determined based on the following:

Four written assignments in which the students will practise applying the concepts covered in class. The assignments should be written using professional language and style and provide sufficient explanation and detail of the rationale on which the answers/solutions are based.

A final exam will be held as a 25 minute long individually scheduled oral examination, reviewing the material of the course.

Graduate students will also carry out a programming project to investigate deeper some aspects that are introduced in class.

6.2 Assessment Details

MATH*4050

Written assignments will be distributed at least one week before the due date, solutions will be posted after they have been marked:

- Assignment 1 (15%), due January 27
- Assignment 2 (15%), due February 17
- Assignment 3 (15%), due March 17
- Assignment 4 (15%), due April 7

Late submissions will not be accepted

Final Exam (40%), to be scheduled during the period April 10-14. The final exams will be recorded. By taking the final exam you agree to this recording.

MATH*6181, ENGG*6790

Written assignments will be distributed at least one week before the due date, solutions will be posted after they have been marked:

- Assignment 1 (10%), due January 27
- Assignment 2 (10%), due February 17
- Assignment 3 (10%), due March 17
- Assignment 4 (10%), due April 7

Late submissions will not be accepted.

Programming project (30%), to be discussed in the first half of the course, due on April 14.

Final Exam (30%), to be scheduled during the period April 10-14. The final exams will be recorded (for archival purposes only, instead of the paper document that a written exam represents). By taking the final exam you agree to this recording.

Grades and interpretation of grades. The normal grading system that is in use by the university applies, based on letter grade and percentage grades. The interpretation of grades is described in detail in the academic calendar.

Email Communication

As per university regulations, all students are required to check their <uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its students.

When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. See the Undergraduate Calendar for information on regulations and procedures for Academic Consideration.

Drop Date

Courses that are one semester long must be dropped by the end of the last day of classes; two-semester courses must be dropped by the last day of classes in the second semester. The regulations and procedures for Dropping Courses are available in the Undergraduate Calendar.

Copies of Out-Of-Class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required, however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

More information: www.uoguelph.ca/sas

Academic Misconduct

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community – faculty, staff, and students – to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

TheAcademic Misconduct Policy is outlined in the Undergraduate Calendar.

Recording of Materials

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

Resources

The Academic Calendars are the source of information about the University of Guelph’s procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via Courselink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g., final exam or major assignment).

COVID-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, that these guidelines may be updated as required in response to evolving University, Public Health or government directives.