Math 218: Differential Equations for Engineers

Erick Knight

Fall 2020

E-mail: e3knight (at) uwaterloo.ca
Web: math.uwaterloo.ca/~e3knight
Office Hours: TBD
Class Hours: TBD
Office: TBD
Classroom: Does not apply

Disclaimer

Due to the nature of the Fall 2020 term, everything in this outline is subject to change. Any such change would be communicated in as far advance as is reasonable, and will be made in a manner that is as fair as possible.

Course Description

This course is an introduction to the theory of differential equations. The aim of the course is for you to be able to recognize and be able to solve differential equations. The course will have a heavy emphasis on examples, especially ones pertinent to engineering and science.

This is the first time I've run a course online, so, while I hope that everything goes smoothly, I make no guarantees. If issues arise, please let me know as quickly as possible via email or Piazza.

Materials

- Course notes will be available here, as well as on Möbius and Learn. These will not match the course exactly, but should be used more as a rough guideline and a supplemental material.
- The current plan is that I will be recording my lectures, and uploading them to YouTube, requiring you to have the link to view them. The links will be on Möbius and Learn. If you are uncomfortable with this, please let me know and I will change plans.
- The book by D. Zill (A First Course in Differential Equations with Modeling Applications) is a frequently used textbook. While I will not be referencing that book, it is potentially a useful source of other perspectives on the theory and examples to work with.

Additionally, here are some useful links:

- LEARN is another university website that will also have a lot of the material uploaded to it.
- Möbius is where most of the course material is. Having provided a link, I will now say that it is recommended to access Möbius through Learn but I am unsure of whether that is necessary or merely suggested.
- Piazza is a discussion forum where you can discuss topics in the class with other people in the class. I will be checking Piazza regularly, so this is one avenue to contact me.
- This is a small site that I have put together that will contain a bunch of files and links. By no means is it a course website but it is a course repository that will be updated.

Prerequisites/Corequisites

This course is about solving equations involving derivatives, so a solid grounding in single variable calculus is required. The prerequisite for taking this course is a Calc II course (MATH 118, 119, 128, 138, or 148; alternatively engineering and earth science students can use SYDE 112). There are no corequisites for this class.

Course Structure

The main learning parts of the course will be lessons on Möbius. The lessons will have a short video explaining a single concept and some exercises that complement the video. There will also be several office hours a week, and a one hour long problem session, where some examples are presented and we collectively work through them.

The office hours and problem sessions will be online, done through some program to be determined (Zoom, Google meet, Bongo, or something else). I tentatively plan on recording the problem sessions and sharing them with the class but this is by no means set in stone.

Homework and Tests

Grades in this course will be broken down as follows (numbers are liable to change between now and the start of the course):

- **25%** of your grade comes from 5 assignments.
- **5%** of your grade comes from the exercises following the lessons.
- **20%** of your grade comes from quizzes on Möbius.
- **20%** of your grade comes from a midterm exam.
- **30%** of your grade comes from the final exam.

Assignments

There will be five assignments throughout the course, and will break down corresponding to various units of the course. These will typically be a handful of problems that explore a certain type of differential equation, typically asking for more longform solutions. You will be expected to upload your solutions to Crowdmark; please clearly delineate which part of your work belongs to which problem to aid the graders. Late work will not be accepted; you are encouraged to upload something well in advance of the deadline. If you are having issues uploading files, please email me *at least 15 minutes before the deadline* with the files you wish to upload and I will try to sort this out if you can't get things uploaded on time.

You are allowed to (and even encouraged to) discuss the assignments with other people in the class. However, when it comes to writing things up, this should be done by yourself. A large part of mathematics is communicating with others and gaining understanding from others, but it is important that you personally understand the material.

Your four best assignments will be worth 6% of your total grade, and your one worst assignment will be worth 1% of your total grade.

Ideally, these will be the most difficult aspect of the course, pushing your understanding of the material and testing your abilities to solve equations.

Möbius work

Both the lessons and the quizzes will be on Möbius. The lessons will have a few multiple choice problems attached, while the quizzes will have a larger variety of questions. You will get three attempts on the lessons. The quizzes will be one hour long, and your final submission is the only one that counts.

Unlike the assignments, you are not allowed to discuss quizzes. There will be some amount of randomization but the function of these is to test your own understanding.

Ideally, these should be the easiest part of the course. Nothing immensely complicated will come up, all problems will be directly in line with what is discussed in class, and all numbers will work out nicely.

Exams

There will be a midterm and a final. The exact breakdown of the exams is a little flexible, but they should be roughly 1/4 multiple choice, 1/2 solving equations, and 1/4 conceptual problems.

The midterm most likely will be during a 48-hour period on October 19-21, and will cover units 1-4. The midterm should take roughly 3-4 hours to complete, providing a buffer to students, and allowing students to begin the test at a time appropriate for their time zone. The final will be during the final exam period, and it will also be given a 48-hour window but should only take 3-4 hours to complete. The final will be comprehensive, but with a larger emphasis on topics covered in units 5 and 6.

Tentative Schedule

The schedule is tentative and subject to change.

Weeks	Möbius Units	Topics
1-3	1 & 2	Terminology, first order differential equations
3-5	3	Second order differential equations
5-6	4	Oscillations
6-9	5	Laplace transforms
9-12	6	Systems of linear differential equations

Academic Integrity

In order to create and curate a culture of academic integrity, students are expected to promote honesty, fairness, respect, and responsibility. Students are expected to know the information here.

Grievances

If a student feels that a decision affecting their university life has been unfair in any manner, then they may have grounds for a grievance. Policy 70 (and especially section 4), as seen here, details the proper procedure for filing a grievance. If there is any doubt, contact the math department's administrative assistant, and they will provide further guidance.

Discipline

Students are expected to know what constitutes violations of academic integrity and accept responsibility for their actions. If a student is unsure about whether something constitutes a violation, wants help avoiding violations, or wishes to know course policies about group work and collaboration, they are encouraged to ask the course instructor, academic advisor, or undergraduate dean. For more information on offenses and types of penalties, Policy 71 (as seen here) provides a complete outline. For information on typical penalties, there are guidelines here.

Appeals Process

Students may appeal decisions and penalties made under Policies 70 and 71 if there are grounds. If a student believes that they have a ground for an appeal should read Policy 72 (as seen here) for further guidance.

AccessAbility

The AccessAbility Office collaborates with all the academic departments at the University of Waterloo to arrange accommodations for students with disabilities without compromising the academic integrity of the course. If you require accommodations, you should register with the AccessAbility Office at the beginning of each term.

Currently, everything is physically closed, so the best ways to contact them are online at https://uwaterloo.ca/accessability-services/, via phone at (519) 888-4567 ext. 35082, and via email at access@uwaterloo.ca.

In the event that the university opens up, they can be found at Needles Hall, Room 1132.

Learning Objectives

Below are the intended learning objectives for this course. The numbers after them correspond to the CEAB requirements as found on the next two pages.

- A student should be able to convert real-world scenarios to common differential equations and systems of differential equations (2).
- A student should be able to identify and employ valid problem solving techniques (1).
- A student should be able to navigate new solution techniques based on unusual substitutions (1).
- A student should be able to describe theoretical concepts with a math or engineering emphasis (1).
- A student should know basic ODE terminology (1).

Graduate Attributes

The Canadian Engineering Accreditation Board (CEAB) has defined a list of 12 graduate attributes that graduating students are expected to possess. These are:

1. **A knowledge base for engineering**: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

2. **Probelm analysis**: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

3. **Investigation**: An ability to conduct investigations of complex problems by methods that include appropriate analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

4. **Design**: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

5. **Use of engineering tools**: An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

6. **Individual and team work**: An ability to work effectively as a member and leader in teams, preferably in a multidisciplinary setting.

7. **Communication skills**: An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

8. **Professionalism**: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

9. **Impact of engineering on society and the environment**: An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

10. **Ethics and equity**: An ability to apply professional ethics, accountability, and equity.

11. **Economics and project management**: An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

12. **Life-long learning**: An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

Reference: Engineers Canada Accreditation Board, 2015 Accreditation Criteria and Procedures, 2015, ISSN 1708-8054, available at https://engineerscanada.ca/accreditation/accreditation-resources.