

Math*3200 – Real Analysis – Fall 2021



(Revision: September 8, 2021)

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. This includes on-campus scheduling during the semester, midterms and final examination schedules. All University-wide decisions will be posted on the [COVID-19 website](#) and circulated by email.

For information on current safety protocols, follow these links:

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

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

1 INSTRUCTIONAL SUPPORT

1.1 Instructor

Dr. Matt Demers

mdemers@uoguelph.ca

Office Hours

Mondays immediately after class (9:30 - 11 or thereabouts, details to come on Courselink)

2 LEARNING RESOURCES

2.1 Course Website

Various resources, solutions, announcements and grades will be regularly posted to the Math*3200 Courselink page. It is your responsibility to log in and check the page every day.

2.2 Required Resources

The primary resource for the course will be the notes that we build together over the semester. These will consist of a collection of base notes (provided through Courselink when

possible) as well as the proofs and examples we craft together in class.

2.3 Recommended Resources

Closer and Closer - Introducing Real Analysis, by Carol S. Schumacher.

Most of the concepts, notes, and proofs from the course are adapted from this book. While we will do several examples and explorations that deviate from the flow of this textbook, this might give you a really useful extra source of examples and exercises.

2.4 Additional Resources

Lecture Information:

Lectures will be provided face-to-face, but simultaneously broadcast through Zoom and also recorded to post for later.

In summary: Lectures are being designed this semester to cater to as many different preferences and needs as possible, given the uncertain and transitional nature of these times. If you have any suggestions or questions related to delivery and how I can create a better experience for you, please do not hesitate to get in touch.

Weekly Exercises:

A few extra problems may be posted to Courselink each week or recommended from the textbook. Even though they will not be for grades, these are there for you to practice with, beyond those that we cover in lectures and assignments. To gain the best understanding possible, I highly recommend that you attempt these as or soon after they are posted.

Other:

I might post some resources or provide links from time to time if I create something or come across something that I believe might be helpful to you. Anything like this would be posted to the Courselink site, so again, check it every day.

2.5 Communication & Email Policy

Please feel free to ask any questions during or just after lectures. Do not feel intimidated about contributing during class, because active learning is much more effective than just copying down notes! This is especially important in an abstract course like this: Remember, the material will be brand new (and challenging) to everybody. If you can't ask me a question during or after class, there are still options for help:

- Come to my posted office hours. Don't ever hesitate to tune in, even if you think you are behind in your studying. Getting you caught back up is **exactly** what those opportunities are there for!

- Send me an email (mdemers@uoguelph.ca). If you do this, it would be extremely helpful for you to *attach a picture of your work*, so I can easily see where you might be stuck and be able to help you more quickly.

3 ASSESSMENT

3.1 Dates and Distribution

Any missed assessments will have their weight transferred automatically to the final exam. You do not need to provide any documentation; you do not need to contact me.

Weekly Assignments:

Worth 30% of your grade (your lowest grade among these assignments will be dropped)

Short take-home assignments will be given each week to help cement new concepts. These will be posted on Fridays, and due at the end of Monday office hours (the first will be given out September 10). These will aim to help you describe definitions, provide examples (or counterexamples), prove some small results, and gain a better feel for some of the abstract concepts that we have covered. You are expected to write up your answers independently.

Tests:

Wednesday, October 8
8:30 - 9:30 am
Worth 20% of your grade

Wednesday, November 3
8:30 - 9:30 am
Worth 20% of your grade

Tests will be virtual and open-book, with solutions to be submitted through Crowdmark. More details on the tests will be given over Courselink ahead of each.

Final Exam:

Monday, December 14 at 11:30 am
Worth 30% of your grade

The final exam will follow a similar format to the tests, and will be comprehensive, covering material from the entire course.

The use of Chegg or any other quick-help websites is strictly prohibited. Please note that it is much easier to detect a “Chegg answer” than you might think. Be smart about the choices that you make.

If your test solutions are submitted late, a grade penalty will be applied. Past a designated time, the test weight will instead be automatically dropped and added to your final exam weight. Details on this will be provided ahead of each test.

Important: By submitting any solutions (or portion) to any assessment, you are committing to have the assessment graded and for the result to be contributed to your final grade. In other words, you cannot “drop” a test after seeing that you performed below your expectations on the assessment.

3.2 Course Grading Policies

Missed Assessments:

If you know in advance that you will be unable to attend any tests due to medical, psychological, compassionate, or other reasons, please email me. We may be able to come to an agreement to reweight the test to other components of the course, or provide an alternative assessment, depending on your situation. I ask that you provide me with at least two weeks of notice. I will try to schedule an alternative time, as close to the test time as possible, to write the scheduled assessment (but for clarity, I cannot guarantee that such an arrangement will be possible). See below for details and consult the undergraduate calendar for information on regulations and procedures for Academic Consideration:

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

Accommodation of Religious Obligations:

If you are unable to meet an in-course requirement due to religious obligations, please email me within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml>

Passing grade:

You must receive a final grade of 50% or greater in order to pass this course.

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).

4 AIMS, OBJECTIVES & GRADUATE ATTRIBUTES

4.1 Calendar Description

4.2 This course provides a basic foundation for real analysis. The rigorous treatment of the subject in terms of theory and examples gives students the flavor of mathematical reasoning and intuition for other advanced topics in mathematics. Topics covered include the real number line and the supremum property; metric spaces; continuity and uniform continuity; completeness and compactness; the Banach fixed-point theorem and its applications to ODEs; uniform convergence and the rigorous treatment of the Riemann integral.

Prerequisite Courses: Math*2000, Math*2210, One of Math*1160 or Math*2160

4.3 Course Aims

This course is taught with the goal of continuing to develop the logical, problem-solving, creative, and abstract thinking skills that students have first encountered in Math*2000. Many of the concepts presented will provide a deeper and more rigorous treatment of material that students will already be familiar with. So, it is hoped that students will emerge from this course with a greater appreciation for concepts involving the real number line, real functions, sets, proof techniques, and more; while extending to new ideas that set the stage for more advanced analysis courses.

4.4 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability to:

1. Explain various properties of the real number line by building from basic field axioms toward more sophisticated results.
2. Define metric spaces.
3. Discern between open and closed sets; finite, countable, and infinite sets; interior, boundary, and limit points, and the closure of a set.
4. Work with sequences in a variety of contexts, and explain convergence of sequences and uniform convergence of functions.
5. Rigorously define familiar topics such as limits, continuity, and the Riemann integral.
6. Understand the importance of completeness, compactness, and the Heine-Borel theorem.
7. Calculate fixed points for various functions or operators and understand various consequences of Banach's Fixed Point Theorem.

4.5 Instructor's Role and Responsibility to Students

As your instructor, I pledge to:

1. Come prepared to each lecture and deliver course material in a professional way that facilitates learning for a variety of students and learning styles.
2. Respond to you. This includes, as time permits, questions during or after lectures, during office hours, or through email. You are more than welcome to contact me at any time through these means if you have questions or concerns about the course or new concepts.
3. Evaluate you fairly, providing prompt feedback on your performance and justification for any grades you are given. I must provide academic consideration, where appropriate, as described in Section 3.

4.6 Students' Learning Responsibilities

As a member of this class, you are expected to:

1. Take advantage of the learning opportunities provided during lectures and assignments, and through CourseLink.
2. Treat myself and other students with dignity whenever you address them, in-class or online.
3. Genuinely try all homework in a timely manner and make the effort of attempting optional practice questions, especially if you have faced some trouble with math courses in the past.
4. Seek help if you have tried the homework and are still having difficulty with the course content. This means talking to me! Contact me through email or in office hours (*not* just at the last minute!) and possibly consider other resources as I recommend them to you.
5. Check all of your posted grades with tests that have been returned to you, to verify that the correct mark has been recorded. If not, then for tests, get in touch with me right away in person or through email, and we will figure things out. For lab assignments, contact your TA and they will do the same.
6. Notify me, as described in Section 3, in the case that there are academic conflicts that are known in advance. If illness, work, or extra-curricular activities are causing you to struggle, you are advised to keep me up-to-date on your progress, so that I can be more helpful to you.

4.7 Relationships with other Courses & Labs

Math*2000, Math*2210, Math*1160 or Math*2160. These courses provide some fundamental tools that will be helpful in understanding new concepts introduced in this course.

Follow-On Courses

Math*4200 (Advanced Analysis), Various Topics in Mathematics courses.

Many senior courses will come with the expectation that students have a grasp of many of the fundamental concepts from this course. Real Analysis also provides some important

background for many research areas, for those students interested in pursuing graduate studies.

5 TEACHING AND LEARNING ACTIVITIES

5.1 Timetable

Lectures:

Mondays, Wednesdays and Fridays, 12:00 - 12:50 pm through Microsoft Teams.

5.2 Lecture Schedule - (Please note that the timing may vary slightly)

| Lecture(s) | Topic | Text Chapter | Learning Outcomes |
|------------|---|--------------|-------------------|
| Lecture 0 | Introduction + Course Outline | N/A | N/A |
| 1-5 | Basics of the Real Number Line | 1 | LO 1 |
| 6-7 | Metric Spaces | 2 | LO 2 |
| 8-9, 11-16 | Open Sets, Closed Sets, Sequences | 3 | LO 3,4 |
| 10 | Test #1 | N/A | N/A |
| 17-18 | Real Functions, Limits, and Continuity | 4, 5 | LO 5 |
| 19-21 | Completeness and Compactness | 6, 7 | LO 6 |
| 22 | Test #2 | N/A | N/A |
| 23-25 | Fixed Points and Banach's Fixed Point Theorem | 10 | LO 7 |
| 26-27 | Iterated Function Systems and Fractals | - - - | LO 7 |
| 28-30 | Integration of Real Functions | 11 | LO 5 |
| 31-33 | Uniform Convergence of Functions | 12 | LO 4 |
| 34-35 | Catch-Up/Review | N/A | N/A |

5.3 Drop Date

Students will have until the last day of classes to **drop** courses without academic penalty. The deadline to **drop** two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - **Dropping Courses**

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml>

Graduate Calendar - **Registration Changes**

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml>

Associate Diploma Calendar - **Dropping Courses**

<https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml>

5.4 Other Important Dates

Thursday, September 9: Classes commence

Monday, October 11: Thanksgiving Day (no classes scheduled)

Tuesday, October 12: Fall Study Break Day (no classes are scheduled)

Thursday, December 2: Tuesday class schedule is in effect

Friday, December 3: Last day of classes; Monday class schedule is in effect

6 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.

6.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml>

A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
<https://academicintegrity.uoguelph.ca/>

7 ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact Student Accessibility Services as soon as possible.

For more information, contact SAS at 519-824-4120 ext. 56208 or email sas@uoguelph.ca or see the website: <https://wellness.uoguelph.ca/accessibility/>

8 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, classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9 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: <https://www.uoguelph.ca/registrar/calendars>

Mental Health Services:

One out of every five students in Canada experiences some sort of mental health issue at some point in their academic career. If you find yourself facing a mental health crisis, or just need to talk to someone, please consider taking advantage of one of the following resources available to University of Guelph students:

Counselling Services: Visit the Counselling Services website (<https://wellness.uoguelph.ca/counselling>) to get information on resources available to you, both online and in-person. You can also visit them at Health Services (J.T. Powell Building, ext 53244) where they offer individual and group counselling sessions by appointment or walk-in.

Student Support Network: is located in the Wellness & Education Promotion Centre in the J.T. Powell Building and offers confidential, peer-based, drop-in support.

Good2Talk: ([1-866-925-5454](tel:1-866-925-5454)) is a free, 24/7 student hotline that provides professional counselling and referrals for mental health, addictions and well-being.

Here 24/7: ([1-844-437-3247](tel:1-844-437-3247)) specializes in assessment, referral and appointment booking and is available 24/7 for crisis support.

You are not alone and you will not be judged for asking for help.