

# Math\*3200 – Real Analysis – Fall 2020



(Revision: September 7, 2020)

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://news.uoguelph.ca/2019-novel-coronavirus-information/>

The University will not normally require verification of illness (doctor's notes) for fall 2020 or winter 2021 semester courses. However, requests for Academic Consideration may still require medical documentation as appropriate.

---

## 1 INSTRUCTIONAL SUPPORT

### 1.1 Instructor

**Dr. Matt Demers**

[mdemers@uoguelph.ca](mailto:mdemers@uoguelph.ca)

### Office Hours

Mondays after class (1 - 2 pm or so) and Fridays, 10 - 11 am, through Microsoft Teams

---

## 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.

## 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 given live, three times per week through Microsoft Teams (you will receive an invite as we approach the first day of the course). Many of the concepts in this course are abstract and challenging and having the ability to interact with me or hear live explanations and examples will be of benefit. It will certainly be useful to tune in on a regular basis.

### 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](mailto: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

#### Class Assignments:

Worth 20% of your grade (your lowest grade among these assignments will be dropped)

Rather than watch me prove stuff all the time, it will be “your turn” to do some work and get in some practice. These will be very short assignments that are given in each Monday class. You will have the chance to complete the assignment either by yourself or with a partner, using any resources you like. I will be available to help you out as well. The material will be related to concepts recently covered in the course.

#### Overnight Assignments:

Worth 25% 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 Wednesdays, to be submitted online by the beginning of class (12:00 noon) on Fridays. These will aim to help you describe definitions, provide examples (or counterexamples), and gain a better feel for some of the abstract concepts that we have covered. These will generally be quite short, but you are expected to write up your answers independently.

#### Tests:

Friday, October 16

12:30 - 1:30 pm + Video Meeting

Worth 15% of your grade

Friday, November 13

12:30 - 1:30 pm + Video Meeting

Worth 15% of your grade

Tests will be provided in two components:

a) A written component, through Courselink, where you will submit your written solutions through Crowdmark. Open books are permitted and there may be sections where you are permitted to collaborate; otherwise, however, it is expected that you will write tests on your own.

b) An oral component, consisting of a friendly (!) 5-10 minute video conversation with me. Topics will rotate from student to student, so you may not receive exactly the same questions as your classmates; however, I will be careful to balance this for fairness. This part of each test will focus on providing definitions, examples, and counterexamples, rather than having to think of proofs on the spot. A signup sheet will be provided at least a week in advance for you to schedule an appointment with me that is convenient for both of us. **You must be sure to source a webcam or other video tool, so that I can verify that you are not reading from notes during these meetings!**

#### Final Exam:

Monday, December 14 at 11:30 am

Worth 25% of your grade

The final exam will follow a similar format to the tests, with two different sections (written and oral).

### 3.2 Course Grading Policies

#### **Missed Assessments:**

If you are unable to write any tests due to medical, psychological, or compassionate reasons, please email me. 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

#### **Missed Tests:**

If you miss a test due to acceptable grounds for granting accommodation, the weight of the missed assessment will be added to the final exam. There will be no makeup midterm tests. If you know in advance that you have a conflict for a test, provide me with at least two weeks of notice. I will try to schedule an alternative writing time *ahead* of the scheduled assessment (but for clarity, I cannot guarantee that such an arrangement will be possible). Only in very exceptional circumstances will I allow for an alternative time that is afterward.

---

## 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
8-13, 15-16	Open Sets, Closed Sets, Sequences	3	LO 3,4
14	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
22-24	Fixed Points and Banach's Fixed Point Theorem	10	LO 7
25, 27	Iterated Function Systems and Fractals	- - -	LO 7
26	Test #2	N/A	N/A
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 10: First day of classes

Monday, October 12: Thanksgiving Day (no classes scheduled)

Tuesday, October 13: Fall Study Break Day (no classes are scheduled)

Thursday, December 3: Tuesday class schedule is in effect

Friday, December 4: 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](mailto: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>