

Math 361-01, Real Analysis, Fall 2022

TR 12:30-1:50pm, SCI 018

Instructor: Dr. Amy DeCelles

Email: amy.decelles@betheluniversity.edu

Webpage: <https://amydecellesmath.org>

Office: Science Building 013

Office phone: 7-7095

Tentative* Office Hours: MW 11-11:50, T 3-3:50, R 2-2:50, F 9-9:50

**If you anticipate wanting to come to office hours regularly, and none of these times work for you, please email me about this within the first week of the semester.*

Course Description: A rigorous treatment of the real number system. Topics include: sequences, series, limits, continuity, uniform continuity, uniform convergence, differentiation, Riemann integration, and power series. Advanced topics may include metric spaces.

Course Prerequisites: Grades of C- or above in MATH 132 and MATH 293.

Credits and Workload Expectations: 3 credits: 6 hours per week outside the classroom.

Textbook: *Elementary Real Analysis*, Second Edition (2008), by Brian S. Thomson, Judith B. Bruckner, and Andrew M. Brookner. Free pdfs are available for download, and hard-copies are available on demand; see <http://classicalrealanalysis.info/Elementary-Real-Analysis.php>.

Course Objectives:

- Listen to and read mathematics with greater understanding and discernment, particularly in the context of an algebraic argument (M1, ME1, M4, ME4);
- Construct more clear, effective, and precise mathematical proofs (M2, M4, ME4);
- Generally communicate mathematical ideas and information more clearly, effectively, and precisely through both oral and written means (M4, ME4); and
- Exhibit proficiency in both conceptual understanding and computational techniques for the content outlined in the course description. (M1, ME1)

Homework: Homework is assigned in a “rolling trio”: reading assignments, discussion problems, and written problems. For example, for Thurs Sep 1, you are to write up the solution to a problem from Sections 1.9-10 (which we will have discussed already, in class Tues Aug 30), work on discussion problems for Sections 2.1-3 (which we will discuss in class on Thurs Sep 1), and read and answer questions on Section 2.4-I (which we will discuss in class Tues Sep 6).

Collaboration and Consultation: I encourage you, when working on homework, to collaborate with fellow students, to reread the textbook, and to ask the professor or the Learning Commons tutors for help. You are also free to consult other textbooks or online resources for general information on the topic. However, *you may not at any point consult any worked solution to an assigned homework problem*. If in doubt about the acceptability of a certain kind of collaboration or consultation, ask the professor. Please see the university policy on academic dishonesty, below.

Attendance: Attendance in class is expected, and a portion of the final grade comes from preparation for and participation in class. Absences for official university functions will be excused, provided that the instructor is notified in advance. Absences due to qualifying family or medical emergencies will also be excused, though the instructor reserves the right to ask for verification. In the case of an **excused absence**, it is the student's responsibility to **contact the instructor in advance** and, if desired, make arrangements for an assignment to **compensate for the missed class work**.

Late Work: Late work is typically not accepted. The lowest two scores in each assignment category (RQ, D, W) will be dropped at the end of the semester. Extensions on other assignments will be considered if requested before the due date, and work may certainly be submitted before the due date, if arrangements have been made with the professor in advance. If there is a serious, unforeseeable reason for missing more than one week of class, it is the student's responsibility to contact the professor as soon as possible and to make an appointment with the professor upon returning to classes to make a plan, e.g. whether to continue with the course, take an incomplete, or withdraw; and if continuing, how to make up missed work.

Exams: The exams in this class will be a combination of individual and group work. It will be important for the whole group to be present on the exam day. Please put the scheduled exam days on your calendar at the beginning of the semester, and, if there is any anticipated possible scheduling conflict, speak to the professor about this during the first week of class.

Final Course Grade: The overall score for this course will be computed as outlined below.

- Preparation and Participation (15%): reading questions (7%), discussion problems (8%)
- Written Problems (30%): typically one problem per class, written up nicely
- Quizzes (5%): tentatively scheduled for Aug 30, Sep 8, Oct 18, and Nov 15
- Exams (30%): tentatively scheduled for Tues Sep 20, Thurs Oct 27, Tues Nov 29
- Final Presentation (20%): scheduled for Thurs Dec 8, 10:30-12:30

Final letter grades will be determined from the overall score as follows:

A	93-100	B+	87-89	B-	80-82	C	73-76	D+	67-69	D-	60-62
A-	90-92	B	83-86	C+	77-79	C-	70-72	D	63-66	F	0-59

Incompletes: Grades of I are normally not given in this course. However, they may be granted due to extenuating circumstances if (i) at least 60% of the course work has been completed at a level of C or better and (ii) the student demonstrates the ability to complete the remaining coursework outside of the classroom. In such cases, a well-documented petition should be submitted to the professor well before grades are due to the Registrar. Please see the university policies on [incomplete grades](#) and [withdrawing from a class](#).

Education Majors: Please use the link below to review all appropriate standards.

<https://bethelcollege.instructure.com/courses/11416/pages/standards-library>

Learning Commons: Located on the lower level of the Miller/Moore Academic Center (AC), the [Learning Commons](#) offers in-person and online tutoring services to all Bethel students,

including help with any sort of writing projects, from conception to completion. Tutors are trained to give thoughtful feedback and advice on a variety of study skills, understanding concepts pertaining to relevant coursework, and overall writing concerns.

DEI: Bethel University respects the dignity of all God's image-bearers, and stands against racism, prejudice, and discrimination. Because Christ calls us to love our neighbor as ourselves, Christian discipleship includes pursuing the good of those who suffer injustice due to their color, race, or ethnicity. Therefore, we aim to continually transform our classrooms into safe and hospitable spaces where we listen to one another with mercy, learn from and value each other with tenacity, and commit to pursuing justice for the most vulnerable in our community.

Accessibility and Accommodations: Bethel University strives to make learning experiences accessible to all participants. If you anticipate or experience physical or academic barriers based on disability, please contact the Center for Academic Success to discuss options. To schedule an appointment, email rachel.kennedy@betheluniversity.edu or call 574-807-7460.

Academic Dishonesty: The student handbook (p. 156) states: "Any act of deceit, falsehood or stealing by unethically copying or using someone else's work in an academic situation is strictly prohibited.

1. A student found guilty of plagiarism or cheating will receive an "F" (zero) for that particular paper, assignment or exam. Should this occur, the professor will have an interview with the student and will submit a written report of the incident to the academic dean.
2. If a second offense should occur, the student will be asked to appear before the professor, the academic dean and the vice president for student development.

The student should realize that at this point continuation in a course and even his/her academic career may be in jeopardy. In the event of a recommendation for dismissal, the matter shall be referred to the Student Development Committee."

Cell Phones: Cell phones must be turned off and stowed in book bags during class. Any student using a cell phone for any reason (without permission) will be asked to leave the class and an unexcused absence will be recorded. Students using cell phones during exams or graded activities may be cited for cheating (at professor's discretion). In the case of expected emergencies, students may seek permission from the professor to leave their cell phones on during class, but the phone must remain in the book bag. Professors reserve the right to have operational cell phones in class.

Covid-19: Students are expected to follow current Bethel University policies (e.g. re: masking); students not in compliance may be asked to leave the classroom and be recorded as absent.

Disclaimer: This syllabus is not a legal contract, but serves as a general outline for the semester. The professor reserves the right to announce in advance necessary adjustments to the course as the need arises.

Tentative Schedule See the following pages for a tentative semester schedule, a plan for the first unit, and a tentative list of assigned homework problems.

Tentative Schedule, Real Analysis, F2022

Tues	Thurs
August 16, 2022	August 18, 2022
	Intro to Course; 1.1-1.4 Intro to Real Numbers
August 23, 2022	August 25, 2022
1.5-1.6 Bounds; Sups and Infs	1.7-1.8 Archimedean Property of \mathbf{R} and Inductive Property of \mathbf{N}
August 30, 2022	September 1, 2022
1.9-1.10 Density of Rationals, Metric Structure	2.1-2.3 Sequences and Countable Sets
September 6, 2022	September 8, 2022
2.4-I Convergence	2.4-II Convergence
September 13, 2022	September 15, 2022
2.5 Divergence	2.6-2.7 Boundedness; Algebra of Limits
September 20, 2022	September 22, 2022
Exam 1 (1.1-2.4)	2.8-2.9 Order Properties; Monotone Criterion
September 27, 2022	September 29, 2022
Service Day	2.10-2.11 Examples of Limits; Subsequences
October 4, 2022	October 6, 2022
2.12 Cauchy Criterion	Fall Break

Tues	Thurs
October 11, 2022	October 13, 2022
4.1-4.2 Sets, Points	4.3-4.4 Sets, Topology
October 18, 2022	October 20, 2022
4.5-4.6 Compactness; Countability (Omit 4.5.2, 4.5.3.)	5.1 Intro to Limits (Omit 5.1.3)
October 25, 2022	October 27, 2022
5.2 Properties of Limits	Exam 2 (2.5-4.6)
November 1, 2022	November 3, 2022
5.4-5.5 Continuity; Properties of Cont. Fcns.	5.6 Uniform Continuity
November 8, 2022	November 10, 2022
5.7-5.9 Extremal Properties; Darboux Property; Discontinuities	7.1-7.2 Intro to the Derivative
November 15, 2022	November 17, 2022
7.3-7.4 Computations; Continuity	7.5-7.6 Local Extrema; Mean Value Theorem
November 22, 2022	November 24, 2022
7.7, 7.9 Monotonicity; Darboux Property	Thanksgiving
November 29, 2022	December 1, 2022
Exam 3 (5.1-7.6)	7.10 Convexity

Final Exam: Thurs Dec 8, 10:30-12:30

Real Analysis, Unit 1 Plan, F2022

Tues	Thurs
August 16, 2022	August 18, 2022
	Intro to Course; Preview 1.1-1.4 Intro to Real Numbers In class today: • D 1.1-1.4 (if time allows)
August 23, 2022	August 25, 2022
1.1-1.4 Intro to Real Numbers (as needed) 1.5-1.6 Bounds; Sups and Infs Due today: • Read 1.1-1.6, RQ 1.1-6 • D 1.1-1.4 (as needed), D 1.5-1.6 • Read 1.7-1.8, RQ 1.7-1.8	1.7-1.8 Archimedean Property of R, Inductive Property of N Due today: • W 1.4, W 1.5-1.6 • D 1.7-1.8 • Read 1.9-1.10, RQ 1.9-1.10
August 30, 2022	September 1, 2022
1.9-1.10 Density of Rationals, Metric Structure Quiz 1 (Sups and Infs) Due today: • W 1.7-1.8 • D 1.9-1.10 • Read 2.1-2.3; RQ 2.1-2.3	2.1-2.3 Sequences and Countable Sets Due today: • W 1.9-1.10 • D 2.1-2.3 • Read 2.4; RQ 2.4
September 6, 2022	September 8, 2022
2.4-I Convergence (Intro.) Due today: • W 2.1-2.3 • D 2.4-I	2.4-II Convergence (Cont.) Quiz 2 (Convergence) Due today: • W 2.4-I • D 2.4-II • Read 2.5; RQ 2.5
September 13, 2022	September 15, 2022
2.5 Divergence Due today: • W 2.4-II • D 2.5 • Read 2.6-7, RQ 2.6-7	2.6-2.7 Boundedness; Algebra of Limits Due today: • W 2.5 • D 2.6-2.7 • Read 2.8-2.9, RQ 2.8-2.9
September 20, 2022	September 22, 2022
Exam 1 <i>Exam 1 covers 1.1-2.4.</i>	2.8-2.9 Order Properties; Monotone Criterion Due today: • W 2.6-2.7 • D 2.8-2.9 • Read 2.10-2.11, RQ 2.10-2.11

*An asterisk next to a problem indicates that I have modified the problem or provided a hint. (A problem in parentheses is a challenge problem. Make sure you understand the other problems before attempting the challenge problems.)

Assigned Textbook Problems

Section	Discussion	Written
1.3	0*, 5, 7	
1.4	1	2
1.6	1, 6, 7, 16, 17	19
1.7	1, 3, 5	4
1.8	1	
1.9	1, 6, 7	
1.10	2, 3, 4	9
2.2	1, 9	
2.3	1, 3, 6	4
2.4-I	1, 2, 3, 5, 6	8
2.4-II	10, 11, 12, 13	14
2.5	1, 2, 3, 6, 9	7
2.6	1, 2, 3, 4	5
2.7	1, 2, 5	
2.8	1, 5	
2.9	2, 3	6
2.10	1, (3)	
2.11	3, 4, 6, 11, 12	13
2.12	1, 4, 6, 8	9
4.2	1, 3, 4, 12, 20	18
4.3	3, 4, 6, 12	18
4.4	2, 4, (5), (6), (7)	
4.5	2, 3, (5), 7	14
4.6	1, 2, 6	
5.1	1, 3, 9, 31	5
5.2	1, 10, 17, 24, 38	13
5.4	7, 9, 17, (20)	11
5.5	1, 2, (3)	
5.6	5, (6), 8, 9, 13	17
5.7	2*, 5, 6	3
5.9	1, 13	
7.2	3, 4, 16, 21	12
7.3	5, 17, 22	21
7.4	1	
7.5	1, 4	
7.6	2*, 6, 11	8*
7.7	3, 4*	
7.9	1, 3, 7	4
7.10	2, 6	3

*See the supplemental notes for a modification or hint.

A problem in (parentheses) is recommended but not required.