Professor

Dr. Rebekah B. Johnson Yates
Office: Library 131
Email: rebekah.yates@houghton.edu
Office Hours: posted on webpage.
In person is the best way to contact me. Email is the next best way.

Webpage

All assignments and other course materials beyond the textbook will be posted on our class webpage. Annoncements will be posted there and/or communicated by email, so you should check your Houghton email at least once a day during the semester. If you miss class, it is your responsibility to determine what you have missed by checking the webpage and asking another student in the class.
https://facultysites.houghton.edu/rebekahyates/RealAnalysisI.htm

Location/Time

MWF 12–1:05 PM in Paine 212

Text (required)

Understanding Analysis by Stephen Abbott, 2nd edition, published by Springer

Catalog Description

"This course develops a rigorous foundation for the fundamental topics covered in calculus: continuity, differentiability, integrability, and convergence based on limits and the axioms of the real number system. Prerequisites: MATH 182, MATH 210, and MATH 261. Liberal Arts." 4 credits.

Course Objectives

In this course, students will

- extend their knowledge of the topics from calculus, emphasizing the theoretical ideas more than the computational skills.
- study new topics such as the theory of sequences, continuity theorems, uniformity, and basic point-set topology.
- begin to develop the ability to understand and construct analysis proofs.
- learn some of the historical development of analysis, including the individuals who have played a major role in this development.

Departmental Outcomes

This course addresses all of the Houghton College Math Department Learning Outcomes for mathematics majors.

- Effective Thinking and Communication: Students will develop effective mathematical thinking and communication skills.
- Liberal Arts: Students will explore and articulate ways in which mathematics is essential to a liberal arts education and informs and enriches a Christian life.
- Persistence: Students will experience open-ended inquiry and demonstrate persistence in solving problems.
- Independent Work: Students will develop the ability to solve a variety of mathematical problems independently.
- Collaborative Effort: Students will develop the ability to collaborate with others in solving mathematical problems.
- People and History: Students will be able to identify several significant mathematicians, some of their contributions, and how these contributions impacted mathematics, other disciplines and culture.
- Content Knowledge: Students will demonstrate understanding of core content in calculus, linear algebra, abstract algebra, and real analysis.

Institutional Outcomes

Though not explicitly assessed in this course, learning in this course addresses the following Houghton College Essential Learning Outcomes: Christian faith, critical thinking, logical & quantitative reasoning, and ethical reasoning.

Daily Work

Each class day (almost), you will have three parts of an assignment:

I. Reading and inquiring: due at the beginning of class. These assignments will be graded on completion with a good faith effort. We will discuss your work for parts (a)–(c), and you will turn it in occasionally, but you will keep your notes for yourself separately as we will not spend class time writing down definitions that are already in our readings. Assessment for this part will be included in the participation category.

   (a) Read and respond: read the assigned material, rereading as needed. Reading mathematics is an active process: have a writing utensil and paper ready to take your own notes and work through parts that seem unclear to you. Write your clear responses to the assigned reading/reflection questions.

   (b) Ask questions: Write down your own questions from the reading (e.g., new or old concepts you find confusing, connections to other ideas, examples you thought of, misconceptions that were clarified) and be ready to ask the questions in class. Note: many of your questions will come up as you are reading, so if you need to change the order of parts (a) and (b), feel free to do so—just label them clearly.

   (c) Quantify: record how much time you spent on Part I.

II. Exercises: For these introductory/warmup/review exercises, work individually and then consult with me and other class members outside of class time. You will present some of these to the class, and you will respond to your classmates' presentations with questions, comments, suggestions, and further ideas. As such, you need to complete or at least seriously attempt each of the exercises each class day so that you are prepared to engage in the class discussion around the exercises.

III. Problems: assigned (almost) each class day after we've discussed the relevant material in class. These problems will be due as hard copies at the beginning of class on Wednesdays (so any Part III problems assigned from the previous Wednesday, Friday, and Monday should be turned in together by the beginning of class on Wednesday). Each submission should be labeled with the corresponding Daily Work number. Multiple pages must be stapled in order.

   Note: while you are welcome to use textbooks as resources (but not to copy solutions from them), looking at solutions on the internet and using generative AI is not acceptable and will be reported to the Provost's Office as an academic integrity violation with the accompanying consequences.

   See Part III Guidelines on the next page for more details.

In-Class Participation

You are expected to attend class, be prepared for class, and actively participate in all class activities. At the end of the semester, you will submit a proposed participation grade with justification using the guidelines below. Note: I reserve the right to assign a different grade than you give yourself if I judge that you have graded yourself incorrectly.

- **To earn an A**, you should complete all assigned reading and exercises and be ready to present each day for all but at most 2 days, you should regularly comment usefully on others' presentations and ask questions that highlight key ideas, and you should contribute ideas and listen carefully to others during group work.
- **To earn a B**, you should complete all assigned reading and exercises and be ready to present each day for all but at most 5 days, you should regularly comment usefully on others' presentations and ask questions that move the class discussion forward, and you should contribute ideas and listen carefully to others during group work.
- **To earn a C**, you should complete all assigned reading and exercises and be ready to present each day for all but at most 7 days, you should listen carefully to and occasionally comment usefully on others' presentations and ask questions and offer insights during class discussions, and you should contribute some ideas and listen carefully to others during group work.
- There is no description for a **D or F** because these grades represent a fundamental breakdown of expectations. A D represents a meaningful but unsucessful attempt at earning a C or above. An F represents such a severe lack of engagement, effort, or understanding that there is no evidence of meaningful progress (credit to David Clark and Robert Talbert for this paragraph).

Quizzes

Quizzes will be announced at least one class period in advance. Quizzes will generally consist of stating definitions and results, giving examples or counterexamples, and standard problems/proofs. Quiz problems will be marked with E, M, R, or N as described in the Part III guidelines section, and problems that earn an R can be revised and resubmitted within one week of receiving the graded work. Each revised quiz problem must also include a reflection following the same guidelines as revisions for homework problems.

Celebrations of Learning

There will be one midterm and one final celebration of learning (some call them exams), both of which will have an in-class portion and a take-home portion. The date for the midterm exam will be announced in class. The in-class portion of the cumulative final exam will be given during our final period, **Wednesday, May 7, 10:30 AM–12:30 PM**. Celebration of Learning problems will also be marked with E, M, R, or N. Midterm problems that earn an R can be revised according to directions given at the time the graded work is returned.

Part III Guidelines

Some problems will be designated as "pair problems": you will work with another class member on these problems and submit one solution for your pair.

Other problems will be designated at "individual problems": Work on these on your own and then, as needed, consult with me and your classmates. After your consultations, write up your final solutions entirely by yourself without comparing them with other people's solutions. The solutions you hand in should be entirely your own and should include a sentence stating the names of your collaborators (those with whom you discussed the problem).

You will be required to type at least one solution per week for the first half of the semester and then at least two solutions per week for the second half using LaTeX.

The solutions you turn in should be final, polished versions. If you do not have a final, polished solution at the due date, write up what you can and turn it in so that you can earn an R and get feedback toward a revision. Not turning something in will result in an N and you will lose the option to revise that problem without a token. Each problem will receive feedback and one of the following marks:

- **E** xcellent: the solution/proof uses correct logic, applies appropriate proof techniques well, has excellent clarity, precision, reasoning, flow, organization, and notation.
- **M** eets Expectations: the solution/proof uses correct logic with perhaps one or two details unclear, applies appropriate proof techniques well, is easily understandable with reasonable clarity, precision, reasoning, flow, organization, and notation.
- **R** evise: the solution/proof makes a reasonable attempt to address the problem but has several holes, logical flaws, issues with precision, clarity, organization, or notation that require revision.
- **N** ot Assessable: there is no reasonable engagement with the problem or the solution is unreadable.

If you earn an R on a problem, you should revise that problem (and you are welcome to consult with me on your revision) and resubmit it on any Wednesday with your new Part III problems for an opportunity to change the grade to an E or M. Important limitation: you may resubmit a maximum of 3 Part III problems (individual problems, not assignments) per week. Resubmissions must also include a short reflection on what was incorrect the first time and how your understanding has changed with your revision in order to be eligible to receive an E or M; any resubmissions without a reflection will not be graded.

Late work: Assignments that are not submitted on time will earn an N and cannot be revised without using a token.

Tokens

You will begin the semester with two tokens that you can use to buy a 24-hour extension on a problem set or an additional problem revision. You can earn extra tokens by taking advantage of opportunities announced in class throughout the semester, such as attending a Math and Science Colloquium presentation on a math topic and then writing a few paragraphs about how the presentation changed your perspective on/enlarged your understanding of mathematics (*not* a summary of the presentation).

Assessment

Your grade will be based on daily work, quizzes, in-class work/participation, and celebrations of learning. Your final base course grade (without a plus or minus) will be assigned based on the following chart. To earn a particular base grade, you must meet the requirements in every category in that row.

Base Grade	Part III		Quizzes		In-Class CoLs		Take Home CoLs		Part. grade
	% E	% E/M	% E	% E/M	% E	% E/M	% E	% E/M	
A	30	90	50	90	20	85	30	90	A
B	20	80	25	80	15	70	15	80	B
C	0	70	0	70	0	55	0	70	C
D	0	60	0	60	0	40	0	60	D

- For your participation grade, you will submit a proposal at the end of the semester with your final Celebration of Learning suggesting what grade you should earn based on the guidelines detailed in the In Class Participation section on page 2 of this syllabus.
- The guidelines in the table above are the minimum requirements for earning that particular grade; exceeding requirements (e.g., earning an E on 90 % of your Part III problems) also meets the requirements for that grade. Note: I reserve the right to change the minimums, but I will never increase them; i.e., any change I make will only maintain or benefit the grade this chart and the notes below would assign.
- If you do not meet all the requirements for a D, you will earn an F for the course.
- **Plus/minus grades**: If you meet all the minimum requirements for a base grade *and* two of the HW/Quiz/CoL categories meet the minimum requirements for the next higher grade *and* your in-class participation has been consistently positive, you will earn a plus on your grade (unless you already have an A as Houghton does not give A+'s).

  If you meet all the minimum requirements for a base grade (e.g., B) except one, and that one is in the next lower category, you will earn a minus on your grade (e.g., B-).

  If you meet all the minimum requirements for a base grade *and* your in-class participation has been inconsistent or has negatively impacted the class environment on more than one occasion, you will earn a minus on your grade.

Technology in the Classroom

Other than using visualization tools as instructed, we will be practicing an electronic-device-free classroom in order to engage deeply with the material and each other. Please turn off your computers, cell phones, and smart watches and stow them in your bag upon entering the classroom and leave them there for the duration of the class unless instructed to use a device for visualization.

Attendance

If you are unable to come to class, please let me know as soon as possible. Since class time involves your active participation, missing class without a valid excuse will adversely affect your grade.

Academic Integrity

Honesty is the foundation on which all intellectual endeavors rest. To use the ideas of others without acknowledging the authors of those ideas belies the nature and purpose of academic life. At Houghton, where we strive to live out Christian calling and commitment, personal integrity, including academic honesty, should be the hallmark of all our work and relationships. Houghton's full Academic Integrity Policy, including procedures for addressing violations, can be found in the Academic Catalog: https://www.houghton.edu/undergraduate/majors/academics/catalog/
Any work or writing you turn in should be your own, and you are responsible for ensuring that you do not copy anyone else's work or writing (this includes not copying things from the internet or using generative AI). See III. Problems for further information about completing assignments.

Accommodations

If you have an academic or physical disability that requires accommodations please contact the Academic Support and Accessibility Services in the Center for Student Success located on the first floor of the Chamberlain Center (585–567–9622). With appropriate documentation, you will be afforded the necessary accommodations. For more information about Academic Support and Accessibility Services go to https://www.houghton.edu/undergraduate/student-life/student-success/.

Suggested Goals for Students

Adapted from Dr. Robert Brabenec's syllabus for Analysis I

- To grow in your abilities to ask questions and make conjectures.
- To review results from calculus and improve your problem-solving abilities.
- To gradually learn how to write careful proofs of analysis results.
- To understand the historical development of analysis and the contributions of individual mathematicians.
- To do enough exercises to understand the theory and to see that there are usually several effective approaches to a given problem.
- To gain an overview of the main themes in analysis in addition to a knowledge of the details.
- To gain skill in using precision in statements of concepts and results and in details of problems and proofs.
- To realize that it is okay not to understand everything in the course and to persevere in understanding as much as possible.
- To gain an awareness that mathematics (including analysis) is a part of God's creation and that it is a worthy field of study for a Christian.
- To gain experience in working with and explaining ideas to others.

Advice from Former Students

Wisdom from those who have taken Real Analysis from me:

- Be prepared to work hard. If you do not make a serious effort, you will not be able to keep up.
- Realize that it takes a while for the content to "sink in."
- Expect to get stuck and find help. The learning comes from the processing, not the succeeding.
- Do the reading before class! Keep on top of memorizing the theorems and definitions.
- Don't be discouraged if at first you don't do so well.
- Make sure you have a good foundation in proofs and don't get discouraged. Stay on top of the homeworks and ask questions. Write down everything you know and hope something gets you somewhere.
- Prove everything and assume nothing and eventually you'll figure out what you don't have to prove and can simply assume to be true.

Time Commitment

In accordance with the guidelines of 2–3 hours of work for each credit hour for a course, the well-prepared student should spend approximately 8–12 hours of work per week beyond the time spent in class. If you find that you are spending significantly more time than this, please let me know so that I can help you be more efficient or adjust the workload. If you are spending less time than this, you may not be investing enough time to learn well.

Tentative Schedule

This schedule is subject to modification throughout the semester.

Weeks 1–2	Introduction to Analysis and Chapter 1
Weeks 3–5	Chapter 2
Week 6	Chapter 2 and Chapter 3
Week 7	Chapter 3, Midterm Exam
Weeks 8–9	Chapter 4
Weeks 10–11	Chapter 5
Weeks 12–13	Chapter 7
Week 14	Chapter 8
Finals	**Final Celebration of Learning (in-class portion) Wednesday, May 7, 10:30 AM–12:30 PM**