Professor

Dr. Rebekah B. Johnson Yates
Office: Library 131 Email: rebekah.yates@houghton.edu
Office Hours: Tuesday 1–2 pm, Wednesday 1:30–2:25 pm, Thursday 2:15–3:15 pm
If you need to make an appointment to see me outside of office hours, please send me an email suggesting several times between 9 AM and 4 PM that will work for you.

In person is the best way to contact me. Email is the next best way.

Webpage

All assignments and other course materials will be posted on our class website `https://facultysites.houghton.edu/rebekahyates/Proofs.htm`. Announcements 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 website and asking another student in the class.

Location/Time

MWF 2:30–3:35 pm in Library 140; first half semester course

Materials

We will have some readings from various sources, primarily from *Mathematical Reasoning: Writing and Proof*, Version 3, by Ted Sundstrom, which is freely available at `https://scholarworks.gvsu.edu/books/24/`.
We will also use LaTeX, a free typesetting system for mathematics, throughout the semester. In addition, the text *Mathematics Through the Eyes of Faith*, edited by James Bradley and Russell Howell, is an excellent companion book to this class (recommended but not required).

Description

From the catalog: "Introduces the central idea of proof in mathematics and some standard proof formats used throughout the math major. Includes propositional logic, an introduction to predicate logic, direct proof, proof by contradiction and mathematical induction. Fulfills General Education Mathematics requirement. Liberal Arts. Prerequisite: MATH 181 (or MATH 170/171 or MATH 161)" 2 credit hours; required for a math major, a math or math/science concentration for a CESD major, and a computer science major.
Note: since this is a two-credit, half-semester course, you should expect to spend *at least 8–12 hours per week outside of class* studying and doing homework for this course.

Course Goals

This course provides a solid foundation for the main work of upper-level mathematics courses (i.e., proofs) as well as for upper-level computer science course topics. In this course, students will

1. learn several proof techniques including direct proof, proof by contrapositive, proof by contradiction, and induction.
2. learn to carefully write clear mathematical proofs.
3. learn foundational mathematical concepts from set theory, number theory, and functions that will arise in later mathematics and computer science courses.
4. develop skills in reading, writing, and speaking about mathematics, both formally and informally.

Department Goals

Course Goals 1 and 3 support the Mathematics Department Content Knowledge goal; Course Goals 1, 2, and 4 support the Mathematics Department Effective Thinking and Communication Goal; Course Goals 2 and 4 support the Mathematics Department Independence, Collaboration, and Persistence Goal; and Course Goal 4 supports the Mathematics Department Liberal Arts goal.

Essential Learning Outcomes

This course fulfills the General Education Mathematics core course requirement and contributes to students' progress on the following Essential Learning Outcomes at Houghton:

- 2: Practice scholarship informed by a Christian view of the world with integrity and respect for all.
- 4: Demonstrate intellectual and practical skills including critical reasoning, effective and creative communication, and quantitative thinking through application to progressively more challenging problems and projects.
- 6: Practice ethical decision-making, creative problem-solving, and teamwork for service and leadership in the home, workplace, church, and community.

Daily Work

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

I. Reading and responding: This is 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 book. 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/make observations: Write down your own questions from the reading and be ready to ask the questions in class. Examples of things you may have questions or observations about include new or old concepts that are confusing to you, connections to other ideas, examples you thought of, misconceptions that were clarified, etc. You should consider recording what you found to be explained well in the reading, what was interesting, what was confusing, and what required rereading but you eventually understood. 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: work individually and then consult with other class members and me outside of class time on these exercises, which will involve a variety of problems and proofs. 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 after we've discussed the relevant material in class; due on Fridays (problems assigned the previous Friday, Monday, and Wednesday) as hard copies at the beginning of class. Work on these on your own and then consult with other class members and with me as needed. Finally, write your solutions by yourself without comparing them with other people's solutions. The solutions you hand in should be entirely your own and must include your scrap work and rough drafts, clearly labeled. You should work toward typing the final versions using LaTeX; to that end, starting in the second week of class, you will be required to type at least one problem per week using LaTeX. These problems will be graded as Excellent (E), Meets Expectations (M), Revise (R), and Not Assessable (N). Problems that receive an R must be revised and resubmitted within two class periods of receiving the graded work. Problems not accompanied by scrap work and rough draft(s) will receive an N.

   Note: as the purpose of the course is to learn proof techniques, the results you will be proving in this class are generally well-known results that have been proven. For this reason, the only resources you are allowed to use in completing assignments are our course textbook and talking with your classmates, me, or one of the other professors. While I encourage you to discuss problems with others, you must write your own solution for a problem, so when writing your solution, you must not refer to anyone else's solution or notes, you should not be discussing the solution aloud at the same time as writing your own solution, and you must give credit to any collaborators by writing their name(s) in the margin next to your solution. You may not use AI in completing assignments other than for help with specific LaTeX coding questions.

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

Proof Portfolio

At the end of the course, you will submit a typed (in LaTeX) proof portfolio that will collect and improve examples of your work from the course, add some new work, and reflect on what you have learned. To compile this portfolio, you must keep all your written work from the course that has been returned to you and faithfully work to improve any areas that were deficient. More details are at the end of the syllabus.

In-Class Participation

Class periods will require your active involvement, both with the professor and with your fellow students. Come prepared to be engaged in your learning by presenting, interacting with others' presentations, listening, asking and answering questions, and staying on task during group activities. Choosing not to actively participate will adversely affect your understanding of the material, which will consequently adversely affect your grade.

Celebrations of Learning

Each Friday there will be a mini-Celebration of Learning (quiz) at the end of class. There will be a final Celebration of Learning on the last day of class, **Monday, October 12**, during our regular class time. The final celebration will include both proofs and exercises and will take the entire class time that day.

You may make a second attempt at one non-definition mini-Celebration of Learning problem per week by making an appointment with me at least 24 hours in advance to discuss what you missed on the first attempt and try a new problem.

Assessment

Your course grade will be based on Participation, Problems, mini-Celebrations of Learning, the final Celebration of Learning, and the Portfolio. Your final course grade will be assigned based on this chart and the guidelines below it:

Base Grade	Participation grade	Problems		mini-CoLs		Final CoL		Portfolio grade
		% E	% E/M	% E	% E/M	% E	% E/ M	
A	A	50	90	40	90	30	85	A
B	B	20	80	20	80	10	75	B
C	C	0	70	0	70	0	60	C
D	D	0	60	0	60	0	50	D

- To earn a particular base grade, you must meet the minimum requirements in the table above in every category in the corresponding base grade row. Exceeding requirements (e.g., earning an E on 60% of your mini-celebration of learning problems and an M on 30% still puts you in the A row) also meets the requirements for that base 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 in a row for a particular base grade *and* two categories meet the minimum requirements for the next higher grade, 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 row, 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, your final grade will be one letter grade lower than your base grade.
- For example, a student who earns an A for Participation, an E on 55% and an M on 35% of the Problems, an E on 25% and an M on 60% of the mini-Celebration problems, an E on 20% and an M on 60% of the final Celebration problems, and a B on the portfolio receives a base grade of B. Since the student's grade is in the A row for two categories, the student will earn a plus on their grade, so the student's final course grade will be a B+.

Tokens

You will begin the semester with two tokens that you can use to buy a one-class extension on a problem or an additional attempt at a mini-Celebration of Learning problem. You can earn extra tokens by taking advantage of opportunities announced in class throughout the course. Your first such opportunity is to find a typo in this syllabus on your own and tell me about it in person (not by email) sometime before class starts on Friday, August 28.

Technology in the Classroom

Other than on specifically announced occasions, we will be practicing an electronic-device-free classroom in order to engage deeply with the material and each other. Please turn off your cell phones, computers, and smart watches and store them in your bag upon entering the classroom and leave them there for the duration of the class.

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.

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/`.

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 AI). See III. Problems for further information about completing assignments.

Tentative Schedule This schedule is subject to modification throughout the course.

Week 1	Symbolic Logic
Week 2	Symbolic Logic and Proof Methods
Week 3	Proof Methods
Week 4	Set Theory
Week 5	Set Theory
Week 6	Functions and Relations
Week 7	Functions and Relations
Monday, October 12	**In-Class Final Celebration of Learning**

Further Information on Assessment

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 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 1 day, 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 3 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 5 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 unsuccessful 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).

Problems: The majority of problems will be proofs; what you turn in should be a final, polished proof, written after you've done scratch work and drafts on other paper, which you will turn in with your final version. If you do not have a final, polished proof 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 or only turning in a final version will result in an N and you will lose the option to revise that problem without using 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, the problem was late and unaccompanied by a token, or the scratch work and draft(s) are missing.

Celebrations of Learning Problems on mini-Celebrations of Learning will be assessed with the EMRN scale described above. You may make another attempt at up to one non-definition problem per week by making an apointment with me at least 24 hours in advance to discuss what went wrong the first time and try another problem like the one on which you earned an R or N. The final Celebration of Learning will occur on the last day of class, and, as such, there will be no revisions for that celebration.

Proof Portfolio Guidelines

Your proof portfolio is a place to showcase what you have learned during this course and reflect on your strengths and weaknesses. While the portfolio will help me assess both your achievements and your understanding of proof structures and logic, this is also a learning opportunity for you to consolidate what you have learned and continue to improve as you prepare for the final.

Your portfolio is a collection of **4–6 of your best written proofs** and short essays on the reflections assigned throughout the course. Your portfolio should meet the following requirements:

- **Types of Proofs:** Your proof portfolio should contain at least one direct proof, one proof by contrapositive or contradiction, and one proof by induction.
- **Content of Proofs:** Your proof portfolio should contain proofs that address three of the following four content areas:
  - integers (e.g. even/odd/divisibility),
  - set equalities and inclusions,
  - algebraic equations, and
  - other content (geometry, functions, etc).
- **Improvement Over Time:** One of your proofs should include with it previous iterations of the proof. Include at least two prior iterations, if possible. With this proof, you should write a paragraph or two that explains how each proof is an improvement on the previous ones and reflect on your overall growth that led to this improvement.
- **Independent Work:** At least one proof should be included that was not presented in class, worked on in class, or required to be written up. Some possible sources include extra problems from the textbook or a problem from a list distributed in class in early October.
- **Reflection Essays**
- **Participation Grade Proposal**: see above for guidelines
- Correctly typeset in **LaTeX**.

There are multiple ways to organize your proof portfolio and as long as the requirements above are met and the categories each proof meets are clear, you are welcome to choose an organization that works for you. You may earn extra credit by including a second independent proof or by choosing to include more challenging proofs. Your portfolio is due at the final Celebration of Learning.