Discrete Structures

CSCI 246

Instructor Info

Dr. Michael Wojnowicz (Mike)

Office Hrs: Mon & Wed 1-1:45p, Wed 3:15-4:45p

Barnard 352

https://mikewojnowicz.github.io/

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Course Info

Prereq: Calculus, although this is not used.

Class meetings: Mon, Wed, Fri 2:10-3p

Reid 401

TA Info

Fatima Ododo

Mon, Thurs 10-11am

Student Success Center (Barnard 259)

fatima.ododo@student.montana.edu

Tutor Info

Kelly Joyce

kelly.joyce1@student.montana.edu

Thurs 4-6pm

SmartyCats Center (2nd floor Renne)

Course description

Mathematical concepts used in computer science with an emphasis on mathematical reasoning and proof techniques. This course covers mathematical thinking (elementary logic, theorems, proof techniques), discrete collections (such as sets and lists), functions and relations, counting (including permutations and combinations), and miscellaneous topics (recursions, Big-O notation, graphs). Writing and understanding proofs will be an important part of this course.

Textbooks

Primary text

Scheinerman, E. R. (2013). *Mathematics: a discrete introduction.* Third edition.

Supplemental text

Hamkins, J. D. (2020). *Proof and the Art of Mathematics.* MIT Press.

Learning Outcomes

- To understand several central concepts from discrete mathematics that are used throughout computer science;
- To learn to reason mathematically and communicate ideas in a clear and concise manner;
- To use induction and other techniques of mathematical proofs.

Learning Philosophy

This course will use an “inquiry-based learning" approach. This means that classes will not be lecture-oriented. Instead, to quote Dr. Dana Ernst,

> *You will be expected to work actively to construct your own understanding of the topics at hand with the readily available help of me and your classmates. Many of the concepts you learn and problems you work on will be new to you and ask you to stretch your thinking. You will experience frustration and failure before you experience understanding. This is part of the normal learning process. If you are doing things well, you should be confused at different points in the semester.*

Active learning has been shown to increase student performance in STEM courses (e.g. see [1, 2]).

Class activity

A typical class meeting will be structured as follows:

Mon/Wed
- Reading quiz: 5 mins.
- Mini-lecture: 20 mins
- Group exercises: 20 mins

Fri
- Reading quiz: 5 mins
- Problems quiz: 10 mins
- Mini-lecture: 15 mins
- Group exercises: 15 mins

Group exercises

The group exercises are for collaborative problem-solving. Students will be split randomly into groups of three to work on problems using the whiteboards (or windows). Mathematics is not a spectator sport!

Daily readings

Before each class meeting, you will be assigned a reading from the textbook. The reading serves preparation for the group exercises. Before some classes, you will be given a short reader response questionnaire (with questions like, "what did you find confusing?") posted as a survey Brightspace. Each class meeting will begin with a 5-minute reading quiz.

Problems quiz

The problems quiz will be based on the problems given in-class.

FAQs

What are discrete structures?

A discrete structure refers to a mathematical system that is composed of distinct, separate elements, as opposed to continuous structures where elements can vary smoothly. Think of a digital clock vs. an analog clock (where second hand loops around continuously without stopping). Examples of discrete structures include sets with finitely many elements (e.g. the integers 1 to 10), lists, graphs, and logical statements.

What is discrete mathematics?

Discrete mathematics is the study of discrete structures and mathematical operations that can be performed upon them.

Why study discrete mathematics?

It is the mathematics underlying almost all of computer science. Here are a few examples: (1) designing high-speed networks and message routing paths, (2) finding good algorithms for sorting, (3) performing web searches, (4) analyzing algorithms for correctness and efficiency, (5) formalizing security requirements, and (6) designing cryptographic protocols.

Where is discrete mathematics used in the MSU computer science curriculum?

Discrete mathematics is used throughout the curriculum. Proofs in particular play a critical role in CSCI 338 (Computer Science Theory) and CSCI 432 (Advanced Algorithm Topics).

Grading

- Reading Quizzes (Daily): 25%
- Problems Quizzes (Weekly): 20%
- Project: 15%
- Participation: 15%
- Final: 25%

Grades will be assigned as follows:
A: 90-100, B+: 87-90, B: 80-87, C+: 77-80, C: 70-77, D+: 67-70, D: 60-67

Project

The purpose of the project is for students to focus on some aspect of discrete mathematics of particular interest. Students will work in small groups, choose some aspect of discrete mathematics (that was not covered in class), and develop a 5 minute presentation to give to the class. For example, a group might give an overview to public key cryptography, or explore how graph theory underlies web search. More information will be given as the time approaches.

Makeup policy

Quizzes and participation have no makeups. However, I drop 3 reading quizzes, 3 participation days, and 1 problems quiz with no consequence. Missed material beyond that (with a valid explanation) can be replaced with the final exam grade.

Final Exam

The final will be 2pm-3:50pm on Wednesday, May 7 in Reid 401.

Communication expectations

For non-personal questions related to course content, please use the Ask Your Instructor form on D2L, so that all students can benefit from the question and answer. For personal questions, please contact me by e-mail.

Diversity and Inclusivity Statement

I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability - and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. Your suggestions about how to improve the value of diversity in this course are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups.

Accommodations for Students with Disabilities

If you are a student with a disability and wish to use your approved accommodations for this course, contact me during my office hours to discuss. Please have your Accommodation Notification available for verification of accommodations. Accommodations are approved through the Office of Disability Services located in 137 Romney Hall. www.montana.edu/disabilityservices.

Student Conduct

You are expected to abide by MSU's Code of Student Conduct.

Class Schedule

MODULE 0: Course Overview

Wed	Jan 15	Course Overview	

MODULE 1: Introduction to mathematical thinking

Fri	Jan 17	Theorem	Sec 4
Mon	Jan 20	Holiday (Martin L. King Day)	
Wed	Jan 22	Proof	Sec 5
Fri	Jan 24	Counterexample	Sec 6
Mon	Jan 27	Boolean Algebra	Sec 7
Wed	Jan 29	Multiple Proofs	JDH CH 2
Fri	Jan 31	Induction	JDH CH 4.2, 4.3 (skip Thms. 26-28), 6.6, 6.7
Mon	Feb 3	Induction (continued)	JDH CH 4.5-4.6 (skip proof of Thm. 29)

MODULE 2: Discrete Collections

Wed	Feb 5	Lists	Sec 8
Fri	Feb 7	Factorial	Sec 9
Mon	Feb 10	Sets	Sec 10
Wed	Feb 12	Quantifiers	Sec 11
Fri	Feb 14	Operations on Sets	Sec 12
Mon	Feb 17	Holiday (President's Day)	

MODULE 3: Relations and functions

Wed	Feb 19	Intro to Relations and Functions	JDH CH 11.1-11.2
Fri	Feb 21	Intro to Relations and Functions (continued)	JDH CH 11.5
Mon	Feb 24	Relations	Sec 14
Wed	Feb 26	Equivalence Relations	Sec 15
Fri	Feb 28	Partitions	Sec 16 (Optional: JDH Ch. 11.3)
Mon	Mar 3	Functions	Sec 24 (Skip "Counting functions" and "Counting functions, again")

MODULE 4: Counting

Wed	Mar 5	Binomial Coefficients (Combinations)	Sec 17
Fri	Mar 7	Catch-up day	No reading

Mon	Mar 10	Inclusion-Exclusion	Sec 19

MODULE 5: Discrete probability

Wed	Mar 12	Intro to Probability (Part 1)	Sec 30
Fri	Mar 14	Review Day	No Reading
Week	Mar 17-21	Spring Break	
Mon	Mar 24	Intro to Probability (Part 2)	Sec 31
Wed	Mar 26	Conditional Probability /Independence	Sec 32
Fri	Mar 28	Random variables	Sec 33
Mon	Mar 31	Expectation	Sec 34

MODULE 6: Recurrence and computational complexity

Wed	Apr 2	Recurrence	Sec 23
Fri	Apr 4	Big O Notation	Handout to be posted on Brightspace
Mon	Apr 7	Application: Analysis of Algorithm Efficiency	Handout to be posted on Brightspace

MODULE 7: Graph theory

Wed	Apr 9	Fundamentals of Graph Theory	Sec 47
Fri	Apr 11	Subgraphs	Sec 48
Mon	Apr 14	Connection	Sec 49
Wed	Apr 16	Trees	Sec 50

MODULE 8: Group Presentations

Fri	Apr 18	Holiday (University Day / Mike's Birthday)	
Mon	Apr 21	Prepare Group Presentations	
Wed	Apr 23	Group Presentations	
Fri	Apr 25	Group Presentations	
Mon	Apr 28	Group Presentations	
Wed	Apr 30	Group Presentations	
Fri	May 2	Final Preparation	

Note: The class schedule is tentative; it is subject to change as the course progresses.

External Resources

For a list of external resources on discrete mathematics, click here. This list will be updated throughout the semester.

* References

[1] Louis Deslauriers, Ellen Schelew, and Carl Wieman. Improved learning in a large-enrollment physics class. *science*, 332(6031):862–864, 2011.

[2] Scott Freeman, Sarah L Eddy, Miles McDonough, Michelle K Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth. Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the national academy of sciences*, 111(23):8410–8415, 2014.