Discrete Structures

CSCI 246

Instructor Info

Dr. Michael Wojnowicz (Mike)

Office Hrs: Fri 12:30-3:30pm

Barnard 352

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Course Info

Prereq: Calculus, although this is not used.

Class meetings: Mon, Wed, Fri 4:10-5p

Reid 401

TA Info

Paul Cornish

Wed, Fri 3-4pm

Barnard 259

paul.cornish@montana.edu

Tutor Info

TBD

TBD

TBD

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.

Readings

Primary textbook

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

Supplemental readings

For certain topics, I will provide handouts, drawn from:

- Susanne Epp (2020). *Discrete Mathematics with Applications.*
- Lovász, Pelikán, and Vesztergombi (2003). *Discrete Mathematics: Elementary and Beyond.*
- Joel David Hamkins (2020). *Proof and the Art of Mathematics.*

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
- Mini-lecture: 20 mins
- Group exercises: 20 mins
- Discuss exercises: 10 mins

Fri
- Weekly quiz: 20 mins
- Mini-lecture: 15 mins
- Group exercises: 15 mins

Daily readings

Before each class meeting, you will be assigned a reading from the textbook. The reading serves preparation for the group exercises.

Group exercises

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

Weekly quiz

The Friday weekly quizzes will cover group exercises and the readings from the most recent three class meetings (i.e., Monday, Wednesday, and the previous Friday).

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

- Weekly Quizzes: 30%
- Project: 15%
- Participation: 10%
- Midterm: 20%
- Final: 25%

Grades will be assigned as follows:
A: 93-100, A-: 90-93, B+: 87-90, B: 83-87, B-: 80-83, C+: 77-80, C: 73-77, C-: 70-73, D+: 67-70, D: 63-67, D-: 60-63, F: 0-60.

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. There will also be a written component. More information will be given as the time approaches.

Makeup policy

Quizzes and participation have no makeups. However, I drop 4 participation days and 2 weekly quizzes with no consequence. Missed material beyond that (with a valid explanation and documentation) can be replaced with the final exam grade.

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	Aug 20	Course Overview	

MODULE 1: Fundamentals

Fri	Aug 22	Definition	Sec 3
Mon	Aug 25	Theorem	Sec 4
Wed	Aug 27	Proof	Sec 5
Fri	Aug 29	Counterexample	Sec 6
Mon	Sept 1	Holiday (Labor Day)	
Wed	Sept 3	Boolean Algebra	Sec 7
Fri	Sept 5	Multiple Proofs	Hamkins Ch. 2

MODULE 2: Discrete Collections

Mon	Sept 8	Lists	Sec 8
Wed	Sept 10	Factorial	Sec 9
Fri	Sept 12	Sets	Sec 10
Mon	Sept 15	Quantifiers	Sec 11
Wed	Sept 17	Operations on Sets	Sec 12

MODULE 3: Counting and relations

Fri	Sept 19	Relations	Sec 14
Mon	Sept 22	Equivalence Relations	Sec 15
Wed	Sept 24	Partitions	Sec 16
Fri	Sept 26	Binomial Coefficients (Combinations)	Sec 17

MIDTERM

Mon	Sept 29	Review for Midterm	
Wed	Oct 1	MIDTERM EXAM	

MODULE 4: More proof

Fri	Oct 3	Contradiction	Sec 20
Mon	Oct 6	Smallest counterexample	Sec 21
Wed	Oct 8	Induction	Sec 22
Fri	Oct 10	Recurrence	Sec 23

MODULE 5: Functions and Big O notation

Mon	Oct 13	Functions	Sec 24
Wed	Oct 15	Real-valued functions	Epp Sec 11.1
Fri	Oct 17	Big O Notation	Epp Sec 11.2
Mon	Oct 20	Application: Analysis of Algorithm Efficiency	Epp Sec 11.3

MODULE 6: Discrete probability

Wed	Oct 22	Intro to Probability (Part 1)	Sec 30
Fri	Oct 24	Intro to Probability (Part 2)	Sec 31
Mon	Oct 27	Conditional Probability /Independence	Sec 32
Wed	Oct 29	Random variables	Sec 33
Fri	Oct 31	Expectation	Sec 34

MODULE 7: Graph theory

Mon	Nov 3	Degrees	Lovász Sec 7.1
Wed	Nov 5	Paths and Walks	Lovász Secs 7.2-7.3
Fri	Nov 7	Trees	Lovász Secs 8.1-8.3
Mon	Nov 10	Trees	Lovász Secs 8.4-8.5
Wed	Nov 12	Finding the best tree	Lovász Sec 9.1

MODULE 8: Group Presentations

Fri	Nov 14	Prepare Group Presentations	
Mon	Nov 17	Group Presentations	
Wed	Nov 19	Group Presentations	
Fri	Nov 21	Group Presentations	
		Fall Break	
Mon	Dec 1	Group Presentations	
Wed	Dec 3	Catchup Day	

FINAL

Fri	Dec 5	Final Preparation	
Wed	Dec 10	Final (4:00 - 5:50pm)	

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.