Topological Data Analysis
M417 Section 01 (37346)
Spring 2025

Time: **12:30pm-1:45pm TR**	Room: **SEB 308**

Course Description: This course will focus on understanding some current research on geometry and topology pertaining to applications. Students will learn how to bring together the fundamentals of algebraic topology, computational geometry and data analysis to understand ways to visualize and process data. We plan to discuss around some of the following topics:

1. Introduction to metric spaces and some topological ideas
2. Triangulations and Simplicial Complexes
3. Simplicial Complexes on data sets
4. Topics from the following list:
   i) Euler Characteristic and Applications
   ii) Voronoi Diagrams, Delaunay Triangulations and applications
   iii) Persistent Homology and Applications to Data Analysis
   iv) Kernel Methods
   v) Discrete Morse Theory

Prerequisites: Permission from instructor

Co-requisites: There are no co-requisites

Learning Outcomes:

- Familiarity with metric spaces and some topological ideas
- Familiarity with basic algorithms for calculating clustering, Betti numbers, homology cycles, topological persistence, persistence barcodes
- Ability to use available software related to the topics discussed in class.
- Understanding applications in data analysis and machine learning
- Special topics - based on interest

Course Page: tda.mathematics.land

Textbooks: Suggested references will be given out in class

Instructor: Atish J Mitra (email: amitra@mtech.edu)

Office Hours (MUS 203): 11:00am-12:00pm TR, or by appointment. Please send me an email if you need to meet at any other specific time.

Attendance Policy: Regular attendance is strongly recommended.

Grading Policy: There will be multiple homework sets to be turned in (25% total), one in-class exam (20%), take-home exams (25% total) and a project (30%). I do not grade on a curve, and do not assign individual extra credit assignments. Your grades will be independent of how the rest of the class performs.

Grading Scale:

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

Academic integrity:

A zero-tolerance policy will be enforced for academic dishonesty / cheating. Academic dishonesty / cheating includes plagiarism on homework or other assignments (including copying solutions from the internet), copying from or deliberately aiding another student during quizzes / exams, using unauthorized books, notes, calculators or other computing devices, using cell phones, pagers, Apple/Android watches or any other communicating devices during quizzes / exams.

Any student who is found to have cheated on a homework / quiz / exam will receive a penalty (at the discretion of the instructor) ranging from a 0 in that particular homework / quiz / exam to a grade of F in the course. Moreover, the incident of academic dishonesty will be reported to the office of the Provost/Vice Chancellor for Academic Affairs.

You should carefully read Montana Tech's academic dishonesty policies. It is available in the student handbook, which can be found following the link:
https://www.mtech.edu/student_life/student-handbook.pdf

The instructor reserves the right to assign seating arrangements or change a student's current seating arrangement before or during any quiz or exam.

Policy on Generative AI:

While you are encouraged to experiment with Generative AI, be aware that you are not allowed to use such resources for homework and take-home exams for this class. The reason for this policy for our class is that the use of generative AI for mathematics problems often produce incorrect solutions or solutions with incorrect reasoning, and therefore does not help in learning the material.

Miscellaneous Policies:

1. Check Canvas for announcements and other notes regularly. Canvas will be used in this course only to record your scores on quizzes or exams, and not to calculate the course grade. Course grade will be calculated at the end of the semester as per "grading policy" given above.

2. Please do not hold conversations, either with your classmates or through your cell phones, during the lecture. Cell phones/pagers must be put on silent at all times. No texting during class.

3. All unauthorized recordings of class are prohibited. Recordings that accommodate individual student needs must be approved in advance and may be used for personal use during the semester only.

4. It is your responsibility to check all your grades on Canvas before the final exam date and report me in writing if your grades are recorded incorrectly. You should keep all your graded exams/quizzes/classwork/homework until you receive your final course grade.

5. **Special Accommodations**: If you qualify for special accommodations and would like to avail of it, please send me an email to set up an appointment ASAP. When you come for your appointment, please have a letter from your Tech Counselor available.

6. **Emergency Evacuation Procedure:** See university webpage and emails.

Tentative Daily Schedule			
Day	**Date**	**Remark**	**Topic**
1	14-Jan		Introduction to TDA; Basics of Topology
2	16-Jan		Basics of Topology - homeomorphism and homotopy eqv
3	21-Jan		Basics of Topology - EDM (snippet)
4	23-Jan		Basics of Topology - cntd
5	28-Jan		Basics of Topology - EDM (snippet)
6	30-Jan	Last Drop Date 3rd Feb	Planar Triangulations: Voronoi-Delaunay (snippet)
7	4-Feb		Planar Triangulations - "good meshes"
8	6-Feb		Planar Triangulations
9	11-Feb		Planar Triangulations
10	13-Feb		Simplicial Complexes - basics
11	18-Feb		Simplicial Complexes on data (VR,Cech,Alpha) - snippet
12	20-Feb		Simplicial Complexes - storage as data structures on a computer
13	25-Feb		Simplicial Complexes -geometric realization
14	27-Feb		Simplicial Complexes
15	4-Mar		Topology of Offsets - Nerve Lemma
16	6-Mar	STDC	In Class Exam
17	11-Mar	STDC	(Zoom) Simplicial Homology - Z_2
18	13-Mar		Simplicial Homology - computations
	18-Mar	Spring Break	
	20-Mar	Spring Break	
19	25-Mar		Simplicial Homology - data structures and algorithms -snippet
20	27-Mar		Simplicial Homology
21	1-Apr		Topological Persistence - Persistent Homology
22	3-Apr		Topological Persistence - Persistent Homology - algos
23	8-Apr		Topological Persistence - Persistent Homology -PDs, barcodes
24	10-Apr		Topological Persistence - Persistent Homology -kernels
25	15-Apr		Topological Persistence - Persistent Homology
26	17-Apr		Special Topics
27	22-Apr		Special Topics
28	24-Apr		Special Topics
29	29-Apr		Special Topics