NC STATE UNIVERSITY

Math 493/591 Topics in Topology and Geometry and their Applications

TuTh • 1:30 PM - 2:45 PM • 1218 SAS Halll

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Office Hour: TBA (subject to change) or by appointment.

Description 1 What is the shape of the universe: is it curved or flat? How can we extract information from high-dimensional data? Which combinations of copy number aberrations of genes cause cancers? Answers to all of these questions hinge on the notion of shape, which is the central notion of the mathematical fields of Geometry and Topology. In order to get the answers we will build a set of mathematical tools and understand ideas from these areas such as curvature, homology, and category theory. We will encounter such objects as braids, simplicial complexes, and knots. The final list of topics will partially depend on students' interests.
Description 2 Topology aims at studying intrinsic structures of a given object or space. It captures properties of an input object that cannot be removed without tearing the object apart. It is a powerful tool for describing essential features of shapes. On the other hand, geometry is the quantitative study of shape using lengths and angles. Recently, there has been a new trend in developing computational topological and geometric methods for data analysis. Such methods have been incorporated with statistics and machine learning tools and successfully applied in a broad range of fields including computer graphics (e.g, feature identification), visualization (e.g, contour trees), sensor networks (e.g, hole detection), machine learning (e.g, clustering), and computational biology (e.g. breast cancer genomics, lung topology) .

Topics: Tentative list includes but is not limited to point-set topology, manifolds, complexes, topological invariants, CAT(0) spaces, homology, knots and knot invariants, DNA, knots in optical fields, applied topology tools for sensor network coverage, category theory.

Course materials: There is no book that is exactly fits the structure of this class. I will provide detailed lecture notes for most classes. Some of the course topics can be found in:

- Computational Topology: An Introduction, by H. Edelsbrunner and J. Harer, AMS Press, 2009. Some Online course notes by Herbert Edelsbrunner on computational topology is available at `https://www2.cs.duke.edu/courses/fall06/cps296.1/`
- *Knots, Molecules, and the Universe: An Introduction to Topology* by Erica Flapan, AMS, Print ISBN: 978-1-4704-2535-7. Description available at *AMS Website*.
- *Elementary Applied Topology* by Rob Ghrist, ISBN 978-1502880857, Sept. 2014. Chapters available on the *author's website*.

- Algebraic topology: Algebraic Topology, by A. Hatcher, Cambridge University Press, 2002. Online version is available at `http://www.math.cornell.edu/~hatcher/AT/ATpage.html`.

Learning Outcomes At the conclusion of this course, students should be able to communicate mathematical ideas, informally and in definition-proof form, both orally and in writing; be fluent in basic notions in topology and geometry, as well as their recent applications.

Structure: To make learning fun, personalized and beneficial, in addition to hand-in and online homework, you students have a chance to practice writing about mathematics informally, and discussing broader issues inspired by specific problems on our class blog and writing a final project on the topic of your choice (I will provide a list of topics but I am open to your suggestions).
Final paper should be typed, preferably in LaTex, and submitted electronically via email. To reduce the LaTeX start-up cost you can type up your solutions directly in the template provided in Moodle or Overleaf which allows you to use LaTeX online. Here is a list of additional LaTex resources:

- LaTex guides: Getting Started with LaTeX, Dana C. Ernst guide
- Comprehensive LATEX Symbol List

Short and final presentation can be typed-up (PPT, PPTX, Beamer, Prezi, or any software of your choice) or presented on the board. Short presentations will be 3 minutes long, and the final presentations between 20-30 minutes so they should be practiced and carefully timed.

Due dates may be extended for special circumstances. Be sure to request these, if needed, before the due date or asap.

Grading:

Task 00: Posting on the blog, filling in a google form with basic information about your interests and a doodle poll about optimal time for office hour 2%
Homework: Up to 8 hand-in and 8 online sets for a total of 16% + 16%= 32%
Blog: Posting and commenting on the class *blog* 8%
Mid-semester evaluation: Filling in class evaluation 2%
Final Project: Total: 56%

- First draft: 10%
- Short presentation 10%
- Final Paper 20%
- Final Presentation 16%

Modifications to This Document: This document may be modified as needed throughout the course. Changes will be announced.

Accommodations for Disabilities: Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, student must register with the Disability Services Office `http://www.ncsu.edu/dso`, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation at `http://policies.ncsu.edu/regulation/reg-02-20-01`.

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Code of Academic Integrity: Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at `http://policies.ncsu.edu/policy/pol-11-35-01`.

Class Evaluations: Online class evaluations will be available for students to complete during the last two weeks of class. Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will never know how any one student responded to any question, and students will never know the ratings for any particular instructors. In addition, the professor will administer a mid-semester evaluation via google form.