UNIVERSITY OF DELAWARE	**Math 567: Topology and Its Applications**
	Credits: 3**, Section(s):** 101
	Semester: Fall**, Year:** 2017
	Meeting Days, Times, Location and Room: MWF 12:20-1:10, 203 Ewing Hall

1. Instructor Information

Instructor name	Prof. Chad Giusti
E-mail address	cgiusti@udel.edu (e-mail hours: 9AM - 6PM M-F)
Website	http://www.chadgiusti.com/math567.html
Office location	532 Ewing Hall
Office hours	2:30-4 M, 1-2 Tu, 3:45-4:15 W or by appointment
Phone number	(302) 831-0592

2. Course Description

Pre-requisites

Proficiency with linear algebra, writing basic proofs and code; formally, a course in linear algebra such as MATH 349 or MATH 351, a course in computer programming such as CISC 106 or 108, or permission of instructor. No prior exposure to topology will be assumed.

Description

This course is an introduction to the modern discipline of applied topology. **Topology** is a young branch of mathematics, which was created in the early 20th century to **study qualitative properties of objects** for which quantitative analysis is intractable or unreliable**.** This unique perspective makes it ideally suited for modern scientific and engineering applications, where the **systems are complex and interrelated**, and the **data are high-dimensional, noisy and undersampled**.

We will not follow the traditional exposition of these topics, which lingers to discuss some very beautiful mathematical questions about the nature of shape in great deal. Rather, we will encounter these ideas in their role as building blocks for a complex and fantastically powerful piece of mathematical machinery called persistent homology, a tool which is still being actively studied by mathematicians even as we deploy it to find new answers in fields as diverse as biochemistry, signals processing, robotics, and neuroscience.

Because the course does not presume any familiarity with topological methods, the first half of the semester will be focused on developing the fundamental notions and techniques of topology and homological algebra, and will lean toward questions that feel more like pure mathematics. We will, however, always keep in mind the goal of applying these tools, and will pause whenever we have built a sufficient amount of machinery to try something new. Once we have persistent homology firmly in hand, we will spend a great deal more time discussing how to use the tools and interpret what they tell us in terms of real systems -- though every new idea will, of course, require us to develop new mathematics.

3. Learning Outcomes

By the end of the semester, students will be able to:

1. prove fundamental results in topology and homological algebra,
2. compute, by hand and with computer assistance, topological invariants of complexes,
3. select and construct appropriate topological objects to encode data, and,
4. interpret what topological invariants say about those data to answer questions of scientific or engineering interest.

4. Learning Resources

Due to the very recent and ongoing development of the field of applied topology, there are no textbooks that cover the material for this course. I have selected a pair of optional reference texts that cover many of the mathematical and conceptual pieces of the course in some combination, though neither is well-suited as a primary text:

- *Combinatorial Algebraic Topology,* by Dmitry Kozlov
  ISBN: 978-3-540-71961-8 (Print) 978-3-540-71962-5 (Online)
  This is a Springer book, and thus available electronically through the UD Library
- *Elementary Applied Topology*, by Robert Ghrist
  ISBN 978-1-502-88085-7
  This book is through Amazon or electronically for free at Prof. Ghrist's web page:
  https://www.math.upenn.edu/~ghrist/notes.html

Instead, the primary resource will be the course web page:

http://www.chadgiusti.com/math567.html

The page contains all course documents and a schedule (topics may move around or change as the course progresses, but exam dates are fixed). Throughout the term, I will post my notes, homework, links to software tools and resources for those tools, and other information to the web page.

Provided code and sample computations will be written in Julia (http://julialang.org/). There are several tools we may use that are written in other languages, and I will provide installation assistance and Julia wrappers for these tools. You may use any programming language you like for the computational exercises in this course, but code to be handed-in must either be in Julia or the language you choose must be pre-approved by the instructor.

5. Course Assessment

Final Grade Breakdown

The final course grade will be calculated using the following categories:

Course Component	**Percentage of Total**
Weekly Homework	30%
Midterm Exams (2)	20% each
Final Project	30%

Weekly Homework

Homework exercises will be posted to the web page on Friday after class every week and due Friday of the following week. Deliverables must be handed in by the beginning of the lecture on Friday and cannot be submitted electronically unless explicitly specified. Assignments will consist of both mathematical and computational exercises. In the former case, nearly hand-written or typed responses are acceptable. In the latter, any images or code snippets must be printed, but other supporting text can be neatly written or typed as desired. You may use any programming language you like for the computational exercises in this course, but code to be handed-in must either be in Julia or the language you choose must be pre-approved by the instructor.

Midterm Exams

There will be two 50 minute in-class midterm exams on Mondays Oct. 9 and Nov. 6. Exams will cover material up through the preceding week's Wednesday class. The exams will assess your understanding of the mathematical and conceptual underpinnings of the course, and will include statements of fundamental definitions, short proofs and tractable computations. No written materials or technology will be accessible during the exam -- just bring yourself and at least two sharp pencils.

Final Project

In lieu of a final exam, there will be a final project for the course. Working in pairs, students will choose either a) to use the techniques of applied topology to analyze a data set of their choice, or b) to learn about a technique from applied or algebraic topology not covered in the course. The deliverable will be a short (4-5 page) write up of the work done and a poster presentation of the results to the class during the scheduled two hour final exam period. Specific details will be provided in mid-October.

Grading Scale

Students will be assigned the following letter grade, based on the calculation coming from the course assessment section.

Grade	Interval		Grade	Interval
A	94.50 and over		D+	66.50 to 69.49
A-	89.50 to 94.49		D	62.50 to 66.49
B+	86.50 to 89.49		D-	59.50 to 62.49
B	82.50 to 86.49		F	Below 59.49
B-	79.50 to 82.49			
C+	76.50 to 79.49			
C	72.50 to 76.49			
C-	69.50 to 72.49			

Course Policy Document

Attendance

The Faculty Handbook contains the following language regarding excused absences:

“Absences on religious holidays listed in University calendars is recognized as an excused absence. Nevertheless, students are urged to remind the instructor of their intention to be absent on a particular upcoming holiday. Absences on religious holidays not listed in University calendars, as well as absences due to athletic participation or other extracurricular activities in which students are official representatives of the University, shall be recognized as excused absences when the student informs the instructor in writing during the first two weeks of the semester of these planned absences for the semester. “

This course has no formal attendance requirement. However, it is unlikely that students who fail to attend the scheduled lectures will succeed with the course assignments, and I will not provide a review of material that is missed due to unexcused absences. I am always happy to work with you in the case of excused absences.

Late Homework

Homework will only be accepted on Fridays in class, even when late. Each student has two weeks of ”homework grace period” to be used at their discretion. Thus, you may choose to hand in two homework assignments one week late, or one assignment two weeks late, with no expected explanation and at no change in grade. Once these grace weeks are used, no further late homework will be accepted. Homework which is late due to an excused absence will always be accepted without penalty and does not count toward grace weeks. However, except in the case of emergencies, I deeply appreciate being informed that that the homework will be late before the official due date.

Make-up Exams

In the case of an excused absence on the date of an exam, I will work with you to schedule a make-up exam as soon as possible after the exam date. Except in the case of an emergency, such arrangements must be made before the official exam date. At my discretion, a make-up exam may contain different questions than the exam given to the rest of the class, though all reasonable attempts to make the difficulty equitable will be made. The make-up may be proctored by department staff in order to facilitate scheduling conflicts.

Communication

Primary out-of-class contact will occur through office hours (532 Ewing, 2:30-4 MWF, or by appointment) and by e-mail (cgiusti@udel.edu). I will be available to answer e-mail between 9 AM and 6 PM Monday through Friday, and will usually respond to an e-mail within 24 hours of receiving it. While I may respond to e-mail outside of these hours, this should not be expected; my dog gets grumpy when I answer e-mail in the evenings or weekends.

Academic Integrity

Please familiarize yourself with UD policies regarding academic dishonesty. To falsify the results of one's research, to steal the words or ideas of another, to cheat on an assignment, to re-submit the same assignment for different classes, or to allow or assist another to commit these acts corrupts the educational process. Students are expected to do their own work and neither give nor receive unauthorized assistance. Complete details of the university's academic integrity policies and procedures can be found at http://www1.udel.edu/studentconduct/policyref.html Office of Student Conduct, 218 Hullihen Hall, (302) 831-2117. E-mail: student-conduct@udel.edu

Harassment and Discrimination

The University of Delaware works to promote an academic and work environment that is free from all forms of discrimination, including harassment. As a member of the community, your rights, resource and responsibilities are reflected in the non-discrimination and sexual misconduct policies. Please familiarize yourself with these policies at

www.udel.edu/oei. You can report any concerns to the University's Office of Equity & Inclusion, at 305 Hullihen Hall, (302) 831-8063 or you can report anonymously through UD Police (302) 831-2222 or the EthicsPoint Compliance Hotline at www1.udel.edu/compliance. You can also report any violation of UD policy on harassment, discrimination, or abuse of any person at this site: http://sites.udel.edu/sexualmisconduct/how-to-report/.

Faculty Statement on Disclosures of Instances of Sexual Misconduct

If, at any time during this course, I happen to be made aware that a student may have been the victim of sexual misconduct (including sexual harassment, sexual violence, domestic/dating violence, or stalking), I am obligated to inform the university's Title IX Coordinator. The university needs to know information about such incidents in order to offer resources to victims and to ensure a safe campus environment for everyone. The Title IX Coordinator will decide if the incident should be examined further. If such a situation is disclosed to me in class, in a paper assignment, or in office hours, I promise to protect your privacy--I will not disclose the incident to anyone but the Title IX Coordinator. For more information on Sexual Misconduct policies, where to get help, and how to reporting information, please refer to www.udel.edu/sexualmisconduct. At UD, we provide 24-hour crisis assistance and victim advocacy and counseling. Contact 302-831-1001, UD Helpline 24/7/365, to get in touch with a sexual offense support advocate.

For information on various places you can turn for help, click here. For more information on Sexual Misconduct policies, where to get help, and reporting information please refer to www.udel.edu/sexualmisconduct.

Inclusion of Diverse Learning Needs

Any student who thinks he/she may need an accommodation based on a disability should contact the Office of Disability Support Services (DSS) office as soon as possible. The DSS office is located at 240 Academy Street, Alison Hall Suite 130, Phone: 302-831-4643, fax: 302-831-3261, DSS Website (http://www.udel.edu/DSS/www.udel.edu/DSS). You may contact DSS at dssoffice@udel.edu

Non-Discrimination

The University of Delaware does not discriminate against any person on the basis of race, color, national origin, sex, gender identity or expression, sexual orientation, genetic information, marital status, disability, religion, age, veteran status or any other characteristic protected by applicable law in its employment, educational programs and activities, admissions policies, and scholarship and loan programs as required by Title IX of the Educational Amendments of 1972, the Americans with Disabilities Act of 1990, Section 504 of the Rehabilitation Act of 1973, Title VII of the Civil Rights Act of 1964, and other applicable statutes and University policies. The University of Delaware also prohibits unlawful harassment including sexual harassment and sexual violence.

For inquiries or complaints related to non-discrimination policies, please contact:
Director, Institutional Equity & Title IX Coordinator- Susan L. Groff, Ed.D. groff@udel.edu, 305 Hullihen Hall Newark, DE 19716 (302) 831-8063

For complaints related to Section 504 of the Rehabilitation Act of 1973 and/or the Americans with Disabilities Act, please contact: Director, Office of Disability Support Services, Anne L. Jannarone, M.Ed., Ed.S. - ajannaro@udel.edu
Alison Hall, Suite 130, Newark, DE 19716 (302) 831-4643 OR contact the U.S. Department of Education - Office for Civil Rights (https://wdcrobcolp01.ed.gov/CFAPPS/OCR/contactus.cfm)