MATH 363 – Topics in Topology

Spring 2017
MWF 9:00 - 9:50 AM, Swords 330

Syllabus (1/25/17)

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Office Hours: Monday 11 AM - Noon, Tuesday 1-2 PM, Wednesday 1-2 PM, Thursday 11 AM - 1 PM, and by appointment.

Course Home Page: `http://math.holycross.edu/~dbd/math363/math363.html`

Course Materials: Textbook: *Essential Topology*, by Martin D. Crossley.
Publisher: Springer; 2010. Corrected Printing
ISBN (Paperback): 978-1-85233-782-7 (Paperback)
(Available on-line through Amazon.com. Used copies will be fine.)

Prerequisites: MATH 242 and Math 244 or permission of the instructor.

Intended Audience: This course is designed for upper division mathematics majors or non-majors with knowledge of mathematics through the department's intermediate level courses. This course fulfills the department's Geometry/Topology breadth area requirement and carries the Project Course Designation.

Introduction to Topology: Topology is a large area of mathematics that has interesting and important connections to all areas of mathematics and many sciences. As a reference point, geometry is the study of curves and surfaces in space and their analogs in higher dimensions. Two such objects are considered equivalent if one can be transformed into the other in such a way that distances between points on the object are preserved. That is, we think of objects as being rigid. For example, geometrically a circle and ellipse are not equivalent. By comparison, in topology, two objects are considered equivalent if one can be continuously deformed into the other. Consequently, we think of objects as being flexible rather than rigid. For example, topologically a circle and ellipse are equivalent. There are similar examples involving higher dimensional objects–topology can't tell the difference between a football and a basketball, but it "knows" the two are hollow.

Historically topology has been thought of as one of the more theoretical subjects within mathematics and applications have been to other areas of mathematics. The lone exception to this is applications to theoretical physics, which is the most mathematical area within physics. However, in the past 20 years, topological methods have been used in a variety of applications involving data and networks that have been made possible by the development of efficient algorithms. This area of topology is called Topological Data Analysis (TDA) or Computational Topology (CT). The goal of this course will be to cover the standard material needed to develop and apply the basic ideas of TDA. The group projects at the end of the course will all involve TDA. This will necessarily involve learning to use MATLAB and TDA software.

Topics Covered: The text, *Essential Topology*, follows a standard order of topics and builds on concepts from Principles of Analysis. We will cover roughly half the material in the book, which will set the the stage for material that we will need for the end-of-semester projects. Here is the order of topics:

- Metric spaces (not from the text)
- Section 2.3: Open Sets
- Chapter 3: Topological Spaces
- Chapter 4: Topological Properties
- Chapter 5: Deconstructionist Topology
- Sections 6.1: Homotopy and 6.2: Homotopy Equivalence
- Chapter 7: The Euler Number
- Chapter 9: Simplicial Homology
- Topological Data Analysis (TDA): Filtrations and Persistent Homology (not from the text)
- Applications of TDA and projects (not from the text)

Class Format: In addition to lectures, there will be four or five group assignments during the semester. We will devote one class to each of these. Starting after the hour exam we will meet in Swords 219 on occasion to learn how to use Matlab, a widely used mathematical software designed for sophisticated analysis of data, and JavaPlex, a computational topology software package callable from Matlab. Computer assignments will be completed in teams.

Homework: There will be weekly homework and/or group assignments, mostly due on Fridays. Some of the group assignments will involve use of Matlab and JavaPlex. You will have at least a week to complete each assignment.

Exams: There will be one exam covering Chapters 3, 4 and 5. This will focus on definitions, statements of theorems, and short proofs. This is tentatively scheduled for the evening of **Wednesday, March 15** at a time to TBA. There is no final exam for the course.

The Project: In lieu of a final exam there will be a final group project in teams of three students. I will provide a short list of suggested topics. Here is a tentative schedule of project deadlines. After spring break we will set firm dates:

- Choose project teams: Monday, March 20.
- Meet as a group in office hours to discuss possible project topics. Monday, March 20, to Thursday, March 23.
- Submit project topics along with a half page description or abstract. Monday, March 27.
- Submit a detailed project description, Monday, April 3.
- Brief in-class progress report, Monday, April 10.
- Project updates in office hours. Monday, April 17.

- Draft presentations submitted for review, by Friday, April 28.
- Project presentations in-class, Wednesday, May 3 through Tuesday, May 9. The presentations will be 35 to 40 minutes in length. We will schedule one per class and three on the first day of reading period (since there is no final). These should be in PowerPoint or Beamer (to be explained).
- Due date for project write-up, Friday, May 12. The write-ups will include an explanation of your application of TDA, an explanation of how you used TDA, a description of any code that you write on your own, and your results and conclusions. Appendices (possibly submitted electronically) will contain any scripts that you write, your data, and the output that supports your results.

Grading: There are several components to the course grade.

Homework	35%
Collaborative Assignments	15%
Midterm Exam	20%
Final Project	30%
Total	100%

Academic Honesty: The Department of Mathematics and Computer Science adheres to the College's policy on Academic Honesty, which may be found in the College Catalogue. In addition, the department has formulated the attached statement intended to amplify the policy as to how it might apply in mathematics and computer science.