Stanford Math Directed Reading Program Colloquium
Spring 2017, Session 1

Tuesday, June 6, 2017, 5:00pm–6:40pm
Sloan Mathematics Center, rooms 384-H and 384-I (fourth floor)
Dinner available on fourth floor at 4:45pm

Session A, room 384-H

Computation of de Rham cohomology using the Mayer-Vietoris theorem

5:00pm

Lingxiao Li

Mentor: Ben Dozier

De Rham cohomology — the knowledge of which closed forms on a smooth manifold are exact — has deep consequences not only related to the differentiable structure of manifolds, but also to their topological properties. In this talk I will begin by defining de Rham cohomology groups and state their basic properties, in particular their topological invariance. Next I will state the Mayer-Vietoris theorem, a useful tool to compute cohomology of a manifold given that the cohomology of some constituents. Then I will compute the cohomology of spheres and punctured Euclidean space, and use these results to prove the topological invariance of dimension.

Fourier convergence and the Hilbert transform

5:20pm

Dylan Cable

Mentor: Joey Zou

A classical problem in Fourier analysis is to show the convergence of partial Fourier sums. This problem reduces to showing that the partial sum operator is bounded. Fortunately, we can express the partial sum operator in terms of a very nice operator called the Hilbert transform. We will show the Hilbert transform is bounded in L^p using a technique called the Calderon-Zygmund decomposition.

Graph isomorphisms: Furst-Hopcroft-Luks algorithm for group order

5:40pm

Nancy Xu

Mentor: Zeb Brady

Groups and their derivative properties arise naturally in models of the world — bridging intuition for graph symmetries and other mathematical structures. This presentation will explore the question of how we can derive the order of a group given a set of its generators. We show an algorithmic result by Furst-Hopcroft-Luks for finding the order of a symmetric group subgroup in polynomial time.

Introducing Morse theory

6:00pm

Jaydeep Singh

Mentor: Oleg Lazarev

Morse theory is a unique subfield of differential topology, in which a variety of tools from topology, analysis, and dynamical systems are brought to bear on the study of manifolds. In this talk, we will motivate the primary theorems and techniques of non-degenerate Morse theory, and explore them using the example of the topology of a torus. Time permitting, we will discuss some of the classic applications of Morse theory to the study of geodesics and path spaces.

Applications of the probabilistic method to game theory

6:20pm

Dhruv Medarametla

Mentor: Xiaoyu He

Certain problems in game theory can be analyzed very well by introducing the concept of random choice. In my talk, I will introduce the Liar Game, as well as its generalizations, and discuss how we can use the probabilistic method to understand when a winning strategy exists for one of the players. Additionally, I will talk about how we can use this probabilistic proof of existence to motivate an explicit strategy for the winning player.

Session B, room 384-I

Braid groups and configuration Spaces

5:00pm

Quinn Greicius

Mentor: Jens Reinhold

I will describe techniques in algebraic topology used to study certain braid groups in terms of the topological properties of ordered configuration spaces, and will develop the background necessary to state an application of recent work by Church and others in the area of representation stability.

Using homology to prove Brouwer's fixed point theorem and the hairy ball theorem

5:20pm

Pengda Liu

Mentor: Cédric de Groote

In this talk, I will talk about the basic properties of homology and its applications. I will begin with delta complexes and talk about singular and simplicial homology and exact sequences and use them to prove Brouwer's fixed point theorem by calculating homology groups and prove the hairy ball theorem by the notion of degree introduced by homology.

Markov chains

5:40pm

Xingyu Yang

Mentor: Jimmy He

Markov chains are a vital tool in understanding and creating statistical models of real world processes, and are an interesting mathematical structure. In this presentation, we will cover introductory results in the study of Markov chains, focusing particularly on transitivity and recurrence, and we will apply these concepts to the classic example of random walk.

The Fundamental Group

6:00pm

Victoria Tsai

Mentor: Ipsita Datta

The fundamental group is useful for characterizing topological spaces and understanding their equivalence. I will define the fundamental group and give a couple of examples.

The unexpected power of quantum computing

6:20pm

Arvind “Vince” Ranganathan

Mentor: Erik Bates

Typical computing processes are founded on information represented in binary, i.e. strings of 0s and 1s. Quantum computing generalizes this to qubits — the fundamental unit of quantum information — in which a bit is in a superposition of the 0 and 1 states. In this talk, I will be overviewing the fundamental properties of these qubits and exploring some fascinating theorems and clever applications that reveal many of the most interesting, important, and unexpected properties of quantum computing.

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