Class Themes

Algebra

These classes are about algebraic structures, which are roughly speaking different types of sets where one can do different types of operations, and the ways they interact with each other. In doing so, they touch on many beautiful topics: symmetries, the Euclidean plane, integers, and many, many other types of math.

- Introduction to linear algebra (Eric, W1)
- Cluster algebras from surfaces (Kayla, W1)
- Introduction to group theory (Susan, W1)
- Ring theory (Kayla, W2)
- On beyond i (Steve, W2)
- Bonus group theory part 2 (Ben, W2)
- Grammatical group generation (Eric, W2)
- Schubert calculus (Kayla, W3)
- Representation theory (Mark, W3–W4)
- The 17 wallpaper patterns (Emily, W3)
- Curves that classify geometry problems (J-Lo, W3)
- Commutative algebra and algebraic geometry (Mark, W3)
- Infinite groups are weird (Narmada, W3)
- Algebraic solutions to Painlevé VI (Aaron Landesman, W4)
- Finite fields (Aaron, W4)
- Introduction to Galois theory (Sim, W4)

Analysis

Analysis is all about limits: describing what happens to functions when you make very very very very small changes to the inputs. In these classes, you'll think about limits in all sorts of contexts: real numbers, complex numbers, higher dimensions, and applications to other areas of math.

- Overly convoluted plans (Ben, W1)
- Introduction to real analysis: epsilons and deltas (Charlotte, W1)
- The residue theorem (Kevin, W2)
- My two favourite type of sets: Cantor sets and Kakeya sets (Charlotte, W2)
- Nonstandard analysis (Aaron, W3)
- A curious connection between p-adic distances and triangulations of a square (Charlotte, W4)
- Cantor before set theory (Ben, W4)
- Chaotic dynamics and elephant drawing (Ben, W4)
- Baire necessities for Banach–Tarski (Narmada, W4)
- Metric spaces (Steve, W4)

Combinatorics

Combinatorics is the mathematics of the finite. This could mean something like counting the number of objects that satisfy a certain property, or studying the strategies in a finite game. Lots of these classes are

specifically about *graphs* — collections of objects ("vertices") and connections between them — but lots of other combinatorial structures will show up too.

- Introduction to graph theory (Narmada, W1)
- Cluster algebras from surfaces (Kayla, W1)
- Generating functions, Catalan numbers, and partitions (Mark, W1)
- The mathematics of forbidden words (Travis, W1)
- Extremal graph theory (Yuval, W2)
- The Hales–Jewett theorem (Misha, W2)
- The Ra(n)do(m) Graph (Travis, W2)
- Counter? I hardly know 'er! (Narmada and Travis, W2)
- Erdős' distinct distance problem in the plane (Neeraja Kulkarni, W2)
- Hyperplane arrangements (Emily, W2)
- The subsequence game (Misha, W2)
- The probabilistic method (Yuval, W2)
- Szemerédi's {theorem, regularity lemma} (Yuval, W3)
- Ultrafilters and combinatorics (Steve, W3)
- Problem solving: graph theory (Misha, W3)
- Conway's soldiers (Misha, W4)
- Electric charge on matchsticks (Misha, W4)

Computer Science

These classes are all about the mathematical study of computers and algorithms. Which problems can be solved quickly by a computer? Which ones can't be solved at all? How can computers be used to draw conclusions about large amounts of data?

- Complexity theory (Linus, W1)
- Formal proof verification in Lean (Aaron, W1)
- Algorithms for large primes (Zach Abel, W2)
- Quantum computation (Andrew Guo, W2)
- 2-adic computer science (Eric, W3)
- Zero knowledge proofs (Dan Zaharopol, W3)
- Machine learning (NOT neural networks) (Linus, W3)
- The satisfiability problem (Misha, W4)

Geometry

In these classes you'll think about shapes: how to slide them around, cut them up, and measure their lengths and angles. The classes you'll see in this theme range from familiar objects in the plane to much wilder shapes, where even just visualizing them is a challenge by itself.

- Machine geometry (Misha, W1)
- The geometry of music (Emily, W1)
- Teichmüller theory of the torus (Arya and Assaf, W2)
- Schubert calculus (Kayla, W3)
- On beyond on beyond i (Assaf, W3)
- The 17 wallpaper patterns (Emily, W3)
- Curves that classify geometry problems (J-Lo, W3)
- Hyperbolic geometry (Arya, W3)
- Problem solving: cheating in geometry (Zack, W4)
- High-dimensional potatoes (Travis, W4)
- Mathematical billiards (Arya, W4)
- Baire necessities for Banach–Tarski (Narmada, W4)
- Metric spaces (Steve, W4)

Logic/Set Theory

What is a set? What constitutes a valid mathematical proof? Which axioms should we use? These classes are all about using the tools of mathematics to study the foundations of mathematics itself.

- Computability theory (Steve, W1)
- Formal proof verification in Lean (Aaron, W1)
- The continuum hypothesis (Susan, W2–W3)
- The category of sets (Nic, W2)
- Nonstandard analysis (Aaron, W3)
- Ultrafilters and combinatorics (Steve, W3)
- Cantor before set theory (Ben, W4)

Number Theory

How well do you know the whole numbers, 1,2,3,...? Do you want to get to know them a whole lot better? These classes will help you to learn about the integers and many of their friends, using whatever tools we can get our hands on.

- Introduction to number theory (Mark, W1)
- Jacobi sums (Dave Savitt, W1)
- Algorithms for large primes (Zach Abel, W2)
- Lehmer factor stencils (Aaron and Eric, W2)
- 2-adic computer science (Eric, W3)
- Integer right triangles (David Roe, W3)
- Diophantine approximation (Travis, W3)
- A curious connection between p-adic distances and triangulations of a square (Charlotte, W4)
- The distribution of prime numbers (Viv, W4)
- The abc's of polynomialand (Eric, W4)
- Introduction to Galois theory (Sim, W4)

Probability/Statistics

How likely is an uncertain event to occur? What's the chance of getting struck by lightning, or dealing a winnable Solitaire game? These classes will answer many questions of this flavor, although probably not these specific questions.

- Martingales (Yuval, W1)
- Information theory (Linus, W2)
- The probabilistic method (Yuval, W2)
- Buffon's needle (Ben, W3)
- The distribution of prime numbers (Viv, W4)

Topology

In these classes you'll think about shapes: how they curve, bend, and stretch. These courses can be classified as "topology," as they involve studying properties of shapes that don't change when you deform them continuously.

- The answer is χ (Assaf, W1)
- Degree theory (Zoe, W1)
- Learn topology with PALs! (Arya, W1)
- Brouwer's fixed point theorem (Zoe, W2)
- Common continuity (Zoe, W3)
- Algebraic topology: homology (Zoe, W4)
- Knot theory (Emily and Kayla, W4)