CLASS DESCRIPTIONS—WEEK 2, MATHCAMP 2026

Contents

9:10 Classes

Applications of Eigenstuff (🌶🌶 → 🌶🌶🌶, Mark, $\boxed{\text{TW}\Theta\text{FS}}$)
You may not find the word (if it is a word) "eigenstuff" in your mathematical references, but it's a fast way to avoid spelling out "eigenvalues and eigenvectors". This class is about some of the many applications of eigenstuff that may well be new to you. In particular, I hope to show how useful eigenstuff is for questions like the following. (Disclaimer: Although I'm currently expecting to spend about one day on a short review plus 1. and at least one day on each of 2. and 3., depending on what people have seen already and/or are most interested in, topics may shift a bit.)

1. If after a sunny day, the next day has an 80% probability of being sunny and a 20% probability of being rainy, while after a rainy day, the next day has a 60% probability of being sunny and a 40% probability of being rainy, and if today is sunny, how can you (without taking 365 increasingly painful steps of computation) find the probability that it will be sunny exactly one year from now?

2. If you are given the equation $8x^2+6xy+y^2 = 19$, how can you quickly tell whether this represents an ellipse, a hyperbola, or a parabola, and how can you then (without technology) get an accurate sketch of the curve?

3. Systems of differential equations such as $dx/dt = f(x, y), dy/dt = g(x, y)$, where x and y are unknown functions of the time t and $f(x, y), g(x, y)$ are known functions of two variables, come up in applications outside math—for instance, in population biology. (In practice there might well be more than two unknown functions and correspondingly more differential equations, but this is a good, and hard enough, place to start.) If $f(x, y), g(x, y)$ are linear functions, such systems can actually be solved precisely, using eigenstuff. Having that case is a little too unlikely, and on the other hand for general functions $f(x, y), g(x, y)$ it isn't realistic to get exact solutions to such a system. But we can often use the linear case plus approximation to get information about how the solutions to the actual system will behave, at least in the long run—which is, honestly, all we should hope for when making a mathematical model that is not likely to be completely accurate in the first place!

Homework: Recommended

Class format: Interactive lecture

Prerequisites: The concept of eigenvalue and eigenvector of a linear transformation. (In particular, Glenn's class in week 1 should be plenty.) For application 3. above, a bit of calculus, perhaps including the concept of partial derivative—although I could catch you up on that individually if you haven't seen it.

Concentration (Week 2 of 2) (🌶🌶🌶, Misha, TWΘFS)
This is the second week of a class by the same name that started in week 1.

Homework: Recommended

Class format: Lecture

Prerequisites: The first week of Concentration; talk to Misha if you want to join.

Do Straight Lines Exist? (🌶🌶🌶, *Allan Adams*, TWΘFS)
Do straight lines exist? This is a surprisingly weighty question! And requires a more precise definition of straight than we usually bother with. In this course we will explore the basic ideas of Riemannian geometry, meet its major characters, grapple with the non-existence of God-given coordinates, and tie the shape of straight lines in curved spacetime to the loving pull of gravity.

Homework: Recommended

Class format: Interactive lecture

Prerequisites: None.

Surfaces that Don't Fit in $\mathbb{R}^3$ (🌶🌶, Laithy, TWΘFS)
Some surfaces are easy to picture: spheres, cylinders, donuts. Others are perfectly well-defined, but refuse to sit in ordinary 3-dimensional space without cheating (i.e. self-intersecting).

In this class, we will build surfaces by gluing edges of polygons. A rectangle can become a cylinder, a Mobius strip, a torus, or something stranger depending on which edges we identify and whether we twist them. From there we will meet the Klein bottle and the real projective plane—two surfaces whose usual pictures in 3D are misleading: the apparent self-intersections are artifacts of the picture, not part of the actual surface.

We will introduce orientability through hands-on examples and discover that this is the only obstruction to fitting a surface in $\mathbb{R}^3$. In particular, we will discover that the Klein bottle and real projective plane are non-orientable and hence do not fit in $\mathbb{R}^3$ despite being 2-dimensional objects. If time permits, we will also study the Euler characteristic of these mysterious surfaces.

Homework: Recommended

Class format: Interactive lecture

Prerequisites: You should be comfortable thinking visually about shapes, polygons, and 3D objects; and you should be willing to follow informal arguments about gluing, cutting, and deforming polygons.

Efficiency Frontiers (🌶🌶🌶🌶, Nikita, TWΘFS)
4-chili smörgåsbord. What? Yes!

In many areas of mathematics, we encounter the same general situation: an underlying structure gives rise to a collection of numbers, and we ask which collections of numbers can actually occur. In this class, we will look at several places where this question appears.

(1) **Embedding metric spaces into Euclidean space.** We know that four points in the plane cannot all be 1 foot apart; in fact, their pairwise distances cannot all be odd integers. More generally, when do a given set of numbers represent valid distances between points in Euclidean space?
(2) **Sylvester's criterion.** Suppose that $ax^2 + bxy + cxz + dy^2 + eyz + fz^2$ is always nonnegative. What does this tell us about (a, b, c, d, e, f)?
(3) **Polynomial inequalities.** If $x, y, z \geq 0$, what can we say about the possible values of $x+y+z$, $xy + xz + yz$, and xyz?
(4) **Sturm's theorem.** When does a polynomial $a_n x^n + \cdots + a_1 x + a_0$ have a real root? What can this tell us about its coefficients?

(5) **Wild card.** Depending on how the class goes, this could be a deeper dive into one of the previous days' material, Tsirelson's problem, Shannon and non-Shannon inequalities for entropy vectors, or correlation inequalities in percolation.

Homework: Recommended

Class format: Lecture+Handouts

Prerequisites: Knowing AM-GM, Miurhead and Schur's inequalities, derivatives, determinants, familiarity with mathematical expectations.

The Limits of Computation (🌶️🌶️, *Dan Z*, TWΘFS)
One of the greatest strengths of mathematics is the ability to bring precision to abstract concepts. Concepts like infinity, higher dimensions, information, uncertainty, and much more become something we can analyze and understand.

Another of these abstract ideas that mathematics can make precise is the idea of computation, allowing us to analyze what computers can and can't do and to understand their limits exactly.

In this class, we'll develop a precise mathematical model of a computer (the famous Turing machine) that can provably do anything a computer can do. We'll analyze that model, explaining exactly what computers today can and can't do. Our main focus will be the P vs NP problem, a famous unsolved problem with a million-dollar bounty on it. Although we won't solve it (alas!), we'll learn about some approaches and what they tell us about the very structure of knowledge and proof, discovering a rich world of different types of computational problems and mathematical relationships between them.

Homework: Recommended

Class format: Interactive lecture, where we talk through some big ideas together as a class. The optional homework will include some very challenging problems, so you'll have the opportunity to think through some very big ideas.

Prerequisites: None.

10:10 Classes

Commutative Algebra/Algebraic Geometry (Week 2 of 2) (🌶️🌶️🌶️ → 🌶️🌶️🌶️🌶️, Mark, TWΘFS)
This is a continuation of last week's class. If you would like to join now, ask me (or others who took week 1 of the class) about what we covered and what you might need to catch up on (which I can do as time and energy permit).

Homework: Recommended

Class format: Interactive lecture

Prerequisites: Week 1 of the class, or equivalent knowledge.

Finite Posets and Lattices (🌶️, Riley, TWΘFS)
Partially ordered sets (posets) and lattices show up frequently in mathematics and broadly represent nesting structures of many sorts. In this class, we view these structures from a combinatorial angle. In the first half of the class, we will collect examples of posets and lattices, learn how they can relate to each other, and understand their structure more abstractly. In the second half of the class, we may learn either about Möbius functions, or do a deeper dive into the Catalan numbers, or both. There will be lots of drawing pictures at whiteboards!

Homework: Optional

Class format: Inquiry-based learning

Prerequisites: Nothing beyond Fundamentals, although knowing what the Catalan numbers are may help for the last day.

Geometric Group Theory (🌶🌶, *Johanna Mangahas*, $\boxed{\text{TW}\Theta\text{F}}$S)
A central insight of geometric group theory is that groups are spaces one can move around in. So we start this series with a group drawing class: we use Cayley graphs to map out a variety of finite and infinite groups. This requires some choices, but for geometry on a group to have any meaning, it must be canonical in some sense. Therefore we should learn some coarse language: how to be precise about being imprecise. This prepares us to explore the geometry of groups within groups, which leads us to some subgroup funny business. Distances can get longer when you're restricted to only certain roads. We'll contrast the notion of quasi-isometric embedding with its opposite: subgroup distortion. Finally, what do we learn about a group from its geometry? Plenty for hyperbolic groups. For our last class we explore this feature that certain groups have, which has been foundational for geometric group theory.

Homework: Recommended

Class format: Interactive lecture

Prerequisites: Introduction to Group Theory or its equivalent.

Introduction to Advanced SET Theory (🌶🌶🌶, Della, $\boxed{\text{TW}\Theta\text{F}}$S)
Have you ever played SET and thought it wasn't hard enough? Do I have the games for you! I'll show you some *much* harder games like SET but with a different group (whatever that means), and strategies for finding sets. By the end, you'll be able to impress your friends (assuming they're patient enough to play these games with you), and if you're lucky you might have even learned a bit of math.

(This is not a set theory class. I'm happy to show you the games any time even if you don't take this class, but I might not give away the strategies.)

Homework: Recommended

Class format: Lecture and games

Prerequisites: Basic group theory (e.g. notation like S_3; direct products).

Some Cool Spaces (🌶 → 🌶🌶, Maya+Purple, $\boxed{\text{TW}\Theta\text{F}}$S)
Want to have a nice chill hour while hearing about some cool math and looking at some pretty pictures? Come to Some Cool Spaces! We'll tell you about some of our favorite spaces, focusing on pictures and intuition, and chatting about why we find them cool or interesting. The five days are independent, so you can come to a few and not to the others as you want! There's lots of time at camp to do hard, rigorous, symbolic math; let's make sure we also take time for some chill chats about cool stuff :).

The tentative plan:

- Day 1 (🌶) How do we decide how many "pieces" a space has? The topologist's sine curve and friends.
- Day 2 (🌶) How can we build spaces from orders? The long line and friends.
- Day 3 (🌶) How do we measure holes in a space? A survey of various "weird circles".
- Day 4 (🌶→ 🌶🌶) What are the important properties of the notion of distance? Some fun distance functions on the plane.
- Day 5 (🌶) How can we do algebra to spaces? Telescopes and the rational circle (Purple's favorite space!)

Homework: Optional

Class format: Interactive lecture

Prerequisites: None.

1:10 Colloquia

Mathematics Education in the Age of AI (*Dan Zaharopol*, Tuesday)
Society is changing in dramatic ways as AI's capabilities continue to grow and AI becomes a bigger part of work and our lives. By now, AIs can solve any problem from a college math major and most problems from graduate school. What, then, is even the point of a college education?

As an educator, it's my job to prepare students to succeed in the future, whatever that future might be. So how am I thinking about the role of mathematics education? How should you be thinking about it? What should you be getting out of your education to set you up for impact in the future?

No one knows the answers, but we'll explore those questions and ask how education should be evolving. We'll ask what skills someone should have in order to be successful 5–10 years from now, how education might prepare them for that, and what (if any) AI tools we should be using to teach people. Expect an open discussion, some thoughtful speculation, a few research citations that you may or may not believe, very little absolute certainty, and lots of Q&A and opportunities to reflect together on what the future might bring.

We're going into a wild new world. We'll all benefit from thinking about how to make that journey successful!

Large Cardinals, Left-Distributivity, and Laver Tables (Preston, Wednesday)
Since the early 20^{th} century, it has been known that more than one size of infinity exists (these are called *cardinals*). In particular, two different infinite cardinals describe the size of the infinite sets $\mathbb{N}$ and $\mathbb{R}$. But it has also been discovered that straightforward questions about infinite cardinals (such as, are there more cardinals in between $|\mathbb{N}|$ and $|\mathbb{R}|$?) cannot be answered using the standard axioms of mathematics. In set theory, a common approach is to introduce a *large cardinal*—an extraordinarily large infinite set whose existence cannot be proven, but if assumed, allows you to answer deeper questions about the infinite than previously possible. This talk addresses the question: are large cardinals applicable to questions that are not inherently set-theoretic? We'll see a large cardinal axiom called I3, which will motivate the definition of some otherwise strange-seeming finite algebraic systems called the *Laver tables*. Although relatively simple to define, their properties are incredibly hard to describe. We'll dive more into what all of this means, and what the current state of understanding is on Laver tables!

(tbd) (*Josh Tenenbaum*, Thursday)

Diversity in Math (Staff, Friday)
One of the first corollaries of Rule 1 that we tell you is to make no assumptions, except: Everyone is cool. How do we put this into practice? What can we learn about how people who are different from us experience the world, and how can we support each other to build a stronger community? Come to this event to hear staff share some of their experiences, and to discuss what we can do to uphold Rule 1?

Hyperbolicity Everywhere (*Johanna Mangahas*, Saturday)

We step away from Euclidean intuition and discover the worlds of hyperbolic geometry, by way of the familiar: coral reefs, floofy skirts, and more.

2:10 Classes

Algorithms for Large Primes (Zach, $\boxed{\text{TW}\Theta\text{FS}}$)
Much of modern internet security relies on a counterintuitive principle: **testing** whether large numbers are prime is fast, but **factoring** those same numbers is believed to be infeasible, even with state-of-the-art supercomputers and factoring algorithms.

For example, consider this 617-digit number n:

2664333464 8095867046 5576093999 6492477829 3167703392 9069280739 3742203430 6894180199 6008560427 3016830157
2001680123 3789065097 3898958107 0806318118 4683673312 3293527497 2239499223 4556591528 8113793067 5430234495
2993078042 3831054740 9939628345 1531198154 9765131380 0766059177 1124818938 5264222022 9923580421 3167159800
8031696054 3209862071 3361422691 7778050578 8185651816 0560534873 7003897591 3025092113 6540688190 1267133994
3051789997 1468622991 7583512501 3997096968 2500563822 4555415420 4293081599 1392725264 0878844890 9427113938
6541608014 5087303580 5608026842 7787098480 0607630225 5389783009 4431143344 2572579768 7778533347 3649797638
2981476385 7852347.

This number n is **not** prime and $n + 560$ **is** prime, and a typical laptop can **verify** both of these facts in fractions of a second. By contrast, the technology to **factor** n (and numbers like it) into primes likely does not yet exist, and most encrypted communications (in particular, most internet traffic) depends on this fact! The example n above is copied directly from the public certificate that protects `https://www.amazon.com`, but this security could be breached by anyone who can factor n into primes, so Amazon and all of its users rely on this not being feasible.

To factor a large number and/or test whether it is prime, the naïve “trial division” algorithm considers all potential factors individually: “is it divisible by 2? 3? 4? 5? etc.”. But for numbers with hundreds of digits, this is way too slow, since the universe will literally suffer heat death before this algorithm makes noticeable progress.

So how is it possible to conclude that a large number (like n) is composite *without* factoring it? How can we be sure that a large number (like $n + 560$) is prime *without* testing all of its possible prime factors? We'll explore clever algorithms that enable efficient tests like these, and the elegant underlying number theory.

Topics may include: primality certificates; probable vs provable primes; the Great Internet Mersenne Prime Search; generating large primes; the AKS primality test.

Homework: Optional

Class format: Lecture

Prerequisites: Modular arithmetic: should understand modular inverses and Fermat's Little Theorem. I plan *not* to assume or use any knowledge of abstract algebra.

Bayesian Statistics (*Mira Bernstein*, $\boxed{\text{TW}\Theta\text{FS}}$)
MCMC—which stands not for “Mathcamp Mathcamp”, but for “Markov Chain Monte Carlo”—is a technique for sampling from very complicated probability distributions. This might not sound particularly glamorous, but in fact, MCMC is one of the “top 10 algorithms of the 20th century” (according to the Journal of Computing in Science and Engineering). It lies at the heart of the Bayesian revolution in statistics that began in the 1990's and is still going strong today: there is literally no branch of the natural or social sciences where researchers aren't currently using MCMC. If the above sounds intriguing but you have no idea what any of the words mean (Markov chain? Monte Carlo? Probability distribution? Bayesian?), that's OK—we're going to start from scratch. We'll give you a primer on Markov chains (a really cool topic in its own right), define exactly what MCMC does and why it works, and give a variety of examples to illustrate its role in the Bayesian revolution.

Homework: Recommended

Class format: Interactive lecture

Prerequisites: Vectors and matrices; basic probability; calculus helpful at times but not required.

Everyoune WILL Louve Analysis (🌶🌶, Charloutte, $\boxed{\text{TW}\Theta\text{FS}}$)
Soume staff—whoum I *woun't name*—have been trying tou persuade you tou HATE ANALYSIS! But you should LOUVE ANALYSIS INSTEAD and that's what this class is all about!!

This will be a rigourous introuduction to limits and related councepts in calculus. Counsider the foullouwing questiouns:

- Every calculus student knouws that $\frac{d}{dx}(f+g) = f' + g'$. Is it alsou true that $\frac{d}{dx}\sum_{n=1}^{\infty} f_n = \sum_{n=1}^{\infty} f_n'$?
- Every calculus student alsou knows that $a + b = b + a$. Can you alsou rearrange terms in an *infinite series* without changing its sum?

The answer tou bouth questions is: it depends! We will see that soumetimes the answers are yes, and soumetimes the answers are nou.

To help us study these questiouns and many outhers, our key tool is the "epsiloun-delta definitioun" ouf a limit. This councept can be tricky, sou we will study many examples, and learn about many related noutiouns. Being coumfourtable reasouning with limits is central to ANALYSIS, and it'll oupen the douour tou soume very exciting mathematics in this camp and beyound. AND EVERYOUNE WILL LOVE IT!

Homework: Required

Class format: Mostly interactive lecture, but with some group work

Prerequisites: You should have seen limits before, such as the presentation in a standard calculus course.

Mealy Automata (🌶, Neelam, $\boxed{\text{TW}\Theta}$FS)
Ever wondered how a remarkably simple machine with just a few states and some basic transition rules can generate mind-bogglingly complex behavior? Welcome to the world of Mealy automata. Far from being just basic computer science abstractions, these machines double as powerful algebraic tools capable of acting on infinite trees.

Over three days, we'll fast-track our way from the absolute basics of finite-state machines straight into the gorgeous geometry of tree automorphisms. We'll explore what happens when these machines can run backward or invert their steps, playing around with invertible and reversible automata. Along the way, we'll see how these simple structures can generate massive, infinite groups with weird, fractal-like properties.

If you like discrete math, group theory, or just want to see how a humble machine can completely shatter your expectations, come join us!

Homework: Recommended

Class format: Interactive lecture

Prerequisites: None.

Shirts (🌶🌶, Arya, TWΘ$\boxed{\text{FS}}$)
Take a sphere, and cut out 3 holes in the sphere. The resulting shape is (topologically) a pair of pants! Instead, if you cut out 4 holes—or alternatively, glue two pairs of pants along a seam—the resulting shape is a shirt! In this class, we would like to study the topology, geometry, and dynamics of these objects. In some sense, this is the "smallest" surface for which this yields interesting properties, while being the "largest" surface for which studying these properties isn't too hard. The mathematics involved in twisting a shirt is related to braids, taffy pullers, and juggling. Come find out!

Homework: Optional
Class format: Interactive lecture
Prerequisites: None.

Functional Geometry: Convex Sets in Banach Spaces (, Narmada, $\boxed{\text{TW}\Theta\text{FS}}$)

You've heard that everyone hates analysis, and you've heard that everyone loves analysis, but no matter which of these you accept, it doesn't change the universal truth that everyone *needs* analysis. We think we understand linear algebra and geometry just because we live in $\mathbb{R}^3$. It turns out that our intuition breaks down even in large finite dimensions, and completely flies out the window in infinite dimensions.

In this class, we'll see how the study of infinite-dimensional vector spaces is secretly analysis, and how defining continuous linear maps is secretly geometry which is also secretly analysis. The goal of this class is to prove the Hahn–Banach theorem, which tells us exactly when we can expect geometry to behave in infinite dimensions. This is a standard part of functional analysis, approached from a geometric viewpoint, so we might favor big-picture proofs over symbol-pushing ε-δ ones when we can.

Homework: Recommended

Class format: Interactive lecture

Prerequisites: Be comfortable with linear algebra (vector spaces, bases, and linear maps); Be comfortable with ε-δ limits and continuity; Know what a convex set is; Know the parallelogram law for the standard Euclidean norm. (+1 chili if you haven't encountered infinite-dimensional vector spaces before.)

3:10 Classes

Arithmetic Ramsey Theory (, Bowen, $\boxed{\text{TW}\Theta\text{FS}}$)

Ramsey theory studies order in chaos. If we color a sufficiently large mathematical object, some surprisingly structured patterns are often forced to survive in one color. In Arithmetic Ramsey theory, the objects are integers, and the surviving patterns are equations and arithmetic progressions.

We will begin with an appetizer: Schur's theorem, which says that in any finite coloring of the positive integers, one color contains a solution to

$$x + y = z.$$

This is a beautiful example of how a simple coloring question can force arithmetic structure.

The main course will be Roth's theorem: every sufficiently dense subset of the integers contains a nontrivial three-term arithmetic progression. We will study Roth's theorem from two different perspectives. The first is the Fourier-analytic proof, where arithmetic structure is detected by large Fourier coefficients. The second is the ergodic-theoretic viewpoint, where arithmetic progressions arise from recurrence in measure-preserving dynamical systems. For the ergodic part, we will treat the relevant recurrence theorem as a black box and focus on how it yields a completely different way of seeing Roth's theorem.

The goal is not only to prove several famous theorems, but also to see how the same combinatorial question can be attacked using very different languages: elementary counting, Fourier analysis, and dynamics.

Homework: Recommended

Class format: Lecture

Prerequisites: Linear algebra and basic analysis are required. Students should be comfortable with compactness, measure, and finite-dimensional vector spaces. Prior exposure to Fourier analysis or ergodic theory is not required; we will develop the Fourier ideas from a linear-algebraic point of view, and we will use the necessary ergodic theory as a black box.

Classical Matrix Groups & Lie Theory (, Ben, TWΘFS)

In a group theory class, we usually start off by introducing students to finite groups, often as groups of symmetry for geometric shapes—like the square, the triangle, the rhombus. But as even first-time connoisseurs of the great geometric shapes know, there are other important ones, such as the circle, and the ball.[1] It will perhaps *not* be surprising to learn that the group of symmetries of the circle is *not* finite—some would even call it infinite. The same, of course, is true of the symmetries of the sphere in three-dimensional space.

These groups are in fact *continuous* groups of matrices, which are an important example of **Lie groups**. In this class, we'll talk a bit about the standard tools for studying Lie groups—the Lie algebra, the exponential map, and the Lie bracket. Our main focus, as we go through these, will be the "classical matrix groups", which give very concrete examples of matrix groups. I've mentioned two of these already—the symmetries of the circle and the sphere—and many of the others can be thought of as generalizations of these two. As we go along, we'll see just how much of group theory we can convert into linear algebra, and how much calculus we can sneak into it, too.

Homework: Recommended

Class format: Lecture

Prerequisites: Some group theory, linear algebra, and calculus; in particular:

- Group theory: Know what a group is, know what "conjugation" is;
- Linear algebra: Know the relationship between linear maps and matrices, know what a determinant is;
- Calculus: Know how to take a derivative.

Deeper Dive into Finite Groups (, August, TWΘFS)

This class will win you the Finite Group Game (FGG) against Ben. Let's be honest, groups are FUN. And FUNdamental to ALL of maths. Why not play with it some more? This directly follows an introductory group theory class (like the one last week). We will discuss some very useful topics in group theory and their applications to finite groups. Some topics we will (probably) cover include:

- Group actions and the Orbit-Stabilizer Theorem,
- Classifying groups of small size,
- Sylow theorems and simple groups,
- Some more crazy things including alternating groups, the classification of finite Abelian groups, etc.

Homework: Recommended

Class format: Lecture and interactive worksheet

Prerequisites: Some basic knowledge of group theory, specifically:

- Groups, subgroups, cosets of a subgroup, Lagrange's theorem, order of an element, index of a subgroup, conjugation, first isomorphism theorem, normal subgroup.
- Examples of groups: cyclic groups, dihedral groups, symmetric groups, direct products of groups.

Nimbers (, *Aaron Anderson*, TWΘFS)

A few decades ago, John Conway and some of his colleagues spent several years hard at work playing

[1]Citation: there are a lot of "shape-learning activities" for those students of mathematics whose ages lie between 2 and 5, and most of them include circles.

games. They played classic games like Go, Nim, and Dots-and-Boxes; and catalogued new ones like Hackenbush and Sprouts. Eventually a general theory emerged—not the probabilistic game theory of economists, but a deep combinatorial labyrinth of deterministic possibilities.

We will study (and play!) some of these games, and learn how to beat them. This will end up leading us to a number system called the *nimbers*.

We'll mostly focus on the combinatorial basics of nimbers, but this will open the door to bizarre things like *infinite nimbers*, and *surreal numbers*. Is this overkill to get a little better at the Go endgame? Perhaps.

Homework: Recommended

Class format: Mostly IBL, including time to play combinatorial games, with some short lectures on further material.

Prerequisites: None for the main class—some bonus problems might involve things like ordinal numbers or linear algebra.

Transistors to Programming: Build a Computer from First Principles (, Glenn, $\boxed{\text{TW}\Theta\text{FS}}$)

Have you ever wondered how a computer works? The most basic unit is called a transistor, which you can think of as a simple on-off switch. In this class, we'll start from transistors and build all the way up to a full computer with a custom programming language that allows the user to compute whatever they want. Along the way, we'll explore Boolean circuits, computing with binary, computer memory, and more!

Homework: Optional

Class format: Group work/IBL. Every day will start with a short lesson at the board, then you'll break into groups and work on worksheets where you'll design your own circuits!

Prerequisites: None.