CLASS DESCRIPTIONS—WEEK 1, MATHCAMP 2019

Contents

9:10 Classes

A Convoluted Process. (Ben, Tuesday–Saturday)
The convolution is an important way of combining two functions, letting us "smooth out" functions that are very rough. In this course, we'll investigate the convolution and see its connection to the Fourier transform. At the end of the course, we'll explain the Bessel integrals: a sequence of trigonometric integrals where the first 7 are all equal to $\frac{\pi}{2}$... and then all the rest are not.

Why does this pattern start? Why does it stop? One explanation for this phenomenon is based on the convolution.

Chilis: 🌶🌶🌶
Homework: Recommended
Prerequisites: Know how to take integrals (including improper integrals), some familiarity with limits

Beyond Inclusion/Exclusion. (*John Mackey*, Tuesday–Saturday)
Inclusion/Exclusion is a useful counting method wherein one successively corrects overapproximations and underapproximations. We'll spend one day reviewing Inclusion/Exclusion and then consider Mobius Inversion on Posets and Sign Reversing Involutions.

Mobius Inversion will provide a useful look inside the dual nature of accruing and sieving objects, and cast an algebraic context onto Inclusion/Exclusion. Sign Reversing Involutions will lend a matching perspective to the calculation of alternating sums.

Chilis: 🌶🌶🌶
Homework: Recommended
Prerequisites: Experience with elementary counting and matrix algebra recommended.

Harmonic Analysis on Finite Abelian Groups. (*Mike Orrison*, Tuesday–Friday)
In this course, we will focus on how and why you might want to rewrite a complex-valued function defined on a finite abelian group as a linear combination of simple functions called characters. As we will see, doing so quickly leads to discussions of far-reaching algorithms and ideas in mathematics such as discrete Fourier transforms (DFTs), fast Fourier transforms (FFTs), random walks, and the Uncertainty Principle.

Chilis: 🌶🌶🌶
Homework: Recommended

Prerequisites: Complex numbers (basic arithmetic and geometric interpretations), linear algebra (bases, invertible matrices, eigenvalues, complex inner products, orthogonality), and group theory (examples of finite abelian groups and their subgroups, cosets, homomorphisms).

Introduction to Number Theory. (Gabrielle, Tuesday–Saturday)
Number theory is the study of the natural numbers, which we thought we finished understanding completely in elementary school. It turns out that there is a lot we do not know! We will prove some results that you may have taken for granted in the past (the division algorithm and unique factorization of integers into primes, for example). By the end of this class, you will know much more, such as: What is the relationship between the greatest common divisor and least common multiple of two integers? When does a polynomial with integer coefficients have solutions modulo a positive integer m? When is a number a a square modulo a prime p? (If you don't know what we mean by greatest common divisor, least common divisor, or modulo an integer, do not fear–you will learn all of this, too!)
Chilis: 
Homework: Recommended
Prerequisites: None
Required for: Algorithms in Number Theory (W2); Reciprocity Laws in Algebraic Number Theory (W4); Zeta Functions (W4)

Knot Theory. (Kayla, Tuesday–Saturday)
Why knot learn more about knots? Especially when you canknot find a punnier subject! In this class, we will explore the world of knots and try to figure (8) out how we can tell them apart. Knot theory is still a dynamic branch of mathematics, so in our quest to distinguish all knots, some of our attempts may be trefoiled. But nonetheless, we will valiantly try to distinguish knots using things like Reidemeister moves, as well as numerical, color, and polynomial invariants!
Chilis: 
Homework: Recommended
Prerequisites: None

The Hoffman–Singleton Theorem. (Pesto, Saturday)
There are exactly three known graphs in which

(1) every vertex has the same degree,
(2) there are no cycles of length 3 or 4, and
(3) every vertex is at distance at most 2 from every other vertex.

It's not known whether a fourth such graph exists, but if it does, then its vertices have degree 57![1] We'll prove so by a beautiful application of linear algebra to graph theory.
Chilis: 
Homework: None
Prerequisites: Linear algebra: Understand the statement (not necessarily a proof) that "an $n \times n$ symmetric matrix has n eigenvectors".

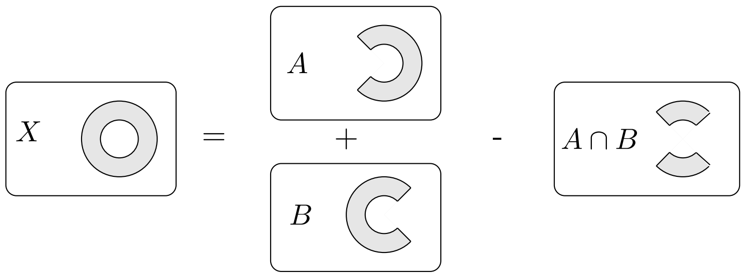
10:10 Classes

Homological Algebra: The Art of Gluing. (*Jeff Hicks*, Tuesday–Saturday)
"Decomposition and gluing" is a general mathematical technique which is used to understand an

[1]Excitement, not factorial.

object in terms of its pieces. When people make that analogy of comparing mathematics to jigsaw puzzles and assembling the small things you know until you see the whole picture, this is the what they are talking about. As a concrete example, think of the way we understand polytopes like cubes and tetrahedra by gluing them together from their vertices, edges and faces.

The goal of this class is to understand the theory of decomposition and gluing. As a simple example, let's suppose that we are trying to compute the number of elements in a set X. We will decompose X into two subsets A and B so that $X = A \cup B$. We can compute the number of elements in X by the principle of *inclusion-exclusion,* which states $|X| = |A| + |B| - |A \cap B|$.



Our framework for generalizing these kinds of arguments is called homological algebra. Instead of using numbers to record our properties, we'll use linear algebra to construct our properties and glue. This framework will allow us to generate insight into the general theory of decomposition and gluing, showing that problems amenable to attack by gluing have subtleties beyond the original questions we were trying to answer. We will mostly be looking at topological spaces—spheres, tori, etc— as our objects of interest to motivate the theory.

As a warmup: you might want to think about why trying to compute the number of connected regions in the shape X above by gluing will magically tell you that X has a hole in the middle (come talk to me about your thoughts, or let me know if you have any questions!)

Chilis:

Homework: Recommended

Prerequisites: We will be using linear algebra in this class. You should know what the dimension of an abstract vector space is, and the rank-nullity theorem. If you're taking linear algebra this week, the first day or two will be a bit rocky.

Cluster: Topology

Infinite Graphs. (*Mia Smith*, Tuesday–Saturday)
In traditional graph theory, a graph is defined to be a finite set of vertices which are connected by edges. However, the requirement that the vertex set be finite feels a little . . . stifling. In this class, we will eschew this requirement and allow *infinitely* many of vertices. By drawing on tools from set theory and graph theory, we will explore what happens when we allow graphs to have an infinitely large set of vertices.

To start, some classical results from graph theory turn out to be far trickier to prove on infinite graphs. For instance, simply proving that every connected graph has a spanning tree will necessitate a dive into the world of posets. However, the admission of infinite graphs opens up possibilities. We can define universal graphs and ask things like, is there a graph that contains every other countable graph as a subgraph? What about a planar graph that contains every other planar graph?

Chilis:

Homework: Recommended

Prerequisites: Some familiarity with graph theory and sets is recommended.

Cluster: Graph Theory

Mathcamp Crash Course. (Kevin, Tuesday–Saturday)
There are two fundamental parts to doing mathematics: the toolbox of notation and techniques that go into proofs, and the ability to communicate your ideas through writing and presentation. Most math books, papers, and classes (including at Mathcamp!) take these things for granted; this is the class designed to introduce and reinforce these fundamentals. We'll cover basic logic, basic set theory, notation, and some proof techniques, and we'll focus on writing and presenting your proofs. If you are new to advanced mathematics, or just want to make sure that you have a firm foundation for the rest of your Mathcamp courses, then this class is *highly* recommended. If you want to build up confidence in working with others mathematically, from simply asking questions in class to writing proofs for others to read to presenting at a blackboard, this class may also be right for you.

Here are some problems to test your knowledge of this fundamental toolbox:

(1) Negate the following sentence without using any negative words ("no", "not", etc.): *"If a book in my library has a page with fewer than 30 words, then every word on that page starts with a vowel."*
(2) Given two sets of real numbers A and B, we say that A *dominates* B when for every $a \in A$ there exists $b \in B$ such that $a < b$. Find two disjoint, nonempty sets A and B such that A dominates B and B dominates A.
(3) Prove that there are infinitely many prime numbers.
(4) Let $f : A \to B$ and $g : B \to C$ be maps of sets. Prove that if $g \circ f$ is injective then f is injective. (This may be obvious, but do you know how to write down the proof concisely and rigorously?)
(5) Define rigorously what it means for a function to be increasing.
(6) Prove that addition modulo 2013 is well-defined.
(7) What is wrong with the following argument (aside from the fact that the claim is false)?

> **Claim:** On a certain island, there are $n \geq 2$ cities, some of which are connected by roads. If each city is connected by a road to at least one other city, then you can travel from any city to any other city along the roads.
> **Proof:** We proceed by induction on n. The claim is clearly true for $n = 1$. Now suppose the claim is true for an island with $n = k$ cities. To prove that it's also true for $n = k + 1$, we add another city to this island. This new city is connected by a road to at least one of the old cities, from which you can get to any other old city by the inductive hypothesis. Thus you can travel from the new city to any other city, as well as between any two of the old cities. This proves that the claim holds for $n = k + 1$, so by induction it holds for all n. QED.

(8) Explain what it means to say that the real numbers are uncountable. Then prove it.

If you would not be comfortable writing down proofs or presenting your solutions to these problems, then you can probably benefit from this crash course. If you found this list of questions intimidating or didn't know how to begin thinking about some of them, then you should *definitely* take this class. It will make the rest of your Mathcamp experience much more enjoyable and productive. And the class itself will be fun too!

Chilis:
Homework: Required
Prerequisites: None

Multivariable Calculus Crash Course. (Mark, Tuesday–Saturday)
In real life, interesting quantities usually depend on several variables (such as the coordinates of a point, the time, the temperature, the number of campers in the room, the real and imaginary parts of a complex number, . . .). Because of this, "ordinary" (single-variable) calculus often isn't enough to solve practical problems. In this class, we'll quickly go through the basics of calculus for functions of

several variables. As time permits, we'll look at some cool applications, such as: If you're in the desert and you want to cool off as quickly as possible, how do you decide what direction to go in? What is the total area under a bell curve? What force fields are consistent with conservation of energy?

Chilis:

Homework: Recommended

Prerequisites: Knowledge of single-variable calculus (differentiation and integration)

Required for: Functions of a Complex Variable (1/2) (W2); Functions of a Complex Variable (2/2) (W3)

Studying Betting Games with Other Betting Games. (Bill, Thursday–Saturday)

Sometimes the best way to study a betting game A is to define a *different* game B on top of it. By analyzing game B, we can then extract information about the original game.

This cool combinatorial technique can be used to prove all sorts of surprising facts. Examples of where we'll use it include:

- Analyzing the expected time for a random walk to leave an interval.
- Analyzing a famous game involving pennies, known as Penney's Game (and named, somewhat confusingly, after its inventor Walter Penney).
- Analyzing the probability of a gambler winning big when the bets are stacked against them.

Chilis:

Homework: Recommended

Prerequisites: Comfortable with probability and expected values.

Super Mario Bros. is NP-hard. (Tim!, Wednesday)

One of the first video games I ever played was Super Mario Bros. on my friend's 8-bit Nintendo Entertainment System. Some of the levels were really hard! But now I can some feel some vindication, because in 2015, researchers mathematically proved that Super Mario Bros. is hard. Specifically, it's impossible for a computer to solve[2] Super Mario Bros. any faster than some of the most notorious computationally hard problems, like the Traveling Salesman Problem and boolean 3-satisfiability (3-SAT).

In this class, we'll talk about what it means for a math problem to be computationally hard, and then we'll show that Super Mario Bros. (and if we have time, other classic Nintendo games like Donkey Kong Country and Legend of Zelda) are NP-hard.

Chilis:

Homework: None

Prerequisites: None

Cluster: Algorithms

The Combinatorics of Boarding an Airplane. (Bill, Tuesday)

Suppose 100 people board an airplane in a random order. When each person gets to their assigned seat, they pause for one unit of time to put their luggage in the overhead bin, possibly holding up everyone behind them. How long will it take, on average, before everyone gets to sit down?

This topic has led to actual academic papers in math and theoretical computer science. In this class, we'll be considering the simplest version of the question. Along the way, we'll see several beautiful ideas from probability and combinatorics, including a famous theorem of Erdős and Szekeres that proves the existence of long monotone subsequences within any permutation.

[2] Here "solve" means examining the map of a level and figuring out whether it's possible to complete the level. To be fair, this wasn't my actual difficulty when I was playing Mario. I struggled more with the Koopas.

Chilis: 🌶🌶
Homework: None
Prerequisites: None

11:10 Classes

Introduction to Gerrymandering. (Assaf, Tuesday–Saturday)
Gerrymandering is the art of winning elections that you really had no business winning by drawing districts behind secret doors in smokey rooms. In this class, we'll embark on a mathematical dive into the world of gerrymandering with shapes, political metrics, data, and graphs. By the end, we'll talk about the current state-of-the-art arguments that appeared in the recent supreme court cases.

This class will have a non-mandatory coding component for those of you who want to learn a bit of coding.

Let's break politics!
Chilis: 🌶
Homework: Recommended
Prerequisites: None
Cluster: Math and the Real World

Introduction to Group Theory. (Shiyue, Tuesday–Saturday)
What do the integers and the set of permutations of n things have in common? They are both groups! You might have seen many many groups before, but what are they? In this class, we will learn the foundational theory of groups, maps between them, and a plethora of examples that will show you the fascinating world of modern algebra.
Chilis: 🌶🌶
Homework: Recommended
Prerequisites: None
Required for: Galois Correspondence of Covering Spaces (W2); Group Theory & Rubik's Cubes (W2); Young Tableaux and Representation Theory (W2); Fundamental Groups (W3); From High School Arithmetic to Group Cohomology (W3); Non-Euclidean Geometries (W3); Zeta Functions (W4); Counting Points over Finite Fields (W4)

Logic and Arithmetic. (*Steve Schweber*, Tuesday–Saturday)
A lot of mathematics can be boiled down to arithmetic. Or, perhaps we should say that a lot of *the practice of* mathematics can be boiled down to arithmetic: regardless of what mathematical objects we're studying, what we're actually *doing* is writing down definitions, theorems, and proofs, and these are just strings of symbols. (Once we precisely define all those terms, of course. But hey, how hard could that be?) And arithmetic is great for talking about strings of symbols.

This suggests a great bit of silliness: can we prove things about what mathematics is/does/can be by just thinking about the natural numbers? It turns out that we can, and there's a lot to say here. This class will focus on understanding what this perspective shift can tell us about the limits (in a non-calculus-y sense) of mathematics, both in terms of what mathematical languages can express and what mathematical systems can prove.
Chilis: 🌶🌶🌶🌶
Homework: Required
Prerequisites: None

Problem-Solving Cornucopia. (Mark, Tuesday–Saturday)
Come and work together (or separately, if you prefer) on a daily variety of interesting problems, which are not arranged by topic - so part of the challenge is to figure out what techniques might be helpful for any particular problem! Although the difficulty of the problems will vary, most should be in the 2- to 3-chili range. This is not a competition-oriented class, although you might well pick up some ideas and/or "tricks" that will be useful to you in the context of competitions. Although there might be an occasional "break" when a point of general interest comes up, most of the time you'll be actively thinking about problems, with hints provided on request.

Chilis: 🌶 → 🌶🌶🌶🌶

Homework: Optional

Prerequisites: None, although some problems will require calculus.

Cluster: Problem-Solving

Why We Like Complex Projective Space. (Will, Tuesday–Saturday)
Parallel lines in Euclidean space don't intersect. This might seem self-evident, but it's kind of annoying if we're trying to figure out how two geometric figures intersect. After all, most of the time two lines will intersect in a unique point, and it's a hassle to check an extra condition just in case they don't. Similar inconsistencies show up when we intersect algebraic curves and surfaces: for example, if we intersect two conic sections, we might get anywhere from 0 to 4 points.

It would be nice to work in a world where these intersection problems have consistent answers. In fact, we can accomplish this by extending to the complex numbers and adding points to our space "at infinity" in a systematic way. The resulting setting, called complex projective space, is trickier to visualize, but it ends up being the most natural place to solve many geometric problems.

In this class, we'll define complex projective space, get a sense for its shape and importance, and look at some classic results on intersections of lines and curves that clean up nicely in this new space. If you're interested in taking a first look at algebraic geometry, seeing a classic example of mathematicians adjusting definitions to make nicer theorems, or dividing by zero with staff supervision, you might enjoy this class.

Chilis: 🌶🌶

Homework: Recommended

Prerequisites: Familiarity with complex numbers. A bit of linear algebra (manipulating matrices and using them to describe transformations of space) may come in handy, but it won't be necessary.

1:10 Classes

Cluster Algebras. (Véronique, Tuesday–Friday)
The goal of this class is to learn what cluster algebras are and prove a few properties about them. We will focus on cluster algebras from surfaces since we can easily visualize them and work on them. The first part is a short introduction to cluster algebras; the second, third and fourth parts are devoted to cluster algebras from surfaces, especially to the expansion formulas for the cluster variables. Expression formulas allow us to easily compute a cluster variable (that is usually a tedious computation). Finally, we will construct a canonical base in terms of snake graphs.

Chilis: 🌶🌶🌶

Homework: Recommended

Prerequisites: None

Cluster: The Cluster Algebra Cluster

Infinite Trees (1/2). (Susan, Tuesday–Saturday)
König's infinity lemma states that a tree of infinite height with finite levels has an infinite branch. So let's ask the obvious[3] followup question: what happens when you have a tree of uncountable height with countable levels? Does this result in an uncountable branch?

Surprisingly[4], no, it doesn't—in this class we'll construct a tree of uncountable height in which every level and every branch is countable! And this isn't the weirdest thing we'll see in this class. We'll see trees that may not even exist—we have to go outside of Zermelo-Fraenkel set theory to find them. Come to this class if you want to find out what it means for a tree to be uncountably tall, delve into the mysteries of the Diamond Axiom, and learn how to pronounce the word "Aronszajn."

Chilis: 🌶🌶🌶
Homework: Recommended
Prerequisites: None
Required for: Infinite Trees (2/2) (W2)

Linear Algebra. (Apurva, Tuesday–Saturday)
Linear algebra is a fundamental language used in almost every area of theoretical and applied math, from abstract algebraic geometry to applied data science. If you can add things together you are probably using linear algebra. Linear algebra is set theory with a vengeance. `https://youtu.be/A05n32Bl0aY`.

In this class, we'll learn about vector spaces, bases, matrices, linear transformations, rank-nullity theorem, change of basis isomorphisms, and take a peek at some other advanced stuff like determinant and eigenvectors. We'll also be doing a lot of proofs.

This class is mostly IBL, i.e. instead of a regular lecture we'll learn by solving problem sheets.

Chilis: 🌶🌶🌶
Homework: Required
Prerequisites: None
Required for: Eigenstuff and Beyond (W2); Multi-Coefficient Solving of Polynomials (W2); Young Tableaux and Representation Theory (W2); Systems of Differential Equations (W3); Quantum Mechanics (W3); Quiver Representations (W3); Young Tableaux and Enumerative Geometry (W4); Representation Theory of Associative Algebra (W4); Counting Points over Finite Fields (W4); (Dys)functional Analysis (W4)

Not Your Grandparents' Algorithms Class. (*Sam Gutekunst*, Tuesday–Saturday)
This class will study algorithms for making progressively more and more complicated decisions: we'll start with finding an "optimal" diet[5] and end with finding optimal routes for Beyoncé's next concert tour. Unlike a traditional algorithms class, we'll spend approximately zero time focusing on running time beyond vague notions about whether or not an algorithm is efficient in a formal sense. Instead, we'll emphasize the ideas behind a whole bunch of beautiful algorithms! We'll cover: Fourier–Motzkin elimination and the ellipsoid algorithm for linear programming, branch and bound for discrete optimization, cool graph theory algorithms that work stupidly well, and state-of-the-art approximation algorithms for the Traveling Salesman Problem.

Chilis: 🌶🌶
Homework: Recommended
Prerequisites: Comfort working in $\mathbb{R}^n$ and the definition of a graph in terms of vertices and edges.
Cluster: Algorithms

[3]for sufficiently weird values of "obvious"
[4]for sufficiently small values of "surprise"
[5]spoiler alert: wheat flour, evaporated milk, cabbage, spinach, and dried navy beans, so maybe not so optimal.

The Centuries-Old English Tradition of Publicly Performing Hamiltonian Cycles in Cayley Graphs of Symmetric Groups (Change Ringing). (Eric + Tim!, Tuesday–Saturday)
In 16th century England, people figured out that they could make church bells louder by hanging them on wheels. Eventually they got bored of just ringing their bells back and forth and wanted to play music. But too bad, they can't. The bells just physically can't do it.[6] What they could do, though, is play all the bells, and then play them all again in a slightly different order. Their goal was to play all the possible permutations of the bells without repetition (an *extent*). This exercise continues to this day; there are over 5000 bell towers in England that are equipped for "ringing the changes."

With only 6 bells, the number of ways to ring all permutations is 6!!![7] But in reality, people perform only a fraction of these extents, developed over time through the constraints they faced:

- Due to physical limitations, consecutive permutations must be similar to each other in a very specific sense.
- Sheet music and other written notes are not allowed; everything must be performed from memory.
- People frequently make mistakes, so there should be enough built-in structure for the conductor to be able to sort out confusion on the fly.

Over the centuries, people developed ways of building up extents from smaller, memorizable, somewhat-recursive building blocks. With enough painstaking effort, we could check change by change that these are valid extents (i. e., that we haven't repeated any orders of the bells). But could we find some underlying structures that would save us work in verifying that we have a valid extent? Can we use this structure to help in building new extents, or in actually ringing ones we come up with? Can we figure out the math that's been secretly underlying this tradition for centuries, and redevelop several hundred years of change ringing in a week using the power of group theory?[8] The answers to some of these questions are yes!

Chilis:

Homework: Recommended

Prerequisites: None

Cluster: The Power of Groups

The Monotone Sequence Game. (Misha, Saturday)
If all campers this year are standing in a row, in any order, we can pick out 12 of them lined up in increasing, or decreasing, order of height.

This is only guaranteed this year: last year, we only had 120 campers, and you need at least 121 for the trick to work.

All of the above is just motivation for the questions I'm really interested in, which are the following:

(1) How many campers do you have to compare to find such a sequence of 12?
(2) Why is the process in question 1 called an "online edge-coloring game"?
(3) What happens if you have to choose all the campers you compare in advance?

Chilis:

Homework: None

Prerequisites: None

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[6] Being hung on a wheel, a bell acts sort of like a pendulum, so it takes a lot of effort to ring it in something other than a fairly even pattern.

[7] Read: "six factorial factorial excitement footnote"

[8] Whether you've seen group theory before or you are new to it, this class is a chance to get your hands dirty with it and actually see and hear important group theory facts.

Colloquia

Should We Vote on How We Vote? (*Mike Orrison*, Tuesday)
Voting is something we do in a variety of settings, but how we vote is seldom questioned. In this talk, we'll explore a few different voting procedures from a mathematical perspective as we try to make sense of the paradoxical results that can occur when we vote in more than one way.

Tournaments Having the Most Cycles. (*John Mackey*, Wednesday)
A round robin tournament is a set of matches in which each contestant plays all other contestants. Just how confusing can the outcome of a round robin tournament be? Directed cycles are an impediment in ranking the participants in a tournament, so let's try to figure out which tournament outcomes have the most directed cycles.

This problem is about three-fourths solved. Open problems and connections with the zeta function will be discussed.

Impostor Phenomenon. (Staff, Thursday)
What is impostor phenomenon? The impostor phenomenon – also sometimes referred to as impostor syndrome – is a pattern in which, even in presence of external evidence to the contrary, an individual doubts their own accomplishments. This leads to a fear of being exposed as a fraud, and a belief that they do not deserve their achievements. For example: the feeling that everyone else in a course is "getting it" and you aren't, or feeling that you need to prove yourself to your peers in order to fit in – these are both instances of the impostor phenomenon (IP) at work.

Impostor phenomenon at Mathcamp: The American Psychological Association says: "impostor phenomenon seems to be more common among people who are embarking on a new endeavor." There's plenty of research showing that the IP affects academic, high school, and high-achieving groups. This has been corroborated by Mathcampers and staff from previous years who have said that they felt like they were impostors at camp.

What is this event? There are a variety of suggested ways to mitigate the impact of the imposter phenomenon: education, communication, and reflection. We'll try to hit all three of these during a colloquium and dinnertime event. During the colloquium, we'll take a look at what might lead people to believe that they are underachieving, and hear some staff experiences with the IP. Afterwards, we will have a discussion period where we can talk about our own experiences, and set goals for lessening the impacts of the impostor phenomenon at Mathcamp.

Colloquium 1.4. (*Po-Shen Loh*, Friday)
Blurb to be updated.

Visitor Bios

Sam Gutekunst. Sam was a Mathcamp mentor in 2015-2017 and visiting faculty in 2018. He's a PhD student in Operations Research at Cornell University working on combinatorial algorithms. At camp, he's a fan of capture the flag, innertube water polo, frisbee, and all sorts of shenanigans!

Jeff Hicks. Jeff ended up in his field of mathematics by always choosing to study things that involved drawing diagrams and pictures. When not studying 6-dimensional spaces, you can find him salsa dancing, playing piano, trying out a new board game, or napping on the nearest soft surface of genus 0.

John Mackey. After giving a final exam early in my career, a group of students remained to chat and discuss the course. Eventually I got up the nerve to ask the students what they thought of the class. One of them exclaimed, "Mackey, you're unbelievable!". I blushed and said, "Thanks so much, that's very kind." After some awkward silence, one of the students offered, "Perhaps you misunderstand."

Here's what you need to know:

(1) I've gotten better at teaching.
(2) We'll have a great time this summer!

Believe it.

Michael Orrison. Michael is a professor of mathematics at Harvey Mudd College, where he has been since 2001. His teaching interests include linear algebra, abstract algebra, discrete mathematics, and representation theory. His research interests include voting theory and harmonic analysis on finite groups. In particular, he enjoys finding, exploring, and describing novel applications of the representation theory of finite groups. He also enjoys cooking, watching movies, and coaching and refereeing soccer.

Mia Smith. Hi, I am Mia! I have been coming to Mathcamp since 2010, first as a camper and then as a JC. During the year I teach at Proof School; feel free to come talk to me about teaching outside of academia (or anything else)! Although I have less time for math research these days, my primary mathematical/research interests are in graph theory and combinatorial geometry. When I am not doing math, I enjoy trail running, hiking, backpacking, crossword puzzling, salsa dancing, and drawing bad cartoons.

Steve Schweber. I'm a postdoc in the math department at the University of Wisconsin - Madison. My research is in mathematical logic, specifically set theory and computability theory; I'm interested in things that don't exist but should and computations you can't do but want to. (All my favorite sentences begin, "X isn't countable, but **if it was**, ...")

Outside of mathematics, I enjoy riding my unicycle, making terrible puns, and playing chess (badly) and frisbee (slightly less badly).