CLASS DESCRIPTIONS—WEEK 4, MATHCAMP 2014

Contents

09:00am Classes

NP-Completeness and Latin Squares. (🌶🌶🌶🌶, Paddy, Tuesday–Saturday)
Fun fact: completing an arbitrary Latin square is an NP-complete task! In this class, we're going to prove this. Specifically, we're going to do the following:

(1) Introduce the concepts of algorithms and runtime.
(2) Define the concepts of P and NP.
(3) Introduce the concept of NP-completeness, and look at a handful of NP-complete problems.
(4) Show that completing a Latin square is one of these kinds of problems!
(5) Discuss some open problems I'm interested in that branch off of this result.

The first two days of this class will focus on talking about P, NP, and NP-completeness. Students who are already familiar with these two concepts are welcome to join the course after these classes; students who are unsure if they are familiar with these concepts are encouraged to talk to me!

Homework: Recommended

Prerequisites: Knowing what a Latin square is; also, what a graph is.

Related to (but not required for): Latin Squares, Models of Computation as Strong as Programming

Tilings, Groups, and Orbifolds. (🌶🌶🌶, *Noah Snyder*, Tuesday–Saturday)

The goal of this course is to understand, classify, and learn to recognize tiling patterns on the plane like this one from the Alhambra:

This course has two goals, one theoretical and one practical. I will outline the classification of wallpaper groups via orbifolds following Conway and Thurston. This will involve a quick trip through symmetry groups, orbifolds, and Euler characteristic. The other equally important goal will be to learn to recognize wallpaper groups in practice. To this end we will spend a certain amount of time both in class and in homework identifying actual tiling patterns from nature.

Prerequisites: Group theory

Homework: Required (but not a lot)

When Factoring Goes Wrong. (🌶🌶, J-Lo, Tuesday–Saturday)
When is a natural number n the sum of two squares? That is, when can you write it as $n = a^2 + b^2$? Perhaps you've already seen a proof that this holds for primes p iff $p \equiv 1 \pmod 4$, but many of these proofs overlook the deeper structure underlying the problem. Not to mention they don't shed much light on the general case of all natural numbers. But it turns out there's a remarkably straightforward description of what's going on... if you know how prime factorization works when complex numbers are involved.

Pythagorean triples, Pell's equation, and several other problems in number theory all turn out to reveal many secrets when you factor the corresponding equations in the right context. In this class we'll take a look at how factoring works in number systems other than the plain old integers. I'll introduce the concept of Unique Factorization Domains, which are fundamental objects of study in modern number theory, and we'll investigate some of the various ways in which factoring can start to look very, very weird.

Homework: Recommended

Prerequisites: A Quick Introduction to Number Theory (divisibility and modular arithmetic); Ring Theory (definition of rings and ideals)

Related to (but not required for): A Quick Introduction to Number Theory, Pythagorean Triples & Unsolvable Equations, Geometry of Numbers

Galois Theory (Week 2 of 2). (🌶🌶🌶🌶, Mark, Tuesday–Saturday)
Building on the material from Week 2 (the first week of this class), we'll start by covering the fundamental theorem of Galois theory, which gives a beautiful correspondence allowing us to find and describe field extensions in terms of subgroups of the Galois group. We will then move on (perhaps with some side trips to scenic overlooks of other material) to sketch the proof that there is no general way of solving polynomial equations of degree 5 or more by radicals, that is, there is no analog of the quadratic formula for degree 5 and higher. (There are such analogs for degree 3 and 4.)

Homework: Recommended

Prerequisites: Galois Theory (Week 1 of 2)

Error-Correcting Codes. (🌶🌶, Kevin, Tuesday–Saturday)
Suppose Misha and Pesto are sending messages to each other about TPS. Misha has a brilliant idea for a problem which he communicates to Pesto by transmitting a series of bits. Unfortunately, not all of the bits reach Pesto intact. Maybe Don nefariously tampers with some of the bits, or maybe Steve sprinkles a few extra in because he thinks it makes the message look prettier, or maybe Paddy eats some of them. One way or another, the information Pesto receives isn't quite right. As a result, instead of TPS being full of beautiful problems, there's an unsolvable problem that ruins the evening for dozens of unsuspecting campers. This disaster could have been prevented! Misha and Pesto could have used *error-correcting codes* rather than transmitting the message verbatim. In this class, we'll study some basic information-theoretic concepts and strategies for encoding messages so that the original information can be reconstructed even if errors creep in during transmission. The error-correcting codes we will discuss in this class have common real-world applications, from bar codes on airport boarding passes to data storage on DVDs. And more importantly, they'd ensure that Misha's message gets through to Pesto intact, even if Paddy eats a large chunk of the data!

Homework: Recommended

Prerequisites: Modular arithmetic

Related to (but not required for): Finite Geometries

10:00am Classes

Problem Solving: Polynomials. (🌶🌶🌶🌶, Pesto, Wednesday–Saturday)
If P is a degree 2014 polynomial and $P(k) = 2^k$ for the first 2015 positive integers k, what's $P(2016)$? What if $P(k) = \frac{k}{k+1}$? More importantly, is there a more systematic way to approach such questions (say, on an olympiad) than to just see the right approach?

I won't spoil the first two, but the answer to the third question is "yes"—come find out!

This is a problem-solving class: I'll present techniques, but most of the time will be spent having you present solutions to olympiad-style problems you'll've solved as homework the previous day.

Disjoint from last year's polynomials problem solving class. Not completely disjoint from two years ago's class; talk to me about conflicts.

Homework: Required

Prerequisites: Linear algebra (enough to be comfortable with the statement "$\{1, x+1, (x+1)(x+2)\}$ and $\{1, x, \frac{x^2}{2}\}$ are bases for polynomials of degree at most 2" and convert between them)

Related to (but not required for): Other problem solving classes; Discrete Derivatives

Geometry of Numbers. (🌶🌶, Ruthi, Wednesday–Saturday)
Let L be all of the points in $\mathbb{R}^2$ with integer coefficients. If I give you a region R in the plane, how many points of L lie inside R? Some of you may know of Pick's Theorem, which gives us one way of

looking at this question in a special case. But what if R isn't a polygon — what if it's super crazy? Does it even contain any points in L? What if we change L a little? What about if I ask the same question for $\mathbb{R}^n$? In this class we will explore these kinds of questions, and maybe even say something about how they relate to questions about the relationship between rational and irrational numbers.
Homework: Recommended
Prerequisites: basic modular arithmetic
Related to (but not required for): A Quick Introduction to Number Theory, When Factoring Goes Wrong

Gödel's Incompleteness Theorem. (🌶🌶🌶, Steve, Wednesday–Saturday)
The usual axioms of arithmetic - associativity and commutativity for + and ×, induction, etc. - let us prove a bunch of very useful things! But, those axioms would be silly if they let us, for example, prove "0=1." In general, we are only interested in *consistent* systems of axioms, that is, systems which do not prove any statement of the form "P and NOT P."

So a natural question to ask is, "How do I tell if these axioms are consistent?" More precisely, "Can I *prove* that these axioms are consistent?" This question is what this class is all about. In 1931, a mathematician named Kurt Gödel surprised everyone by showing that, in fact, *no* reasonably nice set of axioms can prove its own consistency. In particular, he showed that no reasonably nice set of axioms is "complete," that is, decides (proves or disproves) every statement.

In this class, we'll prove - after making precise! - everything I just said; this involves coming up with completely formal notions of "sentence" and "proof," and, more interestingly, finding ways of talking about sentences and proofs as if they were numbers. If time permits, we'll talk a little about how this theorem led to computability theory and to proof theory, two distinct areas of logic.

(A fun note: we'll begin by talking about Gödel's Completeness Theorem, partly because it's relevant, but also because really, if you have an incompleteness theorem, you should also have a completeness theorem proved by the same person just to mess with everyone.)
Homework: Recommended
Prerequisites: Formal proof; uncountability of the reals
Related to (but not required for): Universal Algebra

Scandalous Curves. (🌶🌶🌶, Jeff, Wednesday–Saturday)
Sometimes you see a function, and you are comfortable looking at it. Functions like $f(x) = \sin(x)$ and $g(x) = x^2 + 1$. But sometimes you see a function and it makes you squirm a little bit.

- (Merely Misbehaving) A function like $\frac{1}{x}$ or $|x|$ has some bad points, but is mostly good.
- (Bad) A continuous function which has $f'(x) = 0$ almost everywhere, but increases monotonically from 0 to 1 would be bad (think about the fundamental theorem of calculus), but nothing too terrible to look at.
- (Sinful) A continuous function from the real numbers to the unit square that covers every point in the unit square would make most people uncomfortable.
- (Scandalous) If you are comfortable with a continuous function that is differentiable at no point, then you have a problem.

While it may seem unusual to find a scandalous function, we will show in this class that "most" functions are actually scandalous, and you can't spend your whole life ignoring them. Besides constructing the above functions, we will also explore convergence for functions, metric spaces of functions, random functions and what it means for a function to be "generic".
Homework: Required
Prerequisites: You should be comfortable with "$\lim_{n\to\infty} x_n = x$" and "$f(x)$ is continuous" using $\delta - \epsilon$ definitions.
Related to (but not required for): Moore Method Point-Set Topology

SUPERCLASS!

(Th)ink Machine. (🌶→🌶🌶🌶, Aaron, Tuesday, 11-11:50 and Weds–Saturday, 10-11:50)
Computation is the process of sculpting with information—cutting it down, drawing it out, and shaping it into something new. Like other forms of sculpture, it's both fun to do and beautiful to watch. It's also a creative activity: its results can surprise us, and tell us things we hadn't known before. The aim of this course is to introduce the basics of computer science in a way that emphasizes the aspects described above. We'll see how the idea of "sculpting with information" can be turned into a rigorous definition of computation, and then we'll use our definition to explore the limits of what computers can do. If you love building machines, making art, solving puzzles, or proving by example, this is the course for you. You'll have a lot of creative freedom, and a lot of options for what you want to study. Whether you're a total computer science beginner looking for a 🌶 introduction or a seasoned Turing machine wrangler ready for a 🌶🌶🌶 obstacle course, you should be able to find something fun to do.

This class is a *superclass*, which means that it meets during two consecutive class periods. It's a big time commitment, but it pays off!

11:00am Classes

The Continuum Hypothesis. (🌶🌶🌶🌶, Susan, Tuesday–Saturday)
A continuation of the Week 3 class.

Homework: Required

Prerequisites: None

Discrete Derivatives. (🌶🌶, Tim!, Tuesday–Wednesday)
Usually, we define the derivative of f to be the limit of $\frac{f(x+h)-f(x)}{h}$ as h goes to 0. But suppose we're feeling lazy, and instead of taking a limit we just plug in $h = 1$ and call it a day. The thing we get is definitely not a derivative, but it acts sort of like one. It has its own version of the power rule, the product rule, and integration by parts, and it even prefers a different value of e. We'll take an expedition into this bizarre parallel universe, and then we'll apply what we find to problems in our own universe.

Homework: Recommended

Prerequisites: Calculus (derivatives)

Related to (but not required for): Problem Solving: Polynomials

The Classification of Surfaces. (🌶🌶, *Dan Zaharapol*, Thursday–Saturday)
A *surface* is a topological space that looks locally two-dimensional: that is, like a plane, but possibly curved. Examples of surfaces are objects like spheres, tori, two-holed tori, the projective plane, and the Klein bottle. The world of three-dimensional (and higher) spaces is a great big mess of things that are hard to classify, but – remarkably – we can write down exactly what every possible surface is, in terms of "sums" of a few building blocks. The proof involves lots of pictures and is beautiful and fun.

Related to (but not required for): Combinatorial Topology; How to Cut a Sandwich

Fractal Wanderings: Hanoi and Mandelbrot. (🌶🌶, *Julian Gilbey*, Tuesday–Fri)

– *What does the B in Benoit B. Mandelbrot stand for?*
– *Benoit B. Mandelbrot*

"In the great temple at Benares, beneath the dome which marks the centre of the world, rests a brass plate in which are fixed three diamond needles, each a cubit high and as thick as the body of a bee. On one of these needles, at the creation, God placed sixty-four discs of pure gold, the largest disc resting on the brass plate, and the others getting smaller and smaller up to the top one. ..."

Thus begins the legend of the Tower of Hanoi.

After an introduction to fractals and their fractal dimensions on Tuesday, we will explore this ancient problem (well, it dates back to 1883). It conceals deep secrets and universal truths: it turns out to be intimately connected to a very familiar fractal.

On Thursday and Friday, we will explore the most famous of all fractals: the Mandelbrot Set. On Thursday, we will be in the computer room to introduce complex dynamics. Then on Friday, we will develop this further back in the classroom, leading to an explanation of what the Mandelbrot set is and how it works.

Homework: Optional

Prerequisites: Logarithms; Complex numbers

Related to (but not required for): Fractal zoo

Sieves! (🌶🌶, Ruthi, Saturday)
Maybe you hear the word sieve and you think, I should ask Steve about that. Maybe you think of the Sieve of Eratosthenes. It turns out that sieves are used all the time to study problems in number theory (including in my own research!). We'll talk about some more complicated problems that can be approached with sieve methods, and touch on how they fail at times as well.

Homework: None

Prerequisites: None

Elliptic Functions. (🌶🌶🌶, Mark, Tuesday–Saturday)
Complex analysis, meet elliptic curves! Actually, you don't need to know anything about elliptic curves to take this class, but they will show up along the way. Meanwhile, if you like periodic functions, such as cos and sin, then you should like elliptic functions even better: They have two independent (complex) periods, as well as a variety of nice properties that are relatively easy to prove using some complex analysis. Despite the name, which is a kind of historical accident (it all started with arc length along an ellipse, which comes up in the study of planetary motion; this led to so-called elliptic integrals, and elliptic functions were first encountered as inverse functions of those integrals), elliptic functions don't have much to do with ellipses. Instead, they are closely related to cubic curves, and also to modular forms. If time permits, we'll use some of this material to prove the remarkable fact that

$$\sigma_7(n) = \sigma_3(n) + 120 \sum_{k=1}^{n-1} \sigma_3(k)\sigma_3(n-k)\,,$$

where $\sigma_i(k)$ is the sum of the i-th powers of the divisors of k. (For example, for $n = 5$ this comes down to

$$1 + 5^7 = 1 + 5^3 + 120[1(1^3 + 2^3 + 4^3) + (1^3 + 2^3)(1^3 + 3^3) + (1^3 + 3^3)(1^3 + 2^3) + (1^3 + 2^3 + 4^3)1]\,,$$

which you are welcome to check if you run out of things to do.)

Homework: Recommended

Prerequisites: Complex analysis - if you took Kevin's class, at least one week's worth; it would help if you knew Liouville's Theorem, but I can catch you up on that if necessary.

Related to (but not required for): Cubic Curves; Congruent Numbers and Elliptic Curves; Fermat's Last Theorem for Polynomials

Pants and Co-Pants: an Introduction to Topological Quantum Field Theories. (, *Angélica Osorno*, Tuesday–Wednesday)
A surface is a topological space that locally looks like a copy of R^2. A simple example is a sphere: when we are standing on the earth, it seems flat. A *topological quantum field theory (TQFT)* is a way of assigning algebraic invariants to surfaces (as well as higher-dimensional manifolds). Not only does a TQFT assign numbers to closed surfaces, it assigns linear maps to surfaces with boundary in such a way that you can compute the value on a closed surface by chopping it up into pieces and composing the linear maps on each piece.

In this class we will learn the basic definitions and then explore some examples. The examples will involve a lot of pictures, corresponding to the manifolds we are representing algebraically. The title of the course? It turns out that for TQFT, the most basic surface is a "pair of pants". But sometimes we want to reverse the direction, and then we get a "pair of co-pants".
Homework: Recommended
Prerequisites: Category Theory; Linear Algebra; some topology useful but not required

Sperner's Lemma. (, Tim!, Thursday–Saturday)
Suppose that after Mathcamp you and your new friends decide to hold a reunion in Alaska. You rent an igloo to share, and you will all chip in to pay for it. But how do you decide who gets to sleep where, and how much each person should pay? You'd be willing to pay more to sleep in a bed rather than a couch, and that's still worth more than the frozen floor. Different people have different preferences — some may rather get a nice bed, while others might not care where they sleep as long as they save money. Can you arrange it so that nobody is jealous of another's sleeping spot (with its corresponding price tag)?

Especially if there's a lot of people, it's not clear that you can come up with envy-free room assignments. But it's possible! The justification relies on an aesthetically-pleasing result about coloring points in a triangle. And this unassuming lemma (whose proof is particularly cute) can prove a whole host of other facts too! It gives a way to fairly divide a cake among friends. It can prove Brouwer's fixed-point theorem (if I crumple up a map of Lewis & Clark and throw it on the ground, some point on the map will be on top of the real-life point it represents). It can prove that a square cannot be divided into an odd number of equal-area triangles, but you have to see it to believe it.

Come experience what this lemma can do!
Homework: Optional
Prerequisites: None.

1:00pm Classes

Bernoulli Numbers. (Dave Savitt, , Wed–Sat)

Here are three facts:

- The sum of the fourth powers $1^4 + 2^4 + \cdots + (m-1)^4$ is equal to $\frac{m^4}{4} - \frac{m^3}{2} + \frac{m^2}{4}$;
- We have infinite sums $\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \cdots = \frac{\pi^2}{6}$ and $\frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \cdots = \frac{\pi^4}{90}$;
- The special case of Fermat's last theorem $x^7 + y^7 = z^7$ has no integer solutions with x, y, z nonzero.

In this class we'll explain why these three facts (and generalizations of them involving higher powers) are equivalent, and we'll see what this has to do with the mysterious sequence 1, $-1/2$, $1/6$, 0, $-1/30$, 0, $1/42$, 0, $-1/30$, 0, $5/66\ldots$ of *Bernoulli numbers.*
Homework: None
Prerequisites: Be able to prove $e^{iz} = \cos z + i \sin z$ using Taylor series

Finite Geometries. (🌶, Misha, Tuesday–Saturday)
In 1899, Hilbert wrote down a set of 16 axioms that uniquely characterize Euclidean geometry: that is, up to isomorphism there is only one thing that satisfies them all, and it is the Euclidean plane.

We will stop reading at Axiom 3. Accordingly, we will have many more things that satisfy our axioms, including the Euclidean plane but also including, for example, the cards in a SET deck. (By the way, if you want to know why Projective SET is called that, come to my class.)

Homework: Recommended

Prerequisites: None.

Related to (but not required for): Latin Squares

Generating Functions, Partitions, and Catalan Numbers. (🌶🌶, *sVen*, Tuesday–Saturday)
You may think you know how to count, but there are many clever ways to count that you have probably yet to experience. An especially interesting and powerful tool is *generating functions*, which simply take a sequence and make it into a (possibly infinite degree) polynomial. For example, the Fibonacci sequence has the generating function:

$$1 + x + 2x^2 + 3x^3 + 5x^4 + 8x^5 + 13x^6 + 21x^7 + \cdots,$$

which can be more compactly written as $\frac{1}{1-x-x^2}$. It turns out that algebraic operations on generating functions can help us easily count things that are much harder to figure out by other means. We'll use these to better understand lots of counting numbers, including binomial coefficients, partitions of sets and integers, and the ubiquitous Catalan numbers – a sequence that counts everything from the number of ways n pairs of dinner guests can shake hands to the number of ways of arranging n sets of parentheses:

$$\begin{array}{ccc} () & \longrightarrow & C_1 = 1 \\ ()() \quad (()) & \longrightarrow & C_2 = 2 \\ ()()() \quad (())() \quad ()(()) \quad (()()) \quad ((())) & \longrightarrow & C_3 = 5 \\ \text{etc.} & & \end{array}$$

Homework: Recommended

Prerequisites: None

Geometry of Groups. (🌶🌶🌶🌶, Don, Tuesday–Saturday)
Many groups were originally understood as a set of transformations taking place on some geometric object. Any polygon or polyhedron has both a group of rotations and a larger group of symmetries. A vector space has a group of translations and a group of invertible linear transformations. These groups are often studied in order to understand deeper properties of the geometric object in question.

In the geometry of groups, we'll be going in the opposite direction: start with a group, and then associate a canonical geometric object (actually a metric space) to that group. The new question will be: what properties of the group can be recovered from this object?

It turns out, quite a few. Although a group won't be uniquely determined by its associated space, in this class we'll see what the geometry of a group can tell us about its size, shape, and how well behaved it is.

Homework: Recommended

Prerequisites: Group Theory

Moore Method Point-Set Topology. (🌶🌶🌶🌶, Alfonso, Tuesday–Saturday)
This is the last of our four weeks of Moore Method point-set topology. We will explore nets, filters,

and waffles as a generalization of sequences. All the results that we would hope to be true for sequence, but which are sadly false, become true for these generalizations. And we get to prove (the equivalence of) Tychonoff's Theorem and the Axiom of Choice. What is not to like?
Homework: Required
Prerequisites: If you have some background in point-set topology and would like to join us, please talk to me.

Colloquia

See-Saw Swap Solitaire and Other Games on Permutations. (*sVen*, Tuesday)
We'll take a look at a number of different rule sets for moving among the space of all $n!$ permutations of the symmetric group on n. Some of these will produce mathematically interesting integer sequences, and some will produce games that are fun to play.

Quaternion Algebras. (*Dave Savitt*, Wednesday)
On a crisp fall day in 1843, while taking a walk along the Royal Canal in Dublin, William Rowan Hamilton realized that he could extend the arithmetic of the complex numbers to create an algebraic structure on four-dimensional Euclidean space: $\mathbb{H} = \{x + iy + jz + kw : x, y, z, w \in \mathbb{R}\}$ with $i^2 = j^2 = -1$ and $k = ij = -ji$. Hamilton's key realization was that the multiplication would have to be non-commutative: ij is not equal to ji.

Our questions: can we generalize Hamilton's construction to make other algebraic structures on four-dimensional spaces? If yes, then how many? Along the way towards answering these questions, number theory will enter the picture in surprising ways.

This talk is related to Steve's Week 3 class "On Beyond i", but radically different in destination.

The Future of You! (The Mathcamp Staff, Thursday)
This is an annual Mathcamp event, in which the staff share their educational and career experiences to help you think about your future: how to survive until college, what to look for in choosing a college, how to get the most out of college, and what to do afterwards. (The one thing we won't talk about is how to get into college; that's what you have college counselors for.)

This year, we are hoping to make the event even more interactive, so bring lots of questions. Although the focus will primarily be on the US educational system, much of the discussion should be relevant to students from other countries as well.

Algebra in Higher Dimensions. (*Noah Snyder*, Friday)
We write mathematics, like we write words, on a line. This means you can multiply on the left or on the right, but not on top or bottom. In 2-dimensional planar algebra, you can use the whole page to write your expressions, multiplying in any direction you like. Planar algebras play an important role in operator algebras, knot theory, and quantum groups. Of course there's no reason to stop at the plane: you can also use n-dimensional space to write your expressions, or even more complicated manifolds (although in this talk I'll mostly focus on dimensions 1 and 2).

Visitor Bios

Angélica Osorno. Angélica Osorno's research lies in the intersection between algebraic topology and category theory. In particular, she is interested in understanding how to construct topological structures out of categorical ones. When she is not thinking about topology, Angélica enjoys going to the beautiful natural places around Portland.

Dan Zaharapol. Dan has been at Mathcamp since 1999 as a student, JC, mentor, faculty, and visitor. In grad school he worked in algebraic topology and theoretical computer science. Now he's a social entrepreneur working to create a realistic pathway for underserved students to become scientists, mathematicians, engineers, and programmers.

Dave Savitt. Dave is a professor at the University of Arizona, studying number theory. He has been involved with Mathcamp longer than anyone else: this is going to be his 20th summer! He is visiting with his wife Catherine and daughter Emilia, who is making her Mathcamp debut: she is only 7 months old. When he is not doing math or being Mathcamp's Top Blueberry, Dave is into Scrabble, puzzles, hockey, and gastronomy.

Julian Gilbey. Julian has been a Mathcamp visitor for many years, and was a mentor in the distant past. He was also a high-school math teacher for ten years, and is now creating teaching resources for 11th and 12th graders for the Cambridge Mathematics Education Project. And in his spare time, he has been known to help with the yearbook. . . .

Noah Snyder. Noah is an assistant professor at Indiana University, working in higher dimensional algebra. His other interests include extinct animals, adorable chess, number theory before 1920, and the finite group game.

sVen. sVen (aka Tom Roby) is a professor of math at the University of Connecticut, with interests in combinatorics, algebra, and math education. He is interested in how concrete combinatorial objects, such as integer partitions or lattice paths, help us understand structures in more abstract settings. He particularly likes using conceptual stories ("bijections") to prove identities, and harnessing the power of algebra to count things in sophisticated ways. This is sVen's first visit to Mathcamp, but he has been on the staff of many other summer math programs over the years, including MathPath, the Ross Program (where he was first a student), HCSSiM, and PROMYS (where he was the founding head counselor). In his spare time, sVen is an avid folk dancer, sings in a Bulgarian folk music ensemble, and studies ancient Japanese poetry.