Class descriptions—Week 1, Mathcamp 2006

Contents

Classrooms

Our regular classrooms on Week 1 are Jones 204, Jones 211, Jones 213, Jones 302, Jones 303, and Howarth 005. The colloquia happen at McIntyre 103. Many of George Hart's workshop are at Anderson/Langdon 106. The latex workshop on Friday evening is at Howarth 011.

Classes beginning in Week 1

Applied linear algebra ($**$, Mira, 10am, week 1 of 2 (Weeks 1 and 3))

Linear algebra is one of the most useful methods in mathematics, rich in applications both to the real world and to pure math. One could argue that much of what mathematicians (and physicists, and engineers, and economists) do with their time is try to reduce hopelessly complicated non-linear problems to linear ones that can actually be solved. Thus for many applied fields, the most important math to know is not calculus, but linear algebra.

This is a two-week class offered in Weeks 1 and 3 of camp (with a break during Week 2). Week 1 will be an introduction to the basic framework of linear algebra, with a view toward applications. If you want a more thorough, abstract treatment of the subject, take Anti and Alfonso's course "Vectors & matrices, tensors & spinors". In our class, we will certainly do some proofs, but our goal will be to get to the main tools we need for the applications (eigenvectors and eigenvalues, diagonalization) and we'll skip everything we don't need to get to those tools.

The second week of the course (Week 3 of camp) will be devoted to actual applications. If you already know about eignevectors and eigenvalues, you are welcome to skip Week 1 and come just for Week 3. Topics will include Web search engines, population genetics, image processing, and possibly some others. Another application (spectral clustering) will appear in the classes of Marina Meila, who is visiting on Friday of Week 1. The Week 1 part of the Applied Linear Algebra class should provide precisely the prerequisites that you need to follow her lectures.

Prerequisites: none.

Homework: required.

Required for: "Projective geometry" (Weeks 2–3), "Quadratic forms" (Week 2), "Linear programming" (Week 2), "Convex cones" (Week 3), "Quantum topology" (Week 3), "Semidefinite programming" (Week 4), "Representation of finite groups" (Week 3). Also very useful for Marina Meila's colloquium on Friday. Linear algebra appears everywhere!

Related to: Vectors and matrices, spinors and tensors (Weeks 1–4).

Combinatorial game theory ($**$, Alfonso, 1pm, week 1 of 2)

We have some baskets of berries in front of us and take turns eating them. On your turn, you can eat as many as you want, as long as they are all from the same basket. Then it is my turn to do the same. The winner will be the one who eats the last berry. Ignoring the potential for a stomachache, will you be able to beat me?

This course will focus on combinatorial game theory. We are not interested in playing games (although berries are delicious), but rather on analyzing games, obtaining winning strategies and understanding why they work. *Nim*, the berry game described above, is a model for a large family of them, and there is a whole mathematical theory behind them.

We will end the course with Open Problems in Combinatorial Game Theory: real research problems about games similar to Nim.

Prerequisites: none.

Homework: optional.

Combinatorics (∗, Ellen, 10am, week 1 of 1)

Perhaps surprisingly, knowing how to count objects is extremely useful in abstract mathematics. Being able to count effectively can help you calculate the dimensions of a vector space, understand the representations of a finite group, or even help you compute how close two convex bodies are to each other. In this class, you will learn the basic tools of counting, including (but not limited to) permutations, combinations, and inclusion–exclusion.

Prerequisites: none.

Homework: required.

Required for: "Polytopes" (Week 4).

Related to: all kinds of mathematics!

Constructive Geometry (∗, Dave A, 1pm, week 1 of 1)

This course is about really old math. Ancient math, in fact, from a time when numbers weren't so easily separated from the geometric quantities they represented. We'll see what can be done with basic geometric constructions, find several ways to trisect angles and double cubes, and meet some interesting curves along the way. And of course we'll draw everything we discuss.

Prerequisites: none.

Homework: recommended.

Related to: "Archimedes' school of rock" (Week 2), "Projective geometry" (Weeks 2-3), "Singularities and knots" (Week 4). eeks 2 through 4, and Sam's in week 2.

Fermat's Dream I (∗∗∗∗, Miljan, 1pm, week 1 of 2)

The starting point of number theory is astonishment at the wonders of numbers. The work of Fermat, who is considered to be a founding father of modern number theory, illustrates very well the wonder of numbers. We will learn how mathematicians of later eras little by little found a fascinating world behind each fact discovered by Fermat.

Fermat's Last Theorem states

"For $n \geq 3$, there exist no natural numbers x, y, z satisfying the equation $x^n + y^n = z^n$."

It was proven in September 1994 by Andrew Wiles. This theorem had resisted proof for more than 350 years, representing one of the most spectacular journeys in the history of mathematics. Come and join us in taking the first few steps of it!

Homework: optional.

Prerequisites: We will cover all the necessary prerequisites, but we will do it really fast. Hence, it will be useful to be familiar with groups, rings, and fields.

Related to: "Fermat's last dream II" (Weeks 3-4), number theory in general.

How to read a math paper (∗∗∗, Dave S and David R, 11am, week 1 of 2 (Weeks 1 and 3))

Reading a math research paper is entirely different from reading a math book: instead of building up the necessary background and spelling out every step, the author usually assumes more knowledge from the reader, and leaves many details to be worked out. However, it's a fact of life that mathematicians often have to understand research papers for which they don't have all the necessary background, and it takes a lot of experience to be able to do this. In this course you'll start to get some practice, working in small groups to try to read a recent research paper.

Hyperbolic geometry (∗∗, Dan and Ryan, 9am, week 1 of 1)

Some things, you're just used to. The sum of the angles in a triangle, for example — that's always π. If I take a line ℓ, and a point p, then there's exactly one line ℓ' that's both parallel to ℓ and goes through p. These are all things that hold in Euclidean space, the flat, boring old plane you're used to.

But go to the hyperbolic plane and all these things fall apart. The hyperbolic plane is a place where the angle measures of a triangle tell you what its area is. And there are more parallel lines there than you can shake a stick at...

Through our exploration of hyperbolic geometry, we'll better understand notions of length and what makes a geometry at all, we'll figure out what makes Euclidean geometry Euclidean, as opposed to... something else, and we'll see hints of applications to relativity. Join us for this exploration into new ways of thinking about geometry.

Homework: none.

Prerequisites: high–school geometry and trigonometry. Calculus is useful, but not necessary.

Related to: "Constructive geometry" (Week 1), "Projective geometry" (Weeks 2–3), "Archimedes' school of rock" (Week 2).

Information Theory (∗∗∗, Mira, 11am, week 1 of 2)

In 1948, Claude Shannon published a paper called "A Mathematical Theory of Communication". By the time the paper came out as a book in 1949, its name had changed to "The Mathematical Theory of Communication". It took only a year for people to realize that what Shannon had invented was *the* theory – now usually called *information theory.*

All sorts of communication devices existed in Shannon's day – telegraph, telephone, radio, and TV, not to mention plain old human writing and speech. Shannon's insight was that all these different media could be analyzed within a single mathematical framework: the transmission of *information*, a concept which could be defined mathematically. Shannon showed that any channel – even a very noisy one, with lots of errors and distortion – has a certain rate at which it can transmit information virtually error-free. Anything up to that rate is possible, at least in theory; anything beyond it is hopeless.

Shannon's paper has been called "the Magna Carta of the Information Age" and was the mathematical foundation of the digital revolution: every digital device that you've ever used runs on information theory just as surely as it runs on electricity. But the basic framework of information theory is actually quite elementary. In this course, I hope to let you discover a lot of it on your own – while solving some really fun problems along the way. First, of course, we'll have to define what we mean by "information"; for this we'll need some probability theory, which we'll pick up as we go. We'll talk about the redundancy of English (which Shannon estimated in a really clever way, using a game similar to Hangman) and what this has to do with file compression. We'll go a little beyond Shannon's paper and show how to do some of the things that he only proved were theoretically possible. And while we may not get to the full proof of the Channel Capacity Theorem, we'll definitely get far enough that you'll understand the statement and the intuition behind the proof.

Prerequisites: logarithms, basic probability; some basic combinatorics helpful.

Homework: required

Introduction to groups and group theory (∗∗, Sam, 9am, week 1 of 2)

This class will be a nontraditional introduction to one of the fundamental classes of objects in algebra – groups. Groups are one mathematical way of encapsulating symmetry, and "group actions" are the natural way of representing or realizing these encapsulated symmetries. In this class, we will explore the basic properties of groups mainly by looking at how symmetries act on familiar objects, and to a lesser extent we will look at the abstract structure of groups in and of themselves.

You may enjoy pondering the following question: how many different ways can you permute the four diagonals of a cube, using only the rotational symmetries of the cube?

Required for: "Representation of finite groups" (Weeks 3–4).

Related to: "Symmetric functions" (Weeks 3–4), "Fermat's dream I & II" (Weeks 1–4).

Homework: optional.

Introduction to number theory ($**$, Mark, 11am, week 1 of 2)

How do you find the GCD of two large numbers without having to factor them? What postages can you get (and not get) if you have only 8 cent and 17 cent stamps available? What is the mathematics used when you send confidential information, such as your credit card number, over the Internet? Besides the answers to such questions, number theory offers insight into many beautiful and subtle properties of our old friends, the integers. For thousands of years professional and amateur mathematicians have been fascinated by the subject (by the way, some of the amateurs, such as the 17th century lawyer Fermat and the modern-day theoretical physicist Dyson, are not to be underestimated!) and chances are that you, too, will enjoy it quite a bit.

Prerequisites: none.

Required for: almost anything related to number theory or abstract algebra.

Homework: recommended.

Multivariable calculus (crash course) ($***$, Mark, 9am, week 1 of 1)

In real life, most interesting quantities depend on several variables (such as the coordinates of a location, the time, the temperature, etc.). As a result, ordinary (single-variable) calculus isn't enough to solve most problems. This class will quickly take you through the basics of calculus of several variables. As time permits, we'll see some cool applications in and outside math, for instance:

- if you're in the desert, in what direction should you go to cool off as soon as possible?
- how large is the total area under a bell curve?
- what force fields are consistent with energy conservation? With luck, we'll also cover Green's Theorem, which will be used next week in the complex analysis course.

Prerequisites: Single–variable calculus.

Required for: "Complex analysis".

Homework: recommended.

Proof Techniques ($*$, Marisa, 9am, week 1 of 1)

First of all: you should absolutely take this class if you are unfamiliar with proof by contradiction, proof by induction, proof by construction, or the pigeon hole principle. They're essential at camp (and in life). You should also take this class if you're not comfortable reading and writing proofs, or if you've ever wondered what "Q.E.D." stands for.

On to the description: We will use classical, clever, and creative examples to introduce you to a variety of fundamental methods of proof. My goal for this class is that you are able –in sentences and in symbols– to communicate mathematics with others. By the end of the week, you will be able to write a rigorous mathematical argument and you will feel good about the abbreviations BWOC, TFAE and WLOG.

We'll start by rigorously proving some classics about numbers: "There are infinitely many primes", "The square root of two is irrational", "Every integer greater than 1 is either a prime or a product of primes". We will continue to draw from Number Theory all week, adding in interesting bits from Set Theory, Graph Theory, and Combinatorics as we go. Underlying the whole class will be a conversation about existence and uniqueness, two topics which will crop up over and over at math camp.

Like speaking any language or playing an instrument, the only way to learn to 'speak' or 'play' math is to practice. The daily homework will be both essential and great fun!

Prerequisites: absolutely none.
Homework: absolutely necessary.
Required for: absolutely everything!

Quantum mechanics (a.k.a. The ghost in the electron) (∗∗∗∗, Anti, 11am, week 1 of 1)

"God does not play dice with the universe." – Albert Einstein
"Who are you to tell God what to do?" – Neils Bohr

Quantum mechanics is one of the triumphs of 20th century physics, and yet even today no one can really say what it means. Most physicists say that particles like electrons do not really have properties like location, spin, and velocity until you measure them, which forces them to randomly pick one value out of many possible ones. This randomness is what Einstein objected to. However, there are competing interpretations, including some which eliminate randomness. In this class, we'll learn the mathematics behind quantum mechanics, which one has to understand abstractly before arguing about what it means. We'll prove the Heisenberg uncertainty principle, which states that you can never measure both a particle's position and momentum to arbitrary precision at the same time. And we'll prove Bell's Theorem, which says that randomness can only be eliminated at the price of introducing 'spooky action-at-a-distance'.

Prerequisites: calculus, matrices, and complex numbers.
Homework: recommended.

A random walk from the marriage theorem (∗∗∗, 9am, Ellen, week 1 of 1)

N men and N women are looking for a spouse. Given their orders of preference, it is impossible to make them all happy, but might it at least be possible to arrange them so that nobody cheats on their partner? Hall's marriage theorem answers this question. Yeah, OK, so some of the reasons for the title of this theorem are sexist and hetero-centric. But the theorem itself is super! From this seemingly innocuous theorem, we'll prove statements about doubly stochastic matrices and the permutohedron. From there, our final result will be Muirhead's inequality; a massive inequality producing machine!

This theorem comes with a bonus you did not see coming: it gives an elegant, non-constructive solution for Problem 8 in the Qualifying Quiz.

Prerequisites: Familiarity (or willingness to pick up on the fly) with matrices, graphs, permutations.
Homework: none.
Related to: "The stable marriage algorithm" (Week 2), "Introduction to graph theory" (Week 2), "Topological graph theory" (Weeks 3–4).

Rational numbers . . . in space! (Or, Diophantine approximations via geometry) (∗∗, Noah, 10am)

The most exciting mathematics is often the result of surprising and unexpected relationships between completely different subjects. Exploiting such a connection, mathematicians attack problems in one field using the intuitions and results from another field. Sometimes this translation will turn a difficult question into an easy one. Here we'll study one such connection between a topic in number theory known as Diophantine approximation and ordinary plane geometry. That is, you'll answer questions like "How well can you expect to approximate a number like π using a fraction?" with geometric techniques. Similarly you'll prove a fundamental result of elementary number theory using geometry.

Homework: required. This class is *by discovery.* You will be guided through a series of problems, but you are expected to do all the work yourself!
Prerequisites: none.
Related to: number theory.

Theoretical computer science (∗∗∗, Dan, 10am, week 1 of 3)

Suppose you have a problem you might give to a computer. Maybe it's to find the shortest airline fare between two cities. Maybe you need to sort a list of numbers, or analyze some data, or compute some really annoying integral. Can the computer do it, and how fast can it do it?

First, we'll answer **can the computer do it at all?** This turns out to be a lot more interesting than you'd think; there are lots of natural problems computers are just unable to answer, *even if you give them* an arbitrarily large amount of time and an infinite amount of memory. We'll find some of these problems and analyze them mathematically, figuring out how they tick and just how they manage to so thoroughly confound a computer.

Afterwards, we'll ask **how long will it take the computer?** This notion of *time complexity* takes us to the P vs. NP question, a million-dollar problem in mathematics; we'll analyze it much more carefully than in the colloquium, state it precisely, and take a look at some of the progress (or lack of progress) on solving it so far.

To analyze these problems, we'll define *Turing machines*, mathematical objects that capture all the power of computers. Through the relative simplicity of a Turing machine, our analyses will become much easier, and we'll begin to understand the true limits of computation.

With the third week and any other extra time (e.g. Week 5), we'll find something interesting to talk about, possibly the complexity classes PSPACE, NPSPACE, and IP.

Some alumns have mentioned they might be interested in retaking this class, and they're welcome to do so: we'll have some new problems to work on and seeing the material twice can really cement your understanding.

Prerequisites: none.

Homework: required.

Required for: "Algorithms" (Week 2).

Related to: "**7MP**: P vs NP" (colloquium, Tuesday).

Moore Method Topology (∗∗∗∗, M@, 10am, week 1 of 4)

This will be a 4-5 week Moore method class, starting with point set topology – topological spaces, open and closed sets, continuity, connectedness, compactness, . . . ; and progressing by the end to the basics of algebraic topology, the fundamental group and/or simplicial homology. Along the way we'll encounter many examples of topological spaces, both tame and bizarre, as well as many of the most important ways of telling them apart. No prereqs, but this class will require written homework as well as presentations, almost daily. Talk to me for more information if interested.

Homework: required, and tons of it. This is Moore method!

Related to: anything topological.

Vectors and matrices, tensors and spinors (∗∗∗, Anti, 1pm, week 1 of 4)

The most familiar sort of vector is just an arrow. It carries two types of information: how long it is, and which way it's pointing. This sort of vector is good at representing distance—"four miles north-northwest"—or velocity—"70 mph due east". But there are other sorts of vectors which are good at representing other things. For example, a 'twisted vector' is a line segment with a direction of rotation around it, and is good at representing spinning objects. This class is an introduction to the study of vectors and related beasts, a subject which is called 'linear algebra'.

Matrices, tensors, and spinors are some of those related beasts. Matrices represent transformations of space, such as rotations, dilations and reflections, while tensors can represent the geometry of space itself. For example, you may have heard that the closer to the speed of light you travel, the slower time runs for you. This is actually a consequence of the geometry of spacetime, which is represented by a tensor.

Spinors represent even more exotic things. For example, there exist objects which, if you turn them around 360 degrees, do not come back to the same orientation they started in. Only if you turn them around twice (720 degrees) do they come back to where they started. These objects are called 'spin-one-half'. Spinors are good at representing rotations of spin-one-half objects. They are closely related to complex numbers, and to quaternions, the 4-dimensional version of complex numbers.

These gadgets also have applications to real-life problems, from mundane ones such as area, volume, and flying objects, to more exciting ones such as spinning tops, gyroscopes, and the geometry of spacetime. By the end of the class, we'll be able to answer questions like "what would you see if you were on a spaceship moving close to the speed of light?" The answer may surprise you!

Homework: required

Prerequisites: High-school algebra, geometry, and trigonometry.

Related to: linear algebra, physics.

Visitor classes

A quick tour of knot theory (∗∗, Abby Thompson, 11am, Wed – Thu)

We'll look at some of the following questions: What is a knot (and you thought you knew that)? When are two knots the same? How can we tell if a knot is really knotted? What is a knot invariant? Why is this a topic for mathematicians, not just sailors? We'll try to answer these and other questions in the two lectures.

Prerequisites: None.

Homework: None.

Related to: "Knots and links" (Week 4).

Does a graph have eigenvalues? (∗∗– ∗∗∗, Marina Meila, 11am, Fri)

Does a graph have eigenvalues? Yes, it does. We will learn what the eigenvalues tell us about the structure of the graph.

Prerequisites: some linear algebra. If you are taking Mira's class, that is enough. As an alternative, Anti will teach an emergency crash-course in linear algebra on Thursday's evening just to prepare you for this exciting colloquium.

Homework: None.

Required for: "Graphs, grouping, and eigenvectors" (Friday's colloquium).

Related to: "Intro to graph theory" (Week 2), "Topological Graph Theory" (Weeks 3–4).

George Hart's workshops (∗, George Hart)

- *Geometric puzzles* (11am, Thu). George will show a series of mechanical puzzles he has designed.
- *Puzzle workshop* (7:30pm, Thu). You will be able to play with the mechanical puzzles, try to solve them, and discuss the underlying mathematics. In addition, you will make your own paper puzzle, and you get to keep it.
- *Intro to Zometool workshop* (11am, Fri). You have seen the balls and struts. Now come and master them!
- *Zometool workshop: 4D models* (11am, Sat). You will learn how to construct models for 4D objects in our three–dimensional space.
- *Group polytope construction.* (6pm, Sun). We will build a giant, many–sided polytope out of Zometool. Everyone's help is welcome; join us for the whole construction or just for a while.

Numbers and topology (∗∗, Yuliya, 11am, Tue – Wed)

Topology is usually thought of as a subject closely related to geometry, and they are often studied hand in hand. However, the basic tools of topology can be applied to sets that we do not think of as geometrical. In this course, we will learn about how these basic tools can be applied to the integers, and we will use what we learn to give an unusual proof of the infinitude of primes.

Prerequisites: Some familiarity with sets (i.e. unions, intersections, and complements) and numbers (i.e. arithmetic progressions and l.c.m.) will be helpful but not required. You do not have to know what topology is — come find out!

Homework: None.

Colloquia

Note: Colloquia do not have star ratings: speakers try to make colloquia interesting and accessible to all Mathcampers. In addition to regular colloquia by visitors and regular staff, we have three special series: *The Seven Millenium Problems*, *Staff Research Colloquium Series*, and *Digestives*.

3–dimensional spaces, or, Where are we? (Abby Thompson, Wednesday, 4pm)

Is the universe flat? We thought the earth was flat for a long time . . . , what about the 3-dimensional universe we live in? If we send a rocket off into space programmed to go “straight”, will it eventually come back to where it started, like what happens if you go “west” long enough starting at a point on the equator? We'll look at some of the possible answers.

Tropical geometry (Sam, Thursday, 4pm)

Strange and beautiful things happen when you pass to the lower latitudes – muddy puddles become blue lagoons, suburban strip malls become beachside cabanas, and complicated algebraic curves become simple line drawings.

In this talk I will introduce some basic objects from tropical (non- archimedean, piecewise-linear) geometry. I will attempt to explain how these arise as limits of objects in ordinary (archimedean, curvy) geometry, and how one can use these “tropical degenerations” to solve problems in ordinary geometry, such as counting the number of curves with specified properties.

Related to: “Tropical curves” (Week 3).

Graphs, grouping, and eigenvectors (Marina Meila, Friday, 4pm)

This lecture is the sequel of “Does a graph have eigenvalues?”. The heroes now are a graph's eigenvectors. We shall see how the eigenvectors help us discover how the graph's nodes group together, or how to “draw” the graph prettily.

In particular, we will obtain information about you from the eigenvalues of a graph whose vertices are mathcampers! Haven't you always wanted to be a vertex?

Prerequisites: : You need to know linear algebra (eigenvalues or eigenvectors), or attend “Does a graph have eigenvalues” (Marina's lecture same day at 11am). As an alternative, Anti will teach an emergency crash-course in linear algebra on Thursday's evening just to prepare you for this exciting colloquium.

The Seven Millenium Problem Series

On May 2000, in order to celebrate mathematics in the new millennium, The Clay Mathematics Institute of Cambridge, Massachusetts selected the Seven Millenium Prize Problems. They focused on important questions that had resisted solution over the years, and allocated an award of $1M for the solution of each one of them. In this series of colloquia we will present these problems to you, in the hope that you will some day solve them and endow Mathcamp with the award!

P vs NP (Dan, Tuesday, 4pm)

As mathematicians, we like to classify things. It turns out that you can classify how ”hard” any particular question to a computer turns out to be, even independently of what kind of computer you try to solve it on! In fact, we've taken common questions asked of computers and separated them into “complexity classes”, groupings according to how hard we *think* the problems are. P is one such complexity class, the set of problems a computer can solve in ”polynomial time,” while NP is the set of problems a *nondeterministic* computer can solve in polynomial time. We'll define these terms, and see why giving a computer the power of nondeterminism *should* make it stronger — that means that we *should* have P is actually smaller than NP. Unfortunately, despite our best efforts, we haven't been able to tell if that's actually true — they might still be equal!

If it turns out that P = NP, then a lot of computer science problems that we think are too hard to do quickly would turn out to be really easy. Sounds great, right? Well the downside would be that public key cryptography, which we use to send credit card information online, would prove to be impossible as we know it. So a resolution to this question has major implications either way.

P vs NP is the biggest outstanding problem in theoretical computer science; it guides almost all theoretical research and attempts to prove it have created whole new branches of study and new models for computation. Come join us as we see the amazing steps that have been taken towards trying to resolve the question.

Staff Research Colloquium Series

In this series of colloquia, our staff members will tell you about their very own research!

Topology of random simplicial complexes (M@, Friday, 4pm)

The aim of this talk is to give some ideas of what a "random" topological space might be, and how we might measure its likely properties. The first 30-40 minutes will be trying to give background material at a friendly pace, and then the last 15-20 minutes will be more like a conference talk. So one should expect that it starts at * and ends at ***** or so.

Digestif

A *digestif* is a crispy, exciting thirty–minute minicolloquium to keep you from napping on Saturday after lunch!

My favorite mathematical magic trick (Mira, 2–2:30pm, Sa)

I saw this trick performed a few years ago by the amazing magician-mathematician Persi Diaconis, who invented it at the age of 13. It connects to all sorts of interesting math like graph theory, coding, and polynomials over finite fields (not to mention ancient Indian drumming). I can't perform the trick with quite the flair of Persi Diaconis, but I'll do my best – and teach you to do it too.

Brief visitor bios

Yuliya Gorlina (University of Arizona – mathematics)

Yuliya is a Mathcamp alumna and former JC. She has been at Mathcamp every year since 1999. She graduated from Caltech and has finished her first year as a graduate student at the University of Arizona.

George Hart (SUNY Stony Brook – computer science)

George Hart is both a professor of computer science and a mathematical sculptor. At Mathcamp, he leads hands-on workshops in which participants explore the geometry of three– (and four–) dimensional space using the mathematical construction set Zometool.

Marina Meila (University of Washington – statistics)

Marina Meila works at the interface of statistics and computer science. She is interested in machine learning by probabilistic methods and in reasoning under uncertainty. In her research, she develops new mathematical and computational methods for inferring structure from data, with applications ranging from computer vision and robotics to bioinformatics and the social sciences.

Abigail Thompson (UC Davis – math)

Abby Thompson studies knots, surfaces and 3-dimensional spaces. A few thousand years ago we thought the earth was flat, which wasn't a bad conjecture given the available local information. Now we know that is is roughly spherical- but how about space? Our information, so far, is still pretty local. What would happen if we set off for*the end of space*? Would we circle back to where we started? Studying 3-dimensional spaces gives us ideas of what the answers might be.