February
Education
Events

Education Events Schedule

February 19, 2023

Time (EST)	1-135	2-105	3-133	5-234
8:00 AM - 8:45 AM	**Breakfast** 5-233			
9:00 AM - 10:05 AM	**Gigliola Staffilani** *Waves: Building Blocks in Nature and in Mathematics*	**Adam Hesterberg** *What does P≠NP mean and why is it hard to prove?*	**Mira Bernstein** *How Gauss Discovered the Gaussian (or Normal) Distribution*	
10:15 AM - 11:20 AM	**Kenta Suzuki** *Infinitely Long Numbers and their Arithmetic*	**Sarah-Marie Belcastro** *Drawing Networks on Doughnuts*	**Hari Iyer** *Point-counting over finite fields*	
11:30 PM - 12:35 PM	**Jeffery Yu** *Advanced Integration Techniques*	**Mincheol Park** *Toric Code: Interplay between Quantum Error Correction and Topology*	**Tanya Khovanova** *Math and Puzzle Hunts*	**Bowen Kerins** *Mathematics of Game Shows*

Time: 9:00 - 10:05 AM

Gigliola Staffilani

Waves: Building Blocks in Nature and Mathematics

Location: 1-135

In this talk I will first give a few examples of wave phenomena in nature, then I will explain how to understand these phenomena, mathematicians use tools from many different areas of mathematics such as Fourier analysis, harmonic analysis, dynamical systems, number theory and probability. I will also give examples of the beautiful interaction between the "concrete" and the "abstract" and how this interaction constantly moves forward the boundaries of research.

Gigliola Staffilani is the Abby Rockefeller Mauze Professor of Mathematics at MIT since 2007. She received the B.S. equivalent from the University of Bologna and the M.S. and Ph.D. degrees from the University of Chicago. Following a Szegö Assistant Professorship at Stanford, she had faculty appointments at Stanford, Princeton and Brown before joining the MIT mathematics faculty in 2002. Professor Staffilani is an analyst, with a concentration on dispersive nonlinear PDEs. At Stanford, she received the Harold M. Bacon Memorial Teaching Award in 1997, and was given the Frederick E. Terman Award for young faculty in 1998. She was a Sloan fellow in 2000-02. Professor Staffilani was a member of the Institute for Advanced Study in Princeton in 1996 and 2003, and member of the Radcliffe Institute for Advanced Study at Harvard University in 2010. In 2013 Professor Staffilani was elected member of the Massachusetts Academy of Sciences and a fellow of the AMS, and in 2014 member of the American Academy of Arts and Sciences. In 2017 she received a Guggenheim fellowship and a Simons Fellowship in Mathematics. In 2018 she received the MIT Earll Murman Award for Excellence in Undergraduate Advising and in 2021 she was elected member of the National Academy of Sciences.

Technicality/Prerequisites: Familiarity with the notation of partial derivatives, infinite sums, Euler notation for complex numbers. I will introduce the Fourier series, but I will write everything down.

Adam Hesterberg

What does P ≠ NP mean and why is it hard to prove?

Location: 2-105

The biggest open question in computer science is whether P, the set of Boolean functions computable in time polynomial by an algorithm that runs in time polynomial in the size of their input for one reasonable definition of "algorithm", equals NP, the set defined the same way for a second, less reasonable definition of "algorithm". We'll give third and fourth definitions of "algorithm" corresponding to analogs of P and NP which actually turn out to be equal. However, if modern computer scientists could prove that P ≠ NP using the (very few) tools we have for proving such statements, the same tools could build an equivalent proof that those analogs of P and NP weren't equal---so we'll need to discover entirely new tools to prove P ≠ NP.

Adam Hesterberg is Assistant Director of Undergraduate Studies for Computer Science at Harvard, where he has taught since 2020, after completing his Ph.D. in Applied Mathematics at MIT, advised by Erik Demaine. He did his undergraduate studies in Mathematics at Princeton University. At Harvard, he teaches a range of introductory theoretical computer science courses, mostly on algorithms and limits of computation. Adam's research interests include graph theory and computational geometry.

Technicality/Prerequisites: This is a technical session. There are no prerequisites, but knowing what it means for a program to run in polynomial time would be helpful.

Time: 9:00 - 10:05 AM (cont.)

Mira Bernstein

How Gauss discovered the Gaussian (or normal) distribution

Location: 3-133

In 1801, astronomer Giuseppe Piazzi observed a new celestial object between Mars and Jupiter, which he called Ceres. Piazzi was able to make 24 more observations of Ceres over the next month, before it disappeared into the sun's glare. The European scientific community was in a tizzy: did Piazzi just find a potential new planet and immediately lose it again? Many prominent astronomers tried to predict, based on Piazzi's limited data, when and where Ceres would next appear. Then a cheeky 24-year-old named Carl Gauss published a prediction that was completely different from everyone else's. You can probably guess how this story ends: Gauss was right and everyone else was wrong.

To make his prediction, Gauss had to develop several new methods in both math and physics. One of these was the celebrated normal distribution (``the bell curve"). Gauss derived it from a simple empirical observation that scientists had known about for centuries without ever realizing its significance. You know it too, but I bet you have no idea how important it is! Come and find out.

Mira Bernstein received her PhD in algebraic geometry in 1999 and has taught at UC Berkeley, Stanford, and Wellesley College. She left academia in 2008; since then, her work has focused on using mathematics and statistics to solve social problems -- from exploring the effects of extending health insurance to low-income populations to using mathematics to fight gerrymandering. Mira is also very active in mathematics education: she has been one of the key organizers of Canada/USA Mathcamp since 1997, was a founding faculty member of Proof School in San Francisco in 2015, and co-founded the Cambridge Math Circle in 2018.

Technicality/Prerequisites: Calculus: you need to be totally comfortable with derivatives and at least vaguely familiar with integrals. Prior familiarity with the normal distribution is helpful but definitely not required.

Time: 10:15 - 11:20 AM

Kenta Suzuki

Infinitely Long Numbers and Their Arithmetic

Location: 1-135

Every integer has a decimal (or binary, ternary, etc.) expansion. I will explore what happens when decimal expansions are extended infinitely, like: ...79284. When the base is a prime number p, this gives the p-adic numbers, an important object in modern number theory. I will discuss applications to finding rational solutions to equations such as $x^2+5y^2=17$ *(the local-global principle), and some of the technique's shortcomings.*

Kenta Suzuki is a sophomore at MIT studying math. He is interested in representation theory—an area in the intersection of algebra and geometry. In his free time, he enjoys running and solving puzzles.

Technicality/Prerequisites: Familiarity with modular arithmetic.

Hari Iyer

Point-counting over finite fields

Location: 3-133

Diophantine equations can be hard to study, and it's often useful to reduce the equation mod a prime. In this talk we survey some historical perspectives and progress on solving polynomial equations over finite fields and interactions with other areas of math.

Hari Iyer is a junior at Harvard studying math. He is interested in pursuing research and currently enjoys studying number theory and algebraic geometry.

Technicality/Prerequisites: Some familiarity with modular arithmetic is useful.

Sarah-Marie Belcastro

Drawing Networks on Donuts

Location: 2-105

Complicated networks are hard to visualize. Even simple networks can be hard to visualize! Sometimes this is just because the drawing is bad, and sometimes it's because there is no good way to draw the network on paper. Can doughnuts help? We will explore these issues as an introduction to an active research area, and you will get to experiment with network drawings yourself. (No actual doughnuts will be harmed during this activity.)

Sarah-Marie Belcastro is a free-range mathematician, currently Director of MathILy and Research Affiliate at Smith College. She earned her Ph.D. from the University of Michigan and did her undergraduate work at Haverford College. Sarah-marie's primary research area is topological graph theory; she is also interested in the mathematics of knitting, dance, infectious disease modeling, and changing the world. She enjoys connecting people to each other, connecting ideas to each other, and connecting people to ideas. Sarah-marie has written the introductory textbook Discrete Mathematics with Ducks and co-edited the volumes Making Mathematics with Needlework and Crafting by Concepts.

Technicality/Prerequisites: None.

Time: 11:30 - 12:35 PM

Jeffery Yu

Advanced Integration Techniques

Location: 1-135

We discuss a plethora of integration techniques which are not typically covered in calculus classes, yet are very useful in many applications such as integration bees, probability theory, and physics. We will take a deep dive into the gamma and beta functions, as well as allude to other tricks. By the end you will be able to quickly compute integrals such as

$$\int_0^\infty x^{2022}e^{-2023x}\,dx,\ \int_{-\infty}^\infty x^2 e^{-(x-2022)^2/2023}\,dx,\ \int_0^1 x^{2022}(1-x)^{2023}\,dx,$$

and understand their significance.

Jeffery Yu is an MIT alum and former HMMT director. He graduated MIT in 2022 with degrees in math and physics, and is now pursuing his PhD at the University of Maryland. His research is in quantum information, where he uses techniques at the intersection of math, physics, and computer science to study the theory behind quantum computing algorithms. (This talk is not directly related to said techniques; it's just math that he thinks is very cool!)

Technicality/Prerequisites: Basic single-variable integration of polynomials and exponentials, including integration by substitution (often called “u-sub”), integration by parts, and limits at infinity. We will briefly review all of these at the beginning. (Note: Those with only AP Calculus AB experience will be able to follow most steps, but may have to treat a couple steps as magic. AP Calculus BC is more than sufficient.)

Mincheol Park

Toric Code: Interplay between Quantum Error Correction and Topology

Location: 2-105

One of the biggest challenges in quantum computation is its reliability. During the computation, errors corrupt the information being processed, because of either computer-environment interactions or the intrinsic imperfections of the device. To perform reliable computation, these errors must be identified and corrected systematically by quantum error correcting codes. In this talk, I will introduce the core idea of the toric code — a canonical example of a topological error correcting code — proposed by Alexei Kitaev in 1997.

Mincheol Park is a junior at Harvard University from South Korea concentrating in Physics and Mathematics. He is interested in the intersection between the field of condensed matter theory and quantum information science, especially the idea or topics in condensed matter theory that can be experimentally tested and can be useful to build quantum processors. Recently, he is working on a project that optimizes error correcting protocols for two-dimensional toric code on Rydberg atom array utilizing reinforcement learning algorithms.

Technicality/Prerequisites: Basic familiarity with the concept of vector space / subspace will be assumed, although this will be reviewed in the beginning of the talk.

Time: 11:30 - 12:35 PM (cont.)

Tanya Khovanova

Math and Puzzle Hunts

Location: 3-133

What is a puzzle hunt? In this talk, we will explore this topic and go over three very mathematical puzzle hunt puzzles.

Tanya Khovanova is a Soviet-American mathematician who became the second female gold medalist at the IMO. Dr. Khovanova graduated with honors from Moscow State University with a master's degree in mathematics in 1981. After completing her PhD at MSU in 1988, she worked for several years in Israel and the US as a postdoctoral researcher. Dr. Khovanova's research interests include combinatorics and recreational mathematics. A lecturer at MIT, Dr. Khovanova founded the MIT PRIMES program in 2010 and currently serves as its head mentor. She is also head mentor for mathematics of the Research Science Institute.

Technicality/Prerequisites: None.

Bowen Kerins

Mathematics of Game Shows

Location: 5-234

Game shows are filled with logical and statistical questions, from the players' perspective but also from the producers' perspective. How are budgets estimated? How are games built toward a particular probability of victory? We'll play games and win prizes, then discuss the math from both sides of the games.

Bowen Kerins *has been writing math curriculum for 20 years. He has been a lead writer on multiple curricula for Grades 6-12, and is the author of an eight-book AMS series. He has a BS in mathematics from Stanford University and a master's in teaching from Boston University. He scored in the top 10 on the USAMO and attended the Math Olympiad Program in 1990. He has been a mathematical advisor for over 20 game shows. He loves Slurpees and once won $1000 for knowing the number of degrees in a right angle.*

Technicality/Prerequisites: We'll do some algebra. It is helpful but not necessary to know combinatorics, such as the meaning of "7 choose 3".

Food Options near MIT

Thanks for coming to the HMMT Education event! We hope you have enjoyed the talks. Below are some nearby lunch options

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Stratton Student Center

Anna's Taqueria - *burritos, tacos, bowls*
First Floor

Cafe Spice - *Indian curries, rice dishes*
Second Floor

Cambridge Grill - *pizza, hamburgers, fries*
First Floor

Shawarma Shack - *Middle Eastern (falafels, shawarma)*
Second Floor

Shinkansen - *fried rice plates, sushi*
First Floor

Massachusetts Avenue

Flour Cafe - *sandwiches, salads, soups*
190 Massachusetts Ave, Cambridge, MA 02139

Oath Pizza
181 Massachusetts Ave Ste 1, Cambridge, MA 02139

Saloniki Greek - *pitas, mezes, Greek plates*
181 Massachusetts Ave #2, Cambridge, MA 02139

Kendall Square

Clover Food Lab - *vegetarian*
5 Cambridge Center, Cambridge, MA 02139

Chipotle Mexican Grill - *burritos, tacos, bowls*
255 Main St, Cambridge, MA 02142