HMMT February 16, 2025
Education Events

Education Events Schedule

Campus Map: https://whereis.mit.edu/

Time (EST)	32-141	32-144	32-155
8:00 AM – 8:50 AM	**Breakfast** **Stata Center**		
9:00 AM – 9:50 AM	**Ilaria Seidel** *Permutations of a Million under a Microscope*	**Jaeyeon Kim** *The Mathematical backbone of generative AI: Diffusion Models explained*	**College Life Panel** *Once You're In!*
10:00 AM – 10:50 AM	**Anand Natarajan** *A Lightning Overview of Bell's Theorem*	**Henry Cohn** *What's the densest sphere packing in a million dimensions?*	**Ju-Lee Kim** *From Daydreams to Theorems*
11:00 AM - 11:50 AM	**James Gintner - The Beauty of Math** *Beyond the Numbers, Why Math Matters* **32-123**		
12:00 PM – 12:50 PM	**Lunch** **Stata Center**		
1:00 PM – 1:50 PM	**Shen Shen** *Robotics and Generative AI*	**Pavel Etingof** *Iterating sin, equivalence classes of variable changes, and finite groups with few conjugacy*	**Julia Mundy** *Synthesis of Novel Quantum Materials*
2:00 PM - 2:50 PM	**Marvin Li** *Stochastic Localization: From the KLS Conjecture to Jailbreaking Large Language Models*		**Daniel Salkinder** *The Reasonable Effectiveness of Mathematics in the Natural Sciences*

9:00 AM – 9:50 AM

Ilaria Seidel

Permutations of a Million under a Microscope

Location: 32-141

What does a permutation of 1, 2, …, 1000000 look like under a microscope? Fix a small integer k and imagine randomly zooming in on k consecutive entries. What is the probability that they appear in increasing order? What about decreasing order? We can write down a probability distribution over the k! possible orderings.

In this talk, we will consider this distribution in the limit as the length of a permutation approaches infinity. Using tools from the intersection of graph theory and geometry, we will show that the set of possible limiting distributions is a polytope (i.e., a many-dimensional polyhedron).

Ilaria Seidel is a junior at Harvard. She loves math that draws inspiration from shapes. Most of her research lies in algebraic combinatorics (a surprisingly pictorial subject), and she is also especially interested in geometry and Teichmüller theory. Outside of math, she enjoys climbing, painting, and eating noodles with her friends.

Jaeyeon Kim

The Mathematical Backbone of Generative AI: Diffusion Models Explained

Location: 32-144

AI has been advancing rapidly in recent years, with diffusion models being a core technology in generative AI. Diffusion Models produces images and videos of exceptional quality. In this talk, we delve into the mathematical foundation of Diffusion Models, exploring how mathematical rigor underpins their development. Concepts and tools from ordinary and stochastic differential equations will be used to provide a comprehensive understanding.

Jaeyeon Kim is a PhD student in the Computer Science Department at Harvard University. He earned a B.S. in Mathematics from Seoul National University.

College Life Panel

Once You're In!

Location: 32-155

All too many talks, webinars, and YouTube tutorials focus on the "how" of getting into schools like Harvard and MIT. But once you're actually in, how can you navigate the intricacies of student life? Avoiding 9 AM classes, not embarrassing yourself in front of a large tour group, or juggling academics and extracurriculars, how do these six talented students manage to do it all? In this panel, we'll be asking students who have not just excelled in mathematics but also distinguished themselves as bonafide students of Harvard and MIT what life is like on these two campuses.

Panelists: Klara Barbic (Harvard '27), Jacob David (MIT '26), Fiona Shangguan (MIT '27), Brian Siew (Harvard '27), Emma Yang (Harvard '25)

10:00 AM – 10:50 AM

Anand Natarajan

A Lightning Overview of Bell's Theorem

Location: 32-141

Quantum mechanics is unsettlingly counterintuitive: it tells us that measurements don't have deterministic outcomes, and it's impossible to simultaneously know the position and momentum of a particle. Are these just features of an incomplete theory, to be replaced by a better theory of physics? In 1964, John Bell came up with a simple experiment to prove that any theory describing our world must be as weird as quantum mechanics, and the Nobel Prize in Physics in 2021 went to the physicists who carried out this experiment in the lab. In this talk I will present Bell's ideas, which can be understood with just high-school probability, a little trigonometry, and a teeny bit of quantum mechanics.

Anand Natarajan is an assistant professor in the theory of computation group in the EECS department at MIT. His research focuses on quantum computing and computational complexity theory. His education was in physics, with a PhD from MIT under Aram Harrow and a BS from Stanford.

Henry Cohn

What's the densest sphere packing in a million dimensions?

Location: 32-144

We aren't going to answer this question, but we'll see why it matters, why it's interesting, and why it's hard.

Henry Cohn is an adjunct professor in the Mathematics Department since 2010 and a principal researcher at Microsoft Research New England, where he was one of three founding members in 2008. He received his Ph.D. from Harvard in 2000 under the supervision of Noam Elkies, after which he joined the theory group at Microsoft Research in Redmond, WA for a year as a postdoc. From 2001 to 2007 he was a researcher at Microsoft Research and affiliate faculty member at the University of Washington. Cohn's research is in discrete mathematics, with interests including discrete geometry, coding theory, cryptography, combinatorics, computational number theory, and theoretical computer science. Cohn was made a Fellow of the AMS in 2015. He received the 2018 Levi L. Conant Prize of the American Mathematical Society (AMS), for his article, A conceptual breakthrough in sphere packing," Notices of the AMS, February 2017.

Ju-Lee Kim

From Daydreams to Theorems

Location: 32-155

Are there three consecutive integers whose product is a square? For a given integer n, is there a right triangle with rational side lengths and area n? Do there exist integers x, y, and z satisfying the equation $x^n+y^n=z^n$?

Daydreaming about these questions could easily fill a few hours, but you'd quickly realize that they are deceptively simple. In this lecture, we will explore several daydreamy questions which evolve into beautiful mathematical ideas.

Ju-Lee Kim joined the MIT mathematics faculty as tenured associate professor in 2007, promoted to full professor in 2012. She received the B.S. from the Korean Advanced Institute in Science & Technology in 1991, and the Ph.D. from Yale in 1997, under the direction of Roger Howe. She had postdoctoral appointments at the École Normale Supérieure, and at IAS before joining the faculty at the University of Michigan as assistant professor in 1998. In 2002, she moved to the University of Illinois at Chicago. Professor Kim's research interests include representation theory, harmonic analysis of p-adic groups, Lie theory and automorphic forms. In 2020 she received the MIT Earll M. Murman Award for Excellence in Undergraduate Advising.

11:00 AM - 11:50 AM

James Gintner - The Beauty of Math

Beyond the Numbers, Why Math Matters

Location: 32-123

In this talk, we look beyond the specific applications of mathematics and explore its purposes on a broader scale. Borrowing from history and philosophy, we seek illumination on how math impacts all facets of our daily lives and the world around us.

James Gintner is a competition math coach better known online as TheBeautyofMath from his YouTube channel and teaching company by the same name. The channel was founded in December 2019 and has grown to over 10,000 subscribers. Coming from a high school with no prior competition math success, he became the only AIME qualifier in his school's history. While attending university, he decided to pursue teaching of the AMC, using his Youtube channel to produce accessible training material for people from all backgrounds. He has taught over numerous AIME qualifiers and USAMO participants, but he is mostly known for his love and passion for mathematics and well-explained solutions to competition problems. His honors include earning the love and affection of his dog Lucky.

1:00 PM – 1:50 PM

Shen Shen

Robotics and Generative AI

Location: 32-141

Robotics and generative AI are reshaping how machines interact with and adapt to the world around them. In this talk, we'll explore the evolution of robotics, from early innovations to the transformative role of AI in enabling creativity, learning, and intelligent decision-making. Along the way, we'll highlight key milestones in the field and discuss how generative AI is driving advancements in areas like simulation, planning, and autonomous systems. For students interested in pursuing robotics and AI in the future, we'll share practical steps, essential skills, and resources to get started in this dynamic and rapidly evolving field.

Shen Shen is a lecturer in the Department of Electrical Engineering and Computer Science (EECS) at MIT, where she designs and teaches courses in machine learning and modeling. Before MIT, she was a lecturer and postdoctoral associate at Princeton University. Shen completed her Ph.D. and S.M. in EECS at MIT, with a focus on robotics, optimization, and educational technology. She also holds dual bachelor's degrees in AeroAstro and English Literature from the Harbin Institute of Technology, where she graduated as valedictorian. Shen's contributions to teaching have been recognized with several honors, including the MIT EECS Outstanding Educator Award. Her academic work spans areas such as machine learning, systems control and verification, and educational innovation. Outside academia, Shen enjoys comedy, skateboarding, and learning new languages.

Julia Mundy

Synthesis of Novel Quantum Materials

Location: 32-155

Quantum mechanics dictates the properties of all materials at the atomic-scale. There exist some materials, however, where the quantum mechanical properties transcend from the microscopic length scales to the macroscopic, producing some incredible effects. These so-called quantum materials could be used in next-generation devices for quantum information or energy efficient computation. I will discuss our group's work to make new quantum materials. We use a technique that allows for "atomic spray painting" and the construction of these new materials with the highest precision.

Julia Mundy is the John L. Loeb Associate Professor of the Natural Sciences and Engineering and Applied Sciences at Harvard University. She received her AB in chemistry and physics from Harvard College and her PhD in Applied Physics from Cornell University. Following her postdoctoral work at UC Berkeley, she started as a professor in physics and applied physics at Harvard in 2018. Her work combines advances in thin film system and atomic-scale imaging to make new materials.

Pavel Etingof

Iterating sin, equivalence classes of variable changes, and finite groups with few conjugacy

Location: 32-144

I will talk about the following three problems:

1. *What happens if you repeatedly press the "sin" button on your calculator?*
2. *What are equivalence classes of variable changes y=f(x) where f(0)=0 and f'(0)=1?*
3. *How to construct "the most noncommutative" finite groups, i.e. ones with as few conjugacy classes as possible (for a given order)?*

Are you wondering what these problems are doing in the same talk? Come and find out!

Pavel Etingof is Professor of Mathematics (since 2005) and the Chief Research Advisor of the MIT PRIMES Program (Program for Research in Mathematics, Engineering and Science for High School Students) since 2010. Etingof received his M.S. in applied mathematics from the Moscow Oil & Gas Institute in 1989, and his Ph.D. in mathematics from Yale University in 1994. Igor Frenkel was his thesis advisor. He went to Harvard as a Benjamin Peirce Assistant Professor in 1994, and joined the MIT mathematics faculty as assistant professor in 1998 (professor by 2005). Etingof's research interests are primarily in studies which intersect representation theory and mathematical physics, such as quantum groups. He serves as chief editor of the Journal of the AMS and of Selecta Math. He has co-authored 8 texts. He served as Chair of the Graduate Student Committee from 2002-05. In 1999 Etingof received a Clay Mathematics Institute Prize fellowship. In 2012 he was selected to be the Robert E. Collins Distinguished Scholar in the Mathematics Department. He was named a Fellow of the AMS in the 2013 Inaugural Class. He was selected by the Institute for the Frank E. Perkins Award for excellence in graduate advising in 2015, and again in 2018. In 2016 he was elected Fellow of the American Academy of Arts and Sciences.

2:00 PM – 2:50 PM

Marvin Li

Stochastic Localization: From the KLS Conjecture to Jailbreaking Large Language Models

Location: 32-141

What do the Kannan-Lovász-Simonovits (KLS) conjecture and large language models (LLMs) have in common? First proposed by Ronen Eldan in 2013, the technique of stochastic localization has been used to make much progress in conjectures in high-dimensional probability, including the KLS conjecture. The original method has been expanded into a broad sampling framework, which encompasses language and image generation models. In this talk, I will introduce the technique of stochastic localization, the KLS conjecture, and some of my own research applying it to explore interesting aspects of reasoning and jailbreaking in generative models.

Marvin Li is a senior at Harvard studying computer science and math. Outside of school, Marvin does research in the theory of generative models and AI safety. In his free time, he enjoys baking, running, and reading.

Daniel Salkinder

The Reasonable Effectiveness of Mathematics in the Natural Sciences What is Math? What is Physics?

Location: 32-155

What is Math? What is Physics? Is the success of physical theories surprising? These questions were posed together in Wigner's famous 1960 "Unreasonable Effectiveness" essay. And today, we delve into these philosophical questions from a pragmatic lens. Through a series of examples from complex analysis to general relativity, we probe whether math is intuitive, what the criteria are for having a good theory of physics, and how a modern way of thinking about theoretical physics helps explain the predictive power of math.

Daniel Salkinder is a junior at Harvard studying Math and Physics. He is interested in anything theoretical, and is especially passionate about the explanatory power of mathematics. He spends most of his time trying to learn things and then teach them to other people, and has been a teaching assistant for Harvard's freshman courses Math 55 and Physics 16.