HMMT Spring Education Events

HMMT Spring

Education Events | **March 6-7, 2021**

Speaker: Saturday, March 6th

8:00 - 9:00 PM EST	**Po-Shen Loh** **USA IMO Coach** **Professor, Carnegie Mellon University** *Applied Pure Math*	*Dr. Po-Shen Loh will talk about his journey which has led to the invention of a categorically new way to fight disease: NOVID. During the talk, the speaker will highlight many places where it ended up being quite useful to have a history of thinking about competition and research math, and of interacting with the math enthusiast community. See link.hmmt.org/pslflyer for more info!*

Classes: Sunday, March 7th

Time (EST)	Classroom 1	Classroom 2	Classroom 3
1:00 - 2:00 PM	**Seung Hwan An** *How Numbers Can Deceive You: Paradoxes in Probability*	**Cengiz Pehlevan** *We don't understand how the brain works. Can mathematics help?*	**Laura Cui** *What is Quantum Entanglement, and Why is it Useful?*
2:00 - 3:00 PM	**Merrick Cai** *A Taste of Topological K-theory*	**Ferran Alet** *Machine Learning in Robotics: Current Progress and Challenges Ahead*	**Mira Bernstein** *A game you can't play (but would win if you could)*
3:00 - 4:00 PM	**Paige Dote** *How to LaTeX*	**Scott Sheffield** *Universal Randomness in 2D*	**Maya Sankar** *Burnside's Lemma*

Education Events

Seung Hwan An

How Numbers Can Deceive You: Paradoxes in Probability

1:00 - 2:00 PM

In the long-running American game show of Let's Make a Deal, the host Monty Hall offers three doors to you. Behind one of them is a brand new sports car, but behind the other two are just live goats. You pick a door, and then Monty Hall opens a door other than the door you picked, which has a goat behind it. Then he offers you the choice of switching to the other unopened door. Unless you really like goats, your aim should be to maximize the chance of winning the sports car. Should you take up on Monty Hall's offer and switch to the other door?

We will discuss why probability problems like this Monty Hall problem stumbled so many people, and how thinking about conditional probability is an extremely powerful tool to resolve "paradoxes" in probability.

Seung Hwan An is a sophomore at Harvard majoring in Physics and Mathematics. He is interested in how probabilistic thinking can help with various quantitative subjects, such as physics, computer science, and social sciences. He is also more broadly interested in electoral politics, baseball, and speedrunning games.

Technicality/Prerequisites: None, although some previous experience with probability and conditional probability will be helpful.

Cengiz Pehlevan

We don't understand how the brain works. Can mathematics help?

1:00 - 2:00 PM

Mathematical modeling provided important insights about biological intelligence. I will review key ideas in this domain and highlight some open problems.

Cengiz Pehlevan (pronounced "Jen·ghiz") is an Assistant Professor of Applied Mathematics at Harvard University. He moved to Harvard from the Flatiron Institute's Center for Computational Biology (CCB), where he was a research scientist in the neuroscience group. Before CCB, Cengiz was a postdoctoral associate at Janelia Research Campus, and before that a Swartz Fellow at Harvard. Cengiz received a doctorate in physics from Brown University and undergraduate degrees in physics and electrical engineering from Bogazici University in Istanbul, Turkey.

Technicality/Prerequisites: None

Laura Cui

What is Quantum Entanglement, and Why is it Useful?

1:00 - 2:00 PM

Maybe you've heard about this thing called entanglement or "spooky action at a distance", but you're not sure what it has to do with the box in front of you currently running zoom.exe. In this talk we'll discuss what quantum entanglement really is and go over some fun game theory examples, introduce concepts in computational complexity and what it means for a problem to be decidable, as well as how it all connects!

Laura Cui is an undergraduate at MIT studying physics and math, and is curious about problems in quantum information and fundamental physics. Laura is also interested in math education, and in particular spreading appreciation for how different parts of math and physics are connected. When not thinking about math, Laura can be found painting, taking walks along the river, contemplating Asian diaspora literature, or appreciating a good cup of tea.

Technicality/Prerequisites: Some familiarity with linear algebra, Boolean logic, and/or familiarity with computational complexity may be helpful, though the talk should be accessible to most people.

Merrick Cai

A Taste of Topological K-theory

2:00 - 3:00 PM

After learning all about the A-theory, the B-theory, etc, you probably figured there's nothing else worth learning here. Wrong! In this class, you can learn about what (topological) K-theory is and also see my dog. This class is a lifesaver and will teach you what to do when your SO responds with the dreaded "K." Namely, you can tell them all about how you looked at vector bundles and you noticed they were almost a group, so you made them a group. And then you remembered that tensors could make them a ring. And just like that, you proposed and lived happily ever after.

Topological K-theory is really the study of vector bundles and how they algebraically interact with each other. Often times, one can find a family of vector spaces which essentially are parametrized by something else - for example, tangent planes to the unit sphere are parametrized by the points on the sphere. By realizing that such examples of topological spaces are fundamentally linked to vector spaces, we can use the power (and simplicity) of linear algebra to understand a number of constructions, including direct sum and tensor product of vector bundles. The key idea is that direct sum and tensor product are just abstract notions of addition and multiplication. So vector bundles are not too different from normal numbers (maybe). You can decide for yourself after this class.

Merrick Cai is a sophomore at MIT studying math and some other things. He has a particularly cute dog named Oreo, which you will get to see if you attend this class. His math interests are still undecided at the moment, but that will not stop him from expanding your mathematical interests!

Technicality/Prerequisites: Familiarity with groups and rings is preferred. You should also be comfortable with linear algebra and certain constructions in linear algebra, especially linear maps, direct sums, and tensor products.

Ferran Alet

Machine Learning in Robotics:
Current Progress and Challenges Ahead

2:00 - 3:00 PM

Robotic hardware has made enormous progress recently, with drones being commonplace and Boston dynamics releasing impressive videos. However, robots are only present in very limited environments, which only require very repetitive actions. Through the lens of the Amazon Robotics Challenge, which required building an autonomous system that could do "pick and place" in a warehouse, we will discuss what robots can and cannot currently do. We will also review how progress in deep learning affects robotics through the biggest recent advancements: a reliable vision for self-driving cars, AlphaZero beating the world champion at Go, and OpenAI successfully transferring a robotic policy learned in simulation to the real world. Finally, we will introduce new research directions that go beyond vision, by teaching robots the sense of touch and generalize with few amounts of data by doing meta-learning.

Ferran Alet is a PhD student at MIT CSAIL working with professors Leslie Kaelbling and Tomas Lozano-Perez on Machine Learning, focusing on meta-learning (teaching machines to learn how to learn). He is also the host of the MIT Embodied Intelligence Seminar and has mentored 15 students during his PhD. Ferran studied Mathematics and Physics in Barcelona thanks to CFIS, a special program for doing two degrees, where he was the valedictorian of his promotion. He participated in science competitions, winning the Spanish Computer Science Olympiad and having medals in the Math and Physics national olympiads. In college, he participated in the Computer Science ACM programming contest, being the most decorated in the history of his regional phase (South Western Europe). In grad school he earned a "La Caixa" fellowship and was responsible for the high-level planner of the MIT-Princeton team for the Amazon Robotics Challenge, which won the stowing task in 2017.

Technicality/Prerequisites: None

Mira Bernstein

A game you can't play (but would win if you could)

2:00 - 3:00 PM

Once upon an infinity, in the Kingdom of Aleph, the king decides to put his 100 advisors to a test. He builds 100 identical rooms. In each room, he places an infinite row of boxes. (This requires an infinite amount of time and space, but that's OK in the Kingdom of Aleph.) In each box, he puts a real number. The sequence of numbers is the same in each room, but otherwise completely arbitrary.

The king tells his advisors that each of them will be locked in one of the rooms. Once this happens, they will not be able to communicate with each other. Each person will be allowed to open all but one of the boxes in their room, after which they must guess the number in the remaining box. If more than one person guesses incorrectly, they will all lose their jobs (and their heads).

The king gives his advisors an infinite amount of time to work out a strategy. Do they have any hope of passing his test? What should they do?

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: This will be a technical talk with lots of student interaction. There are no prerequisites.

Paige Dote

How to LaTeX

3:00 - 4:00 PM

LaTeX is a popular typesetting language used in various academic fields. You've probably seen LaTeX used to type math equations on websites such as Art of Problem Solving and Stack Exchange. In this workshop, participants are encouraged to follow along as we go over how to set up a LaTeX document on Overleaf, and go over some helpful latex features. Come learn how to make your own LaTeX documents in just under an hour!

Paige Dote is a freshman at MIT interested in studying mathematics and philosophy. She's particularly interested in one day being a professor in mathematics. Outside of school, Paige enjoys listening to music, playing board/card games, and advocating for educational equity.

Technicality/Prerequisites: None

Maya Sankar

Burnside's Lemma

3:00 - 4:00 PM

How many ways can we color the faces of a cube red, blue, or green, where two colorings are considered the same if one is a rotation of the other? What if we had n colors instead of 3? Burnside's Lemma gives a general technique to count objects up to some symmetry. We will prove the lemma and do a few applications, building up some group theory along the way.

Maya Sankar majored in math and computer science at MIT and is currently a first-year PhD student studying math at Stanford. She is interested in combinatorics and computer systems. Outside of school, Maya loves to play music, read, and knit, and is delighted to be back on the West Coast where she can enjoy the sun all year round.

Technicality/Prerequisites: None

Scott Sheffield

Universal Randomness in 2D

3:00 - 4:00 PM

My talk will give a broad overview of an active area of research mathematics. I will introduce several universal and canonical random objects that are (at least in some sense) two dimensional or planar, along with discrete analogs of these objects. In particular, I will introduce probability measures on the space of paths, the space of trees, the space of surfaces, and the space of growth processes. I will argue that these are in some sense the most natural and symmetric probability measures on the corresponding spaces. I will then describe several surprising relationships between these canonical objects. Many of these ideas have been historically motivated by physics — especially string theory, conformal field theory, and statistical mechanics.

Scott Sheffield is the Leighton Faculty Professor of Mathematics at the Massachusetts Institute of Technology. Sheffield is a probability theorist, working on geometrical questions that arise in such areas as statistical physics, game theory and metric spaces, as well as long-standing problems in percolation theory. In 2014 he was awarded a Simons Fellowship in Mathematics. In 2017 he was elected by Society members to the Editorial Board Committee of the American Mathematical Society, February 2017 to January 2020. He currently serves as the Postdoc Officer (effective July 2019) in the Mathematics Department. Since 2011, Sheffield has taught 18.600, the introductory probability course at MIT.

Technicality/Prerequisites: Familiarity with basics of probability.