Spring 2022 96th Series

# M*A*T*H COLLOQUIUM

**Sonoma State University Department of Mathematics and Statistics presents a series of informal talks open to the public**

Talks are Free—campus parking is $5

*"The book of nature is written in the language of mathematics" - Galileo*

**Wednesdays @ 4pm in Darwin 103***

*Refreshments postponed due to Covid. Masks Required Indoors.*

**All talks also available on Zoom** (*Feb 2, 9 & 16 **only** on Zoom)

***https://bit.ly/SSU-Math-Colloq-S22***

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**Feb 2 — ZOOM only**

**Structures of Graph Colorings** — **Dustin Ross, San Francisco State University**

Graphs, comprised of vertices and edges connecting them, are some of the most elementary and fundamental objects in mathematics, and applications of graph theory can be found all throughout the sciences (think of atoms and the bonds between them that create molecules, or websites and links among them, or bitcoin accounts and transactions between them, or members of a community and whether they are acquainted). In many applications, it can be useful to label, or color, the vertices of a graph so that no two adjacent vertices share the same color—and then ask how many such colorings the graph has. For example, how many ways are there to color the vertices of a square with 3 colors, or 10 colors, or 5 million colors, so that no two adjacent vertices share the same color? Together, we'll work out a handful of examples and investigate the various structures hidden within chromatic polynomials—polynomials that encode the number of vertex colorings. We'll see a structure of chromatic polynomials that was discovered over 50 year ago, but which was proven true for all graphs only a decade ago.

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**Feb 9 — ZOOM only**

**Waves in Strings: The Special Case of Field Patterns** — **Ornella Mattei, San Francisco State University**

In this talk, we will study the problem of a vibrating string. How does a wave propagate in a homogeneous string when the string is plucked? This is a standard problem in mechanics and it has a well-known solution. So, we will change some of the basic assumptions to turn it into a very challenging problem. First, we will see how the wave propagates when the string is made of two different materials. The key point is to understand what happens at the space-interface between the two materials. Then we will try to solve the following problem: what if the properties of the string suddenly change in time? In other words, what happens if a string made of a certain material, suddenly turns into a string made of another material? What happens at the time-interface? How is the propagation of the wave affected by this time-inhomogeneity? Partial differential equations and boundary conditions will make an appearance, but no knowledge of differential equations or waves is required.

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**Feb 16 — ZOOM only**

**Distance Functions on Computable Graphs** — **Jennifer Chubb, University of San Francisco**

An infinite graph—one made of nodes and edges—is *computable* if there is an algorithm that can decide whether or not a given pair of nodes is connected by an edge. For example, the internet is a computable graph which is, for all intents and purposes, infinite. Given two nodes on a connected, computable graph, a natural question is "What is the length of the shortest path between them (the *distance* between the nodes)?" For a connected graph we can always find such a path and determine its length, but the question of finding a shortest path is harder, and is not in general something we can compute for infinite computable graphs. We will see what it means for something to be non-computable via a classic example called the halting problem. Next we will see that it's possible to encode non-computable information into even very simple, computable mathematical objects. Finally, we will see how non-computable information can be encoded into the distance function of a given graph. So, what is the shortest path between two nodes? We may never know!

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**Feb 23 — ZOOM only**

**The Joy of Statistical Consulting, Mathematical Research, Programming, and Modeling!** — **Students from Math 180, 467, and 470**

As Sonoma State students progress through their math and stats courses, they become more aware of the connections across coursework, the power of using technology effectively, and the variety of applications that mathematics and statistics have in their future lives. Come see some amazing student projects that combine mathematical expertise with student creativity in a selection of our upper division courses from Omayra Ortega's Statistical Consulting course and Mathematical Epidemiology Research Group (MERG), Nick Dowdall's Mathematical Programming course, and Martha Shott's Mathematical and Statistical Modeling course.

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**Mar 2**

**Some Card Tricks and Their Combinatorial Analysis** — **Bala Ravikumar, Sonoma State University, Computer Science**

We will present some card tricks and explain the combinatorics behind them. Some underlying concepts that will be discussed are finite automata, perfect matching in a bipartite graph, de Bruijn sequence etc.

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**Mar 9 — ZOOM only**

**Random Walks, Games and Differential Equations** — **Diego Ricciotti, Sacramento State University**

"Solving a calculus problem is like playing a game." In this talk we will make the previous sentence mathematically rigorous by exploring unexpected and interesting connections between random walks, games, and calculus. In particular, we will introduce the concepts of game values and rewards, and see how they can be used to provide approximations of solutions to certain differential problems.

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**Mar 16**

**Symmetries in Coloring Graphs** — **Sara Krehbiel, Santa Clara University**

The graph coloring problem is the problem of coloring the vertices of a graph so that neighboring vertices always have different colors. This problem models constraint satisfaction problems like the scheduling problem, in which several events (vertices) must be scheduled (colored) such that events with overlapping participants may not occur at the same time. For a given graph $G$ and a fixed number of colors $k$, we can build another graph $C_k(G)$ called a coloring graph, whose vertices are the colorings of $G$, with edges between pairs of colorings that differ on a single vertex of $G$. The permutations of colors induce automorphisms on the coloring graph, resulting in a highly symmetric structure with interesting topological properties. We have developed visualization tools using graph algorithms to build intuition before proving general structural results. I will describe some of the patterns we have uncovered so far and introduce some open problems. This talk is targeted toward undergraduates interested in math and computer science, or anyone interested in patterns and puzzles!

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**Mar 23** — **NO TALK—Spring Break**

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**Mar 30**

**How Do Search Engines Search?** — **Plamen Koev, San Jose State University**

In this talk we will describe the surprisingly simple linear algebra which allows a search engine to find the websites that contain a query and, more importantly, to then sort those so that the most relevant ones are presented first. This will naturally lead to conclusions on how to design a web page so that it is listed as high as possible in the search results. We will demonstrate that implementing this knowledge in practice actually works. We will also talk about the methods the search engines employ to counter such efforts when you try and go too far. Only the most basic understanding of probability will be assumed (e.g., you need to know that if you flip a coin, the probabilities of heads or tails need to add up to 100%, but neither needs to be 50%). From linear algebra, you need to know how to solve a 2-by-2 linear system and understand that a linear system can be larger. Late in the talk, the connection with Markov chains and eigenvalues will be established although no prior knowledge of these concepts will be needed.

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**Apr 6**

**Seki Takakazu** — **Sam Brannen, Sonoma State University**

The Pythagorean Theorem, Bernoulli numbers, Newton's method, and many other famous mathematical theorems and discoveries are named after or credited to Greek and European mathematicians. You may have heard that the Pythagorean Theorem was known to many ancient cultures long before the life of Pythagoras, but did you know that Bernoulli numbers were discovered by a Japanese mathematician, 10 years before Bernoulli? Or that this same Japanese mathematician discovered determinants before Leibniz, and Newton's Method independently of, and possibly before, Newton? This talk will focus on the life and mathematical accomplishments of Seki Takakazu.

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**Apr 13**

**Modeling Population Migrations from Individual Decisions** — **Stephanie Dodson, UC Davis**

Within a population, simple individual-level decisions can translate into complex behaviors when viewed at the population level; this phenomenon is known as emergent behavior. Emergent behavior can be seen in the flow of cars on the highway, flocks of birds in the sky, and animal migrations. For example, blue whales in the Pacific Ocean migrate annually between southern breeding grounds and northern feeding grounds. The whales travel and feed primarily alone, yet the timing and spatial extent of the migration seems to be coordinated among the population each year. In this talk, we will introduce agent-based models and use them to describe how individual-level decisions of blue whales translate into the observed population-level migrations.

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**Apr 20**

**Why Teach? Becoming a Middle or High School Math Teacher** — **Rajeev Virmani, Sonoma State University with teacher panel**

Representatives from the SSU STEP (STEM Teacher Education Pathways) program will be talking about what it's like to be a middle or high school math teacher and how undergraduate students can become one. We will have a panel of SSU grads who are currently working as math teachers and will discuss their experiences.

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**Apr 27 — MATH Festival**

**'FaceTime Math' and the Power of A Good Mathematical Story** — **Erica Walker, Teachers College, Columbia University**

In this talk I share how storytelling, used to great effect in other disciplines, can be a wonderful asset for the mathematics education of people of all ages and interests. Based on 25 years of research and teaching, working with children and adults alike, I describe the importance of storytelling for learning rich mathematics content, socializing people as mathematics 'doers', and contributing to the creation of welcoming, inviting spaces for mathematics, within and beyond schools.

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**May 4**

**What Happens Inside a Black Hole** — **Sung-Jin Oh, UC Berkeley**

Two important problems in the study of partial differential equations are (1) understanding the long-term behavior of solutions and (2) understanding the possible singularities. In this talk, I will introduce these two problems in the context of nonlinear equations that resemble the wave equation, explain how they (amusingly) come together in the mathematical study of singularities of the Einstein gravitational field equation inside rotating black holes, and survey some recent progress.

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Talks may change. Please confirm with the Department: math@sonoma.edu or 707-664-2368

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