MODERN MATH WORKSHOP

MODERN MATH WORKSHOP 2023

OREGON CONVENTION CENTER

WEDNESDAY, OCTOBER 25TH

12:00 – 12:30	**Check-in**	Outside E147-148
12:30 – 12:45	**Welcome Remarks** **Kevin Corlette, IMSI**	E147-148
12:50 – 2:20	**Undergraduate Mini Course I** **Alicia Prieto Langarica and Marco Martinez** Youngstown State University and North Central College **An Introduction to Data Analytics**	E141-142
12:50 – 2:20	**Undergraduate Mini Course II** **Claudio Gómez-Gonzáles** Carleton College **Polynomials, topology, and us**	E143-144
12:50 – 1:30	**Research Talk – AIM** **Daniela Ferrero** Texas State University **Electrical Power Networks, Combinatorial Optimization, & Collaborative Research**	E147-148
1:35 – 2:15	**Research Talk – ICERM** **Vrushali A. Bokil** Oregon State University **Computational Simulation of Maxwell's Equations in Complex Materials**	E147-148
2:15 – 2:45	**Break**	E147-148
2:45 – 4:15	**Undergraduate Mini Course I** **Alicia Prieto Langarica and Marco Martinez** Youngstown State University and North Central College **An Introduction to Data Analytics**	E141-142

Mathematical Sciences Institutes DIVERSITY INITIATIVE · NSF · AMS American Mathematical Society · siam Society for Industrial and Applied Mathematics

MODERN MATH WORKSHOP 2023

OREGON CONVENTION CENTER

WEDNESDAY, OCTOBER 25TH

2:45 – 4:15 **Undergraduate Mini Course II** **E143-144**
Claudio Gómez-Gonzáles
Carleton College
Polynomials, topology, and us

2:45 – 3:25 **Research Talk – IPAM** **E147-148**
Alejandro Morales
Université du Québec à Montréal
Integrability and combinatorics of skew formulas for skew tableaux

3:35 – 4:35 **Panel Discussion** **E147-148**
Personal stories from the path to academia:
Speakers from the Modern Math Workshop will summarize their education and career trajectory, with a lens on their decision process to pursue a PhD and an academic career. Audience Q&A and discussion will follow brief remarks by panelists.

5:30 – 7:30 **Modern Math Workshop Reception** **E145-146**

Mathematical Sciences Institutes DIVERSITY INITIATIVE
NSF
AMS American Mathematical Society
siam Society for Industrial and Applied Mathematics

MODERN MATH WORKSHOP 2023

OREGON CONVENTION CENTER

THURSDAY, OCTOBER 26TH

8:30 – 9:00 **Coffee and Pastries** E147-148

9:05 – 9:45 **Research Talk – SLMath** E147-148
Juanita Pinzón Caicedo
University of Notre Dame
Toroidal integer homology spheres have irreducible SU(2)- representations

9:50 – 10:30 **Research Talk – IMSI** E147-148
Jose Rodriguez
University of Wisconsin, Madison
4x4 Matrices in Algebraic Statistics: From independence to mixing the tree of life

10:30 – 11:00 **Break** E147-148

11:00 – 12:00 **Plenary Talk** E147-148
Johnny Guzman
Brown University
Connections between numerical PDEs and Algebraic Topology

MODERN MATH WORKSHOP

MODERN MATH WORKSHOP 2023

OREGON CONVENTION CENTER

WEDNESDAY, OCTOBER 25TH

Titles and Abstracts

An Introduction to Data Analytics
Alicia Prieto Langarica (Youngstown State University) and Marco Martinez (North Central College)

We will offer an introduction to Data Analytics, which refers to a set of tools designed to extract valuable information from large datasets. Our course will cover the general theoretical concepts that enable the selection of various techniques. Additionally, we will provide a hands-on introduction to the specialized software R. Our primary focus will be on regression methods, highlighting their significance and practical applications.

Polynomials, topology, and us
Claudio Gómez-Gonzáles (Carleton College)

This minicourse will be divided into three parts, with related but distinct topics and prerequisites, and focuses broadly on the geometry and topology of solving equations. The first sub-session, accessible to a general audience, begins with a historical survey of an ancient question ("How do you solve a polynomial?") and some of the beautiful mathematics that has developed through its study. Next, we explore spaces of polynomials from a more topological perspective—you are guaranteed to learn something new about the quadratic formula! —in an open-ended way that hints at venues of ongoing research. We conclude by contextualizing the work of solving algebraic equations in the miracles of classical geometry, pushing beyond the solvable-unsolvable dichotomy, and contemplating math as a rich human endeavor that we find ourselves at the heart of.

MODERN MATH WORKSHOP 2023

OREGON CONVENTION CENTER

WEDNESDAY, OCTOBER 25TH

Titles and Abstracts

Electrical Power Networks, Combinatorial Optimization, & Collaborative Research

Daniela Ferrero (Texas State University)

Electric power networks need continuous monitoring to prevent blackouts and power surges. This is usually accomplished by placing Phasor Measurement Units (PMUs) at strategically selected network locations. Each PMU measures magnitude and phase angle of the electromagnetic wave at the location where it is placed. The synchronized PMU readings are then combined to determine the magnitude and phase angle of the electromagnetic wave at network locations without a PMU. This method requires a PMU placement that provides sufficient information to monitor the entire network, while due to their cost, the number of PMUs should be minimized. When an electrical power network is modeled by a graph, a PMU placement using the minimum number of PMUs corresponds to a minimum power dominating set for the graph.

In 2002, soon after PMU systems were proposed in electrical engineering, power domination was introduced to graph theory. However, the large-scale deployment of wide area measurement systems of PMUs started a decade later. Since then, the cost of a PMU and its installation have been reduced, and PMU readings have been proven useful for many other purposes besides monitoring, which helps to offset system costs. In recent years, the analysis of existing large scale PMU systems has shown that minimizing the number of PMUs alone yields unsatisfactory results, since the lack of redundancy results in lost, or incorrect, PMU readings. While having redundancy implies increasing the number of PMUs, the advantages of having a few additional PMUs outweigh the cost increase. Consequently, new challenges have appeared in both, electrical engineering, and graph theory.

In this talk, I will introduce power domination as a combinatorial optimization problem and then I will present results of my research in this area, obtained in collaboration with many co-authors. While doing so, I will adopt a personal perspective to emphasize the collaborative nature of my research and highlight the role of several NSF supported institutes to enable the collaboration.

Mathematical Sciences Institutes DIVERSITY INITIATIVE
NSF
AMS AMERICAN MATHEMATICAL SOCIETY
siam Society for Industrial and Applied Mathematics

MODERN MATH WORKSHOP 2023

OREGON CONVENTION CENTER

WEDNESDAY, OCTOBER 25TH

Titles and Abstracts

Computational Simulation of Maxwell's Equations in Complex Materials
Vrushali A. Bokil (Oregon State University)

Maxwell's equations are a set of four vector partial differential equations that govern the evolution of electromagnetic waves. In most cases, due to the presence of heterogeneities and complex geometries, it is impossible to solve these equations exactly. Thus, efficient computational methods that are accurate, consistent, and stable are required to be developed to address numerous applications in materials research involving the design of engineered composites such as metamaterials; radar, environmental and medical imaging; noninvasive detection of cancerous tumors; communication and computation; global climate assessment, among others. Many applications involve multiple spatial and temporal scales, spatial and temporal heterogeneities, complex geometries, among other issues. In this talk, I will discuss some of the aspects of the development of robust computational tools for simulating Maxwell's equations. The numerical simulation of these equations and many other complex partial differential equations is routinely addressed at workshops and semester programs organized by the Institute for Computational and Experimental Research in Mathematics (ICERM). I will discuss some of the current programs organized by ICERM that are relevant to this talk and include efforts to diversify the computational mathematics community.

Integrability and combinatorics of skew formulas for skew tableaux
Alejandro H. Morales (Université du Québec à Montréal)

Algebraic combinatorics and integrable probability are two areas of mathematics with recent interactions. In one direction, we have seen many applications of tools and emergence of objects from algebraic combinatorics in integrable models in statistical mechanics. In the opposite direction, tools and ideas from probability and statistical physics have seen application in problems from Algebraic Combinatorics. One example of this is enumerative and asymptotic formulas for important structure constants like standard tableaux of skew shape. No product formula is known to count such tableaux. In 2014, Naruse presented a formula as a positive sum over excited diagrams of products of hook-lengths. These diagrams can be viewed as lozenge tilings of certain regions. Shortly after, Morales, Pak, and Panova gave a q-analogue of Naruse's formula for semi-standard tableaux of skew shapes in terms of restricted excited arrays. They also showed, partly algebraically, that the Hillman-Grassl map restricted to skew shapes is the bijection between skew SSYTs and excited arrays. We study the problem of making this argument completely bijective. For a skew shape, we define a new set of semi-standard Young tableaux, called the "minimal SSYT", that are equinumerous with excited diagrams via a new description of the Hillman--Grassl bijection. The minimal skew SSYT are the natural objects to compare with the terms of another formula for counting skew tableaux by Okounkov--Olshanski. This is joint work with Greta Panova (USC) and GaYee Park (UQAM).

Mathematical Sciences Institutes DIVERSITY INITIATIVE

AMERICAN MATHEMATICAL SOCIETY

Society for Industrial and Applied Mathematics

MODERN MATH WORKSHOP 2023

OREGON CONVENTION CENTER

THURSDAY, OCTOBER 26TH

Titles and Abstracts

Toroidal integer homology spheres have irreducible SU(2)-representations.
Juanita Pinzón Caicedo (University of Notre Dame)

The fundamental group is one of the most powerful invariants to distinguish closed three-manifolds. One measure of the non-triviality of a three-manifold is the existence of non-trivial SU(2)-representations. In this talk I will show that if an integer homology three-sphere contains an embedded incompressible torus, then its fundamental group admits irreducible SU(2)-representations. This is joint work with Tye Lidman and Raphael Zentner.

4x4 Matrices in Algebraic Statistics: From independence to mixing the tree of life
Jose Rodriguez (UW Madison)

A mantra of Algebraic Statistics is that a statistical model can be realized as the restriction of an algebraic variety to a semi-algebraic set. For discrete models this semi-algebraic set is the probability simplex, while for Gaussian models it is the positive definite cone. With this perspective, the statistical inference method maximum likelihood estimation (MLE) can be viewed as solving a system of polynomial equations. For discrete models, the likelihood equations and methods to solve them, were introduced by Hosten, Khetan, and Sturmfels. These equations are with respect to observed data and a model. The number of solutions for generic data is called the maximum likelihood (ML) degree of the model. Thus, the ML degree can bound the algebraic complexity of solving MLE. In this talk I will show how the ML degree connects to statistics, topology and phylogenetics with examples stemming from 4x4 matrices.

Connections between numerical PDEs and Algebraic Topology
Johnny Guzman, Brown University

The finite element method (FEM) is an important tool in approximating solutions to partial differential equations (PDEs). For a few decades now connections between algebraic topology and FEM have been exploited, most extensively by the work of Arnold Falk and Winther in the finite element exterior calculus. In this talk, we will discuss a few of these connections.

Mathematical Sciences Institutes DIVERSITY INITIATIVE
NSF
AMS AMERICAN MATHEMATICAL SOCIETY
siam Society for Industrial and Applied Mathematics