2022 Spring MD-DC-VA Section Meeting Abstracts

Talks are arranged in chronological order. All talks are Saturday, except the workshop and banquet talk.

Workshop

Building Interdisciplinary Partnerships to Create Application-Focused Mathematics Content, A SUMMIT-P Project

Rebecca Segal (on behalf of MD-DC-VA COMMIT) , Virginia Commonwealth University

Friday 4:30-6:30, BE 151/152

This workshop will showcase the collaborative process of creating class activities at Virginia Commonwealth University (VCU) with partner discipline input, allowing Differential Equation students to interact with mathematical content in an application focused format. VCU is part of SUMMIT-P: A National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships that is an extension of work begun in the Curriculum Renewal Across the First Two Years (CRAFTY) project. Along with sample activities, we will discuss how faculty conversations between departments can enrich the mathematics curriculum and lead to stronger student engagement.

Banquet Talk

Back in the Saddle: Cutting through Clutter with Analytic Combinatorics

Sam Ferguson , Metron, Inc.

Friday 8:30-9:30, BE 151/152

When sailors fall overboard in a storm, their lives depend on searchers' abilities to find them before it is too late. Their positions must be tracked until they can be picked up by other vessels. But the tracking instruments are so sensitive that they yield many "false alarms" or, as we call them, "clutter" measurements. The task of finding the targets' most likely positions gets bogged down by the clutter due to a combinatorial explosion in the number of assignments of measurements to targets. Rather than rely on too-slow enumerative methods, we introduce two ideas from analytic combinatorics in the context of amusing examples involving Stirling's approximation of n! and the Fibonacci numbers. Combining these ideas, we get a new "saddle point" approximation of the positions' likelihoods that delivers sufficiently accurate estimates without the slowdown of traditional probabilistic methods.

A Mathematical Model and Analysis of Wireless Power Transfer

Daniel Wright, Christopher Newport University and Norfolk State University
Yasmeen Cox, Christopher Newport University and Norfolk State University
Markevious Tolbert, Christopher Newport University and Norfolk State University

8:20-8:40, HT 122
(student talk)

Transmitting electrical power without the use of cables is a modern convenience that we currently

experience. This engineering breakthrough is called wireless power transmission (WPT), the most basic setup of which involves two RLC-circuits that are coupled with mutual inductance. An RLC circuit is an electrical circuit in series or parallel, consisting of a resistor, inductor, and a capacitor. The key component in WPT is the mutual inductance, this piece connects the two circuits together allowing power to be moved from one circuit to the other and then back. In this project, we derive a mathematical model of an equivalent circuit of a two-coil WPT. The model involves a system of two linear second-order ordinary differential equations with constant coefficients, one of which is non-homogeneous while the other one is homogeneous. We apply elementary methods to derive closed-form general solutions of the system. Then, using specific parameters, we solve the system using various methods: analytical solutions via the Laplace Transform, numerical simulation via Matlab, circuit simulation via MultiSim and then from the data obtained from our simulated circuit in Multisim, we conduct parameter estimation via Excel. While the implementation of Laplace Transforms by hand computations require carefully chosen parameters, using the Matlab, Multisim, and Excel allowed us to analyze the solutions of the system over a larger interval of parameters to include realistic values for the RLC components. Finally, we perform a local sensitivity analysis of the system with respect to the parameters using direct differentiation. Sensitivity analysis is a systematic investigation of the behavior of the dependent variables of a system with respect to perturbation in its parameters. In particular, we produce evolution curves of the rate of change of each of the dependent variables with respect to each of the parameters and compute their 2-norms in order to measure and compare the sensitivities.

The Boudoir Armoire Memoir of Friedrich Oliver Vechs

Dan Kalman, American University

8:20-8:40, HT 204

Friedrich Oliver Vechs is surely one of the most enigmatic figures in the history of mathematics. Ann Dalmak, whose 2015 account in Math Horizons brought his story to popular notice, has recently disclosed an exciting new discovery: a hitherto unknown account Vechs wrote of his early struggles to find a thesis topic. The original manuscript, found hidden in a clothes cabinet in the private chambers of one of Vechs' closest confidantes, only came to light last year when that person moved into a retirement community. By a strange string of circumstances, this boudoir armoire memoir of Friedrich Oliver Vechs came into the possession of Dalmak, who is giving it the rigorous study that it deserves. The purpose of this presentation is to provide a preview of some of Dalmak's findings.

NOTE: This talk was originally planned before the rescheduling of the section meeting, under the assumption that it would be presented much closer to April first. Whether it is still appropriate this late in the month, or indeed at any time at all, is left to the judgment of the listener.

Sallie Pero Mead – Early Female Industrial Mathematician

Greg Coxson, United States Naval Academy
co-author: William Haloupek, Raytheon (retired)

8:20-8:40, HT 205

Sallie Pero Mead (1893-1981) is a figure that should be better known in the Mathematics community. Her work in industrial mathematics had an impact, in particular in the lead-up to World War II. In 1915, when she was hired by AT&T, women were not considered for jobs as professional mathematicians or engineers. They were not expected to stay at a firm for more than a year or two. Mead's 43-year career began with a short stint as a human computer; through her professionalism and her credentials (she had Mathematics degrees from Barnard and Columbia), she quickly became a professional Mathematician, ultimately joining Thornton Fry's Mathematical Research department at AT&T. This talk will discuss her education and her contributions.

False discovery type procedures: caveats to reproducibility–its all about dispersion

Grant Izmirlian, National Cancer Institute
8:20-8:40, HT 216

The first decade of the new millennium is often called the "dawn of the –omics era" Suddenly biomedical studies were capturing tens of thousands of measurements per patient. A common goal was to use these measurements to predict class membership or determine who would respond well to a particular treatment. Typically dimension reduction would be required to reduce the dimensionality of the prediction space to a level less than the number of participants in the study. The oldest tool, Bonferroni adjustment, was quickly deemed much too conservative for –omics. Luckily, 5 years earlier, Benjamini and Hochberg (BH) introduced their procedure which offered much less stringency by introducing a new paradigm. Rather than controlling the family wise error rate, or probability of one or more false positives, their procedure controls the expected proportion of false discoveries or false discovery rate (FDR). This quickly gained popularity and widespread use to such an extent that it became a knee-jerk choice for ensuring validity in biomarker studies. However, a given experiment produces an (unobserved) instance of the false discovery proportion (FDP) while the BH-FDR procedure only guarantees control of its expected value (FDR = E[FDP]). This is adequate if the distribution of the FDP is highly spiked at its mean. Unfortunately, the BH-FDR procedure gets used regularly in situations when this distribution is not at all spiked. In this talk we will discuss a procedure introduced by Lehmann and Romano in 2008 which controls the probability that the FDP exceeds a threshold, or FDX, but this procedure is only slightly less restrictive than Bonferroni adjustment. We present an alternative less restrictive procedure which controls the FDX based on asymptotic approximation and discuss domains of appropriate application of these various procedures.

Bioeconomic analysis of harvesting within a prey-predator system: A case study in the Chesapeake Bay fisheries

John Herrmann, Christopher Newport University and Norfolk State University
Nathan Kolling, Christopher Newport University and Norfolk State University
8:45-9:05, HT 122
(student talk)

Use of biological resources in a sustainable way is very important as over-exploitation on a long run may lead to the stock depletion which in turn may threat biodiversity. Chesapeake Bay is an extremely complex ecosystem, and sustainable harvesting of its fisheries is very important both for the ecosystem biodiversity and for the economic prosperity of our area. Here we use mathematical modeling to study the population dynamics with harvesting of two very important fish in the Bay, menhaden as a prey and striped bass as a predator. We start by fitting the generalized Lotka-Volterra model to real data for the two species obtained from the fisheries in the Bay. We derive conditions for the existence of the bio-economic equilibrium and investigate the stability and the resilience of the biological system. We study the maximum sustainable yield, maximum economic yield, and resilience maximizing yield policies and their effects on the fisheries long time sustainability.

Asymptotic Distributions and Kostant's Partition Function

Maggie Rahmoeller, Roanoke College
8:45-9:05, HT 204

Mathematicians are often excited when different fields of mathematics come together to help solve a specific problem. My field of research, Lie algebra representation theory, is quite abstract. Objects of interest include weights of representations, which are generalizations of eigenvalues. One way to study these weights is to look at Kostant's partition function (a combinatorial tool) or even better, the q-analog of Kostant's partition function. In this talk, we look at the distribution of the coefficients of this polynomial (bringing in ideas from calculus and statistics) and in many instances find that long-term, this distribution approaches a Normal distribution. But does it always?

An intuitive "math hacking" approach to the classical cross-ratio.

Bob Sachs, George Mason University
8:45-9:05, HT 205

As part of an innovative transition/proof course, we developed an intuitive approach to the classical cross-ratio and its invariance under Mobius transformations. In contrast, we quote R. Boas from his excellent MAA Textbook: "We are going to prove the not very intuitive fact ..." While interesting in itself, there is also a valuable meta-lesson for students and instructors. This topic has lovely connections useful for students when we consider permutations acting on the cross-ratio, including the appearance of the Klein 4-group.

The Information Density of DNA

Abdinur Ali, Norfolk State University
Mushtaq Khan, Norfolk State University
8:45-9:05, HT 216

DNA can store large amount of information. One approach to store digital data in DNA is to convert audio files, video files and text files to binary numbers, and then map the result into synthetic DNA bases. The synthetic DNA can be stored in glass particles for long durations. The advantage of using of DNA is that it has high density and durability. In addition, over billions of data bits can be stored and retrieved with high accuracy. In this paper, we will cover some of the algorithms, which synthesize and sequence DNA bases.

Mathematical Modeling of Oncolytic Virotherapy as a Cancer Treatment

Emily Adams, Christopher Newport University and Norfolk State University
Ajeya Dixon, Christopher Newport University and Norfolk State University
Logan Lawson, Christopher Newport University and Norfolk State University
9:10-9:30, HT 122
(student talk)

Virotherapy is a cancer treatment where oncolytic viruses are injected into the cancerous tumor cells. Oncolytic viruses are genetically-engineered viruses that are designed to infect cancer cells but not healthy cells. This project investigates a simple mathematical model of virotherapy. Using a system of five nonlinear differential equations, we perform numerical simulations to investigate the interactions between uninfected cancer cells, infected cancer cells, oncolytic viruses, immune cells, and dead cancer cells. We compute the equilibria and derive conditions for their stability. Using analytical methods we derive the rate of change of the radius of the cancerous tumor and use it as a basis for numerical simulations that establish effectiveness of virotherapy as a treatment. Finally, we perform local sensitivity analysis by deriving differential equations that determine the behavior of the rate of change of a variable with respect to perturbations in a parameter. Sensitivity analysis is very important as it allows identifying the most sensitive parameters of the model, indicating vulnerability of the model pathways, which then may be used to guide medical practitioners in their choice of therapeutic interventions to try in combination with the virotherapy.

Down With Determinants! Completing Axler's Vision
Jeff Suzuki, Brooklyn College
9:10-9:30, HT 204

In 1995, Sheldon Axler issued a call to banish determinants from the undergraduate curriculum, arguing that a determinant-free approach leads to a clearer understanding of linear algebra. We'll illustrate this by looking at a determinant-free approach to finding eigenvalues and eigenvectors that is more efficient, easier to use, and more general than the standard approach using the characteristic polynomial.

Data-driven dynamics of phytoplankton blooms in a reaction-diffusion NPZ model
Seth Cowall, St. Mary's College of Maryland
9:10-9:30, HT 205

Phytoplankton are the base of the marine food web. They are also responsible for much of the oxygen we breathe, and they remove carbon dioxide from the atmosphere. The mechanisms that govern the timing of seasonal phytoplankton blooms is one of the most debated topics in oceanography. Here, we present a macroscale plankton ecology model consisting of coupled, nonlinear reaction-diffusion equations with spatially and temporally changing coefficients to offer insight into the causes of phytoplankton blooms. This model simulates biological interactions between nutrients, phytoplankton and zooplankton. It also incorporates seasonally varying solar radiation, diffusion and depth of the ocean's upper mixed layer because of their impact on phytoplankton growth. The model's predictions are dependent on the dynamical behavior of the model. The model is analyzed using seasonal oceanic data with the goals of understanding the model's dependence on its parameters and of understanding seasonal changes in plankton biomass. A study of varying parameter values and the resulting effects on the solutions, the stability of the steady-states, and the timing of phytoplankton blooms is carried out. The model's simulated blooms result from a temporary attraction to one of the model's steady-states.

Lewis Carroll on the Tortoise and Achilles
Jason Rosenhouse, James Madison University
9:10-9:30, HT 216

Late in his life, Lewis Carroll, of "Alice in Wonderland" fame, published two papers in the academic journal "Mind". Both papers used entertaining puzzles to illustrate what Carroll took to be fundamental issues in the philosophy of logic. We will discuss one of those puzzles in this talk, involving a dialog between characters referred to as the Tortoise and Achilles.

Invited address

Applying Formal Methods to Safety-Critical Systems

J. Tanner Slagel , NASA

9:45-10:50, HT Globe Hall

How do you know a proof is correct? Traditionally, mathematical proofs are socially verified – at least one human, following a set of implicit rules of natural language and logic, determines if the proof is believable. If the proof becomes overly tedious and/or is essential to some safety- or mission-critical application, it becomes necessary to determine the soundness to a higher standard.

'Formal methods' refer to mathematically rigorous techniques and tools that enable specification, design, and verification of hardware and software systems. The specification used in formal methods are statements in a mathematical logic while the formal verifications are deductions in that logic. Formal methods can be difficult or time/resource intensive, but offer a higher level of assurance than standard verification through testing or handwritten proofs.

This talk will introduce formal methods, motivated by applications of interest to NASA, including uncrewed aircraft operations in the national airspace, urban air environments, and wildfire areas. The audience will be given a crash course in mechanically verified proofs in the Prototype Verification System (PVS), an interactive theorem prover.

Sphere Projection of the Sierpinski Triangle

Lily Kimble, Shenandoah University

2:30-2:50, HT 122

(student talk)

Given a sphere with holes in it and a light, the shadows projected from the light can be found by the stereographic projection. Inspired by Henry Segerman's work on 3d printing and projections; I created an algorithm in OpenSCAD using the stereographic projection that codes the tiling of Sierpinski triangles each with 'n' iterations onto a sphere. Then using the algorithm, I 3d printed the sphere so that when light is shined from the north pole the shadows that are projected creates the tiling of the Sierpinski triangles.

Modular Origami Map Coloring Models for the Masses

Eve Torrence, Randolph-Macon College

2:30-2:50, HT 204

The well known Four-color Theorem states that any map on a plane or a sphere can be colored with four colors so that regions that share a boundary are different colors. It is perhaps less well known that the maximum number of colors needed for a map on a torus is 7, on a two-holed torus is 8, and on a three-holed torus is 9. I will display modular origami models I have built of maps on these surfaces. I will also discus how anyone can build these fascinating models using the directions available in my 2022 Bridges conference paper.

A proposed generalization of a full rim hook removal on partitions

Ryan Shifler, Salisbury University
2:30-2:50, HT 205

In 2004 Fulton and Woodward gave a formula to calculate minimal quantum degrees that appear in the quantum product of two Schubert classes in general homogeneous space in G/P. They further specialize this result to the Type A Grassmannian in the language of partitions and rim hook removals. In this talk I will generalize Fulton and Woodward's specialization to all partial flags in Type A using Maya diagrams. Furthermore, I will show that the minimal quantum degree is unique with a combinatorial argument.

Standards-based grading in Calculus with Precalculus
Jacquelyn Rische, Marymount University
2:30-2:50, HT 216

In this talk, I will discuss the implementation of a standards-based grading system into Calculus with Precalculus (a two semester course that is equivalent to Calculus I). In the system, I determine the "skills" that I want my students to learn by the end of the semester. This is 60student's grade determined by homework and a final exam). Each skill appears on three quizzes in a row, and a student needs to solve its quiz questions correctly two times. Once a skill stops appearing on the quizzes, students can still complete it by coming to my office for a "retake." Given my students' diverse backgrounds, the system works well for them. They appreciate being able to come in and get help on the skills they are struggling with and then retake those skills. In this way, they are able to keep going back to the topics that they did not understand.

Optimal Strategies in Hidden Information Games: Welcome to the Dungeon
Grace Walters, Christopher Newport University
2:55-3:15, HT 122
(student talk)

We discuss the game of Welcome to the Dungeon, a hidden information, press-your-luck game. The game involves drawing monster cards, which may be added to the dungeon deck or not. In order to win the game, the sum of the dungeon deck must be below the strength of the player. With each turn, each player must decide whether to draw another card and push their luck, or pass. Different strategies are simulated using MATLAB, along with their win percentages.

Drill Jigs for Wooden Ball-and-Stick Models
Bruce Torrence, Randolph-Macon College
2:55-3:15, HT 204

Custom 3D-printed drill jigs will be introduced, allowing the placement of holes at precise locations on wooden balls. These simple devices, together with widely available tools and materials, are all that is needed to create custom ball-and-stick edge models. Design principles for drill jigs will be discussed, with tips for working with them and examples of models amenable to these construction techniques. An interesting operation on polyhedra underlies the design of these drill jigs.

Washington DC field trip: Mathemalchemy
Alice Petillo, Marymount University

2:55-3:15, HT 205

This session will describe the experience of visiting the Mathemalchemy exhibit at the National Academy of Sciences in Washington DC featured in the MAA Focus October/November 2021. The Mathemalchemy exhibit features contributions from some members of our MD-DC-VA section. Approximately 25 undergraduate students and faculty from Marymount University (MU) in Arlington, VA attended the Mathemalchemy exhibit in April 2022. The students, mostly undergraduates enrolled in a liberal arts mathematics class, completed a pre-reflection, photo story, and post-reflection in conjunction with the field trip. The session will share these tools, practical suggestions, and sample student responses.

Efficacy of Vaccines and medicines for COVID-19

Jerome Dancis, Univ. of Maryland, College Park
2:55-3:15, HT 216

1. The efficacies of medicine and vaccines are usually presented using the relative rates of effectiveness. The FDA recommends using the absolute rates of effectiveness. We will discuss the two rates and their significant differences using examples for vaccines for COVID-19. Spoiler alert: Pfizer's trial of its vaccine showed that its vaccine reduced deaths due to COVID-19, but increased deaths due to heart conditions. 2. We will apply simple logic to the findings of drug trials. When a medical experiment (clinical trial) finds that a drug is not effective at treating a disease, this only implies that the particular protocol used in that trial should not be used. Just as proofs by checking a single example or even checking many examples are not valid in Mathematics, a clinical trial finding that a drug is not effective at treating a disease in no way precludes a different protocol based on the same drug will not be highly effective. This easily happens when there is a Goldilock's dosage that works, but a low dose does not and a high dose is dangerous. We will discuss important examples where this has occurred in drugs for COVID-19.

Role of mixotrophic zooplankton in seasonally-forced plankton blooms

Gillian Carr, St. Mary's College of Maryland
3:20-3:45, HT 122
(student talk)

We investigate the influence of mixotrophic zooplankton (plankton that can both hunt like animals and photosynthesize like plants) in seasonal plankton blooms, periods of rapid plankton population growth. Using a system of ordinary differential equations, we aim to show how mixotrophy and changing light intensity impact seasonal marine plankton blooms. Beginning with a mixotrophic plankton model, we incorporate this seasonal light variability through a sinusoidal function that affects the growth rates of both the phytoplankton and the mixotrophic zooplankton. Then we use model simulations to identify how the changing light intensity initiates a bloom.

Counting Homomorphisms

Chiru Bhattacharya, Randolph-Macon College
3:20-3:45, HT 204

How many homomorphisms are there between two Dihedral groups? This talk discusses a few different approaches to answer this question.

Some Original Estimation/Fermi Problems

Brian Heinold, Mount St. Mary's University
3:20-3:45, HT 205

In this talk, I'll share some estimation problems I've developed over the last few years for my department's core math class.

Change Ringing Supermethods

Kurt Ludwick, Salisbury University
3:20-3:45, HT 216

n change ringing, "change" on n bells is equivalent to a permutation of n objects. Due to inherent physical requirements, allowable ringing "methods" amount to sequences of permutations of order 2 from the symmetric group S_n. An "extent" on n bells is a method that generates each of the n! possible changes on n bells, without repetition. We will modify this definition of "extent" by viewing a ringing method on n bells as a sequence of individual bell ringings, rather than as the usual list of disjoint changes of length n. We will consider a ringing method to include a change if that change occurs anywhere in the ringing sequence. For example, if a method on 4 bells begins with the changes

1234
1324

we would regard this as the sequence 12341324. Viewed in this way, the first eight bell ringings of this method would include not only the changes 1234 and 1324, but also 2341 and 4132. Our objective is to find efficient ways to generate extents under this convention, and in particular to determine the minimal length extent on n bells for any given n. A "superpermutation" on n objects is a string that contains every per- mutation of the n objects as a substring. The modified change ringing extent defined above is thus a superpermutation on n bells. However, such an extent must be change ringable, which means every substring of length n starting from position 1, $n+1$, $2n+1$, etc. in the string must itself be a permutation of the n bells. Superpermutations in general have no such restriction, so our objective amounts to finding minimal length superpermutations under this restriction. Due to their connection to change ringing methods, we will refer to such restricted superpermutations as "supermethods."

Invited address

Cosh, Cosh, B-Cosh

Alex Meadows , St. Mary's College of Maryland
4:00-5:00, HT Globe Hall

The hyperbolic cosine function (cosh) is well known for many reasons, both analytic and geometric. In this talk, we start with a not often celebrated property, that the area under any portion of the graph of cosh is equal to the graph's length. We will explore playful generalizations of this property, by changing our perspective. What if we measure length on the graph differently, say using the length inspired by taxicabs? Beginning from basic ideas of calculus, our investigation of generalized cosh functions and related curves will lead us to some advanced ideas in analysis and geometry, with a few surprises along the way. This talk is based on joint work with Casey Douglas from the University of Houston and Beth Thomas, current grad student at VCU.