Hudson River Undergraduate Math Conference

Smith College, March 23, 2019

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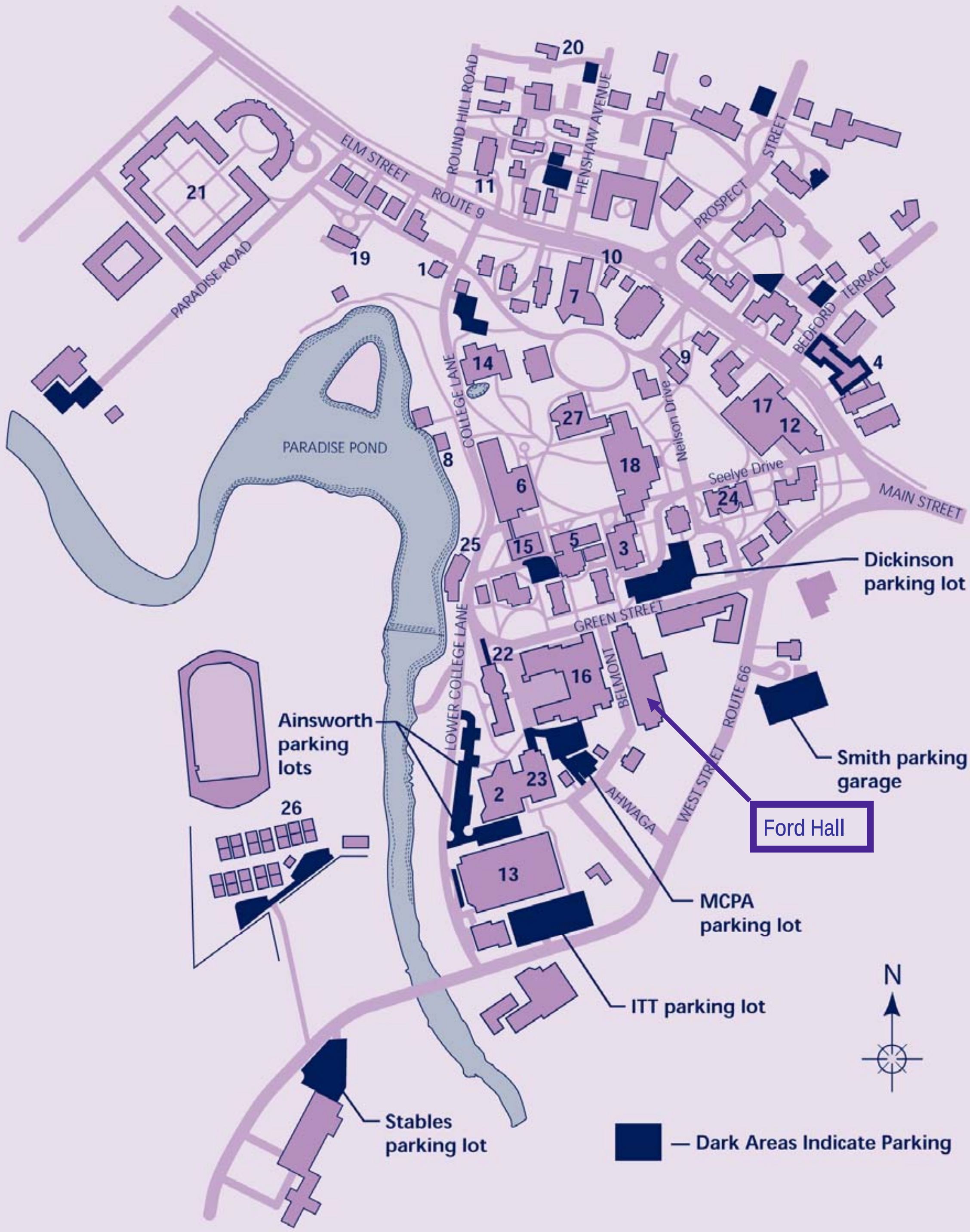

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General Information

Parking: On the morning of the 23rd, you can park at any white-lined space in any of the Smith parking lots (in dark blue on the campus map). The Dickinson parking lot and the Smith parking garage of the closest large lots. The Ainsworth parking lots are also a good option.

Registration & Breakfast: Please register in advance online at the Conference's webpage, or at https://tinyurl.com/hrumc2019. There will be an information desk with abbreviated programs and campus maps in Seelye Hall 106 (Building 24 on the campus map). We will have a light breakfast on the first floor of Seelye.

Parallel Session Talks: All the parallel sessions will take place in Seelye Hall.

Keynote Address: The welcome and invited address will take place in Campus Center (Building 7), upstairs in the Carroll Room (Room 208).

Lunch: Lunch will be served in and around the Carroll Room in the Campus Center.

Schedule Overview

8:00-9:20am	Registration/Breakfast	Seelye Hall 106 and 1st floor
9:30-10:30am	Parallel Sessions I	Seelye Hall
10:45-11:45pm	Welcome & Invited Address	Campus Center, Carroll Room (208)
12:00-1:30pm	Lunch	Campus Center, Carroll Room (208)
1:45-2:45pm	Parallel Sessions II	Seelye Hall
2:45-3:15pm	Coffee Break	Seelye Hall 1st floor
3:15-4:15pm	Parallel Sessions III	Seelye Hall

Internet Guest wifi is accessible anywhere on campus. Choose the network Connect2Smith and enter the password "sophiasmith"

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Welcoming Remarks: Dr. Sarah Pfatteicher, Executive Director of the Five Colleges Consortium

Introduction of the Speaker: Oumayma Koulouh

Keynote Address: Dr. Henry Cohn, Microsoft Research and M.I.T.

Keynote Address:

Dr. Henry Cohn
Microsoft Research and M.I.T.

Title: How to Correct Your Errors Without Knowing What They Are

Abstract: In this talk we'll look at why error terms aren't random and how to take advantage of this lack of randomness to carry out calculations with far more accuracy than we seemingly deserve. Along the way, we'll see a surprising connection between discrete and continuous mathematics.

Biography: This year's plenary speaker will be Henry Cohn, of Microsoft Research New England and MIT. Cohn received his PhD from Harvard University in 2000 under the direction of Noam Elkies. Cohn has received many mathematical honors: he is a Fellow of the American Mathematical Society and received the 2018 Levi Conant Prize for expository writing from the American Mathematical Society.

Parallel Sessions I

Differential Equations and Applied Math — Seelye Hall 101
Chair: Christophe Golé

9:30-9:45 *A Model of Gene Regulatory Networks* (Level 1)
Jack Felag (UVM)
In this mathematical model, networks are evolved in a simulation in order to correct errored codes. These networks can then be thought of as error correcting machines, where it takes in a perturbed binary vector and outputs the desired vector. This talk will describe the biological connection to this work, the evolutionary algorithm, and its applications.

9:50-10:05 *A Mathematical Model of the Presynaptic Calcium Influx in an Alzheimer's Disease Environment* (Level 1)
Massiel Peralta Garcia (Norwich University)
The ability for our brain to remember, synthesize, and manipulate information is directly linked with our neurons' ability to communicate with each other. In Alzheimer's disease (AD), there is a breakdown in the synaptic transmission process, leading to dysfunction in memory and cognitive skills. A leading hypothesis for the neurodegeneration in AD involves the accumulation of amyloid beta oligomers (Aβ) in the brain. This accumulation of Aβ disrupts neuronal calcium regulatory processes leading to an increase of intracellular calcium levels. Sustained increased levels of calcium can trigger apoptosis, a mechanism leading to cell death. Calcium also plays a major role in synaptic transmission. More specifically, during synaptic transmission extracellular calcium enters the presynaptic neuron through voltage-gated calcium channels (VGCC). The presence of Aβ is hypothesized to cause disruption of VGCC and thus affecting a neuron's ability to transmit a signal. The goal of this research is to better understand how calcium flows through various types of VGCCs using a mathematical model. To do this, we use the Hodgkin and Huxley formulation to simulate the membrane potential along with three types of VGCC models. To study the impact of Aβ on calcium influx, we investigate how varying model parameters affect calcium flux. We show that changing the conductance properties of the various VGCCs in the model increases calcium influx into the cell. Altering the time constant of the channels' dynamics also leads to an increase in calcium influx. As such, our results suggest that these mechanisms may be targets of Aβ and play a critical role in an AD.

10:10-10:25 *Jacobi elliptic expansion method* (Level 2)

David Wohlmuth (Western New England University)

The Purpose of this paper is to study a method based on elliptic functions to find traveling-wave solutions to certain nonlinear partial differential equations. Jacobi-elliptic functions are defined as ratios of elliptic functions known as theta functions. Starting with an ansatz in form of a polynomial in Jacobi-elliptic functions, a traveling wave equation solution can be identified. We will apply this method to find traveling wave solutions to the Korteweg-de Vries (KdV) equation which models shallow water waves. The solution produced via this method will find a family of traveling wave solutions, one of which agrees with the well-known soliton solution of KdV.

Applied Mathematics and Statistics Seelye Hall 110
Chair: Mai Dao

9:30-9:45 *Analysis of hydrological model complexity for storm runoff estimation* (Level 1)

Anh Bui (Smith College)

Direct runoff is the water that quickly enters a stream or waterway in response to precipitation events. Knowledge of direct runoff can inform stormwater management and decisions related to flood protection. Previous work established a novel approach to estimate monthly and annual direct runoff by combining the curve number method of the Natural Resources Conservation Service with an exponential distribution of rainfall depths (Guswa et al., 2018). Current work analyzed the accuracy of this approach as a function of varying levels of model complexity. This work considered watersheds represented by a single curve number versus a distribution, curve numbers determined from landscape characteristics versus fit to match observed streamflow, and application of the model on an event-by-event basis versus the use of the novel annual approach. The models were tested with precipitation and streamflow data from the Cocheco and Charles River watersheds in New England, USA. RMSE, maximum error, and relative rank preservation were the primary metrics of accuracy. Accuracy of direct runoff estimates is much greater for the set of models for which the curve numbers were fit to runoff data versus those for which the curve numbers were determined from land-use and soil characteristics. Accuracy is comparable across all models with fitted curve numbers, and the model structure can be utilized which best suits the needs of the study or availability of data.

9:50-10:05 *A Bayesian Analysis of Topographic Influences on the Presence and Severity of Beech Bark Disease* (Level 1)

Obadiah Mulder (Green Mountain College)

This talk will present the use of a Bayesian modeling approach to explore the contribution of topographic factors to both the occurrence and the severity of beech bark disease through examination of small scale patterns of disease. Bayesian modeling is well suited to the analysis of ecological data. It provides flexibility and allows the incorporation of missing or inconsistent data and the estimation of the probability distribution in a theoretically consistent framework. Bayesian models using logistic and ordinal logistic likelihood functions were used to determine the relationship between the independent variables and the probability of a tree being diseased and the extent of disease progression respectively. Our modeling enabled us to estimate the changing probability of acquiring beech bark disease across the landscape as well as to estimate the speed at which the disease spreads. Our applied context will enable me to demonstrate both the strengths and weakness of a Bayesian approach.

10:10-10:25 *Statistical Comparison of Anthurium and Peace Lily Phyllotaxis* (Level 2)

Taylor Stefovic (Smith College)

During the semester, we have been studying the plant patterns (phyllotaxis) of Peace Lilies and Red Anthuriums. In particular we are looking at the arrangement of the flowering structure (inflorescence) of each plant. Peace Lilies and Anthuriums are closely related plants who exhibit different plant organ arrangement. Anthuriums typically have a number of spirals that relate to Fibonacci numbers, while Peace Lilies have exhibited an irregular quasi-symmetric spiralling. We have been taking the inflorescence, rolling it out onto clay, and using a program in MATLAB to examine the resulting patterns of spadix arrangement. Then, we will be using statistics to distinguish the different patterns. By doing this we are hoping to explore how such closely related plants can end up in different phyllotaxis classes.

Combinatorics I Seelye Hall 201
Chair: Joseph Hoisington

9:30-9:45 *Computing the Wiener Index of Families of Graphs* (Level 1)

Margo Theobald, Qianxi Zheng, and Kun Zhou (Skidmore College)

The *Wiener index* of a graph G is simply the sum of the distances between all distinct pairs of vertices. If the graph is part of a family (such as the complete graph K_n, the Ladder graphs L_n, or the Star graphs $K_{1,n}$), we consider the sequence obtained by the Wiener index of each graph in the family. We can determine these indices by showing the sequence satisfies a recursion, which we then solve using generating functions.

9:50-10:05 *Arc Diagrams of Springer Fibers* (Level 1)

Sunita Bhattacharya, Jay-U Chung, and Talia Goldwater (Smith College)

The Springer fiber of a given matrix is a collection of special matrices, called cells, defined by certain linear algebraic conditions. Springer fibers are used in one of the earlies examples of a geometric representation. This talk discusses the Springer fibers of a sequence of even-dimensional square matrices and provides a concise way to represent the cell using combinatorial objects called arc diagrams. We'll describe an algorithm we worked on that bijectively associates noncrossing arc diagrams with the maximal cells of the Springer fiber, as well as conjectures we have about a refinement to dotted arc diagrams.

10:10-10:25 *The Robinson-Schensted correspondence: generalizations and consequences Progressions* (Level 2)

Laura Colmenarejo (UMass Amherst)

This talk aims to be mostly expository, providing some ideas of recent work. The Robinson-Schensted correspondence is a bijection between words of length k in entries $\{1, 2, ..., n\}$ and pairs of tableaux of the same shape, one semi-standard and one standard. This bijection has deep connections within combinatorial representation theory as a model for the decomposition of $V^{\otimes}$, where V is a GL_n-module, under the action of $GL_n \times S_k$ as a general linear group and a symmetric group module.

We explain this correspondence from a purely combinatorial point of view. We also review some generalizations and consequences related to this correspondence, including some recent work done with Rosella Orellana (Dartmouth College), Franco Saliola (UQAM), Anne Schilling (UC Davis) and Mike Zabrocki (York University), where we provide an insertion algorithm from generalized permutations and pairs of standard Young tableaux and multiset tableaux of the same shape.

Graphs, Computer Science and Neuroscience — Seelye Hall 206
Chair: Wenqin Chen

9:30-9:45 *Modeling in Mathematical Neuroscience: Part I* (Level 1)

Caitlyn Parmelee (Keene State College)

The human brain communicates with many specialized cells called neurons. Neurons send electrical signals to each other through connections called synapses. We can use graph theory to model networks of neurons and study the behavior of these networks. The neurons are represented by the vertices of the graph and the synapses by directed edges. We are particularly interested in neural activity that is internally generated rather than the result of an external input. To better understand these emergent dynamics, we study a particular neural network model, the Combinatorial Threshold-Linear Network (CTLN) model. Our goal is to understand how the structure of the network affects its behavior.

9:50-10:05 *Modeling in Mathematical Neuroscience: Part II* (Level 1)

Cameron Spiess (Keene State College)

Previous work with the Combinatorial Threshold-Linear Network (CTLN) models has led to an interest in networks called core motifs. A core motif is a network that has a fixed point supported on all the neurons and no proper subset of neurons supports a fixed point. A fixed point can be described as a "steady state" for the neurons in a particular neural network with neurons in the support all firing at the same rate and the other neurons not firing at all. Fixed points can be found using the graphs that represent the networks. Previous work has determined rules for identifying which subgraphs do, and do not, support fixed points for a network. One of the rules for identifying fixed points is called domination. If domination exists in a subgraph of neurons, then that subgraph cannot support a fixed point of the graph. If every subgraph of a core motif is eliminated by domination, then that core motif is considered to be a strongly core motif. We are interested in strongly core motifs so that we can use them as "building blocks" to build large systems of neural networks that are also strongly core.

10:10-10:25 *Artificial Neural Networks* (Level 2)

Brandon Ledyard (Champlain College)

Machine Learning is an incredibly fast-growing field. Artificial Neural Networks are models that machines follow to learn. In this presentation, I will explain what it means for a machine to 'learn' in the context of Artificial Neural Networks and explain the mathematical concepts that underlie these models. More specifically, we can examine how the machine is able to minimize the difference between its given prediction and the correct prediction and what this really means in a granular mathematical sense.

Math and Politics — Seelye Hall 109

Chair: Paul Friedman

9:50-10:05 *An Analysis of the Financial Contributor Data for the Trump and Clinton Campaigns during the 2016 Presidential Election* (Level 2)

Nicholas Vartanian (UVM)

Understanding the makeup of a political candidate's financial contributor data is important to understanding elections. Presidential elections are at the top of the list when it comes to the importance of money in securing success Due to the connection between money and political power it is critical to unpack the donor data of major political candidates' campaigns. The U.S is a country with growing economic disparities and a two party political system. By analyzing contributor data, we gain insight into the role of wealth in politics as well as how different demographic groups spend to support different candidates. Here we will examine a recent polarizing election: Clinton vs. Trump, 2016. By analysing the contributor data for Clinton and Trump, we achieve a better understanding of the demographics of both candidates' supporters and the distribution of their contribution data.

10:10-10:25 *Gerrymandering: A Comparison of Two Measures of Compactness* (Level 1)

Rae Helmreich (Wheaton College)

Gerrymandering is the act of changing political boundaries so as to favor one political party or class in an election. Much effort has been made in recent years to mathematically define gerrymandering in order to prevent this manipulation. Markov Chain Monte Carlo (MCMC) methods have been used to sample the distribution of all possible redistrictings of a particular area, which allows comparison of specific districtings with the space of all legal districtings. Districting plans in America are required by law to be "compact", though this term is loosely defined by the law. The MCMC method can take into account the compactness of districts, but this requires a strict definition of compactness. However, different groups have used various measures of compactness. An open question in this field is what relationship, if any, exists between different measures of compactness. Two of the methods that have been used are the isoperimetric score and the cut edge score of a districting plan. Isoperimetric score looks at the geography of a districting plan, while cut edges examines the relational structure of a districting plan. Looking at these two seemingly different measures of compactness, we have found a surprising correlation that suggests a relationship between these two measures that can be taken into account in further research.

Set Theory and Topology Seelye Hall 208
Chair: Olivia Del Guercio

9:30-9:45 *Continuum Hypothesis Part 1* (Level 1)

Ashley Whitaker (Westfield State University)

This is part one of a two-part talk on the independence of the continuum hypothesis. From set theory, the continuum hypothesis claims that there is no set whose cardinality is strictly between that of the integers and the real numbers. However, it is not possible to prove or disprove the continuum hypothesis from the axioms of set theory. In this talk we will show we cannot disprove the continuum hypothesis. We will consider Kurt Gödel's constructible universe, L, in which all its sets can be described by strictly simpler sets. The Axiom of Constructability says that all sets are constructible, denoted V=L. We will show that V=L is consistent with ZFC and implies the continuum hypothesis.

9:50-10:05 *Continuum Hypothesis Part 2* (Level 1)
Daniel Blais (Westfield State University)
This is part two of a two-part talk on the Continuum Hypothesis. Using a proof technique called forcing, developed by Paul Cohen, we will take a new approach from part one by showing that having the negation of the Continuum Hypothesis be true and still accepting the Axiom of Choice does not create any contradictions. Forcing helps us prove this consistency and independence by allowing us to build a model of ZF using the Zermelo-Fraenkel axioms and the language of set theory where $2^{\aleph_0} > \aleph_1$, thus implying that ZFC and the negation of the Continuum Hypothesis is consistent.

10:10-10:25 *Tracking the Variety of Interleavings* (Level 1)
Stella Li and Jasmine Noory (Smith College)
In topological data analysis, persistence modules are used to distinguish the legitimate topological features of a finite data set from noise. Interleavings between persistence modules feature prominently in the analysis. One can show that for any $\epsilon > 0$, the collection of ϵ-interleavings between two persistence modules has an algebraic structure. In this project, we study how this structure changes with the value of ϵ.

Parallel Sessions II

Combinatorics II — Seelye Hall 201
Chair: David Vella

1:45-2:00 *Gudermania! New Identities for Euler Numbers* (Level 1)
David Vella (Skidmore College)
In this talk, I set the stage for several subsequent talks by my seminar students. We have been studying generating functions of sequences this semester. Two themes of the course have been using generating functions to solve recurrence relations, and obtaining combinatorial identities by using composite generating functions. In this introductory talk, we get the ball rolling by using the Gudermannian function and its properties to derive identities for the Euler numbers E_n.

2:05-2:20 *Bernoulli Numbers and some Generalizations* (Level 1)
Scott Shangguan, Peter Lin and Suchen Shi (Skidmore College)
One may generalize the famous Bernoulli numbers B_n in various ways. For example, one could consider the *Bernoulli polynomials* $B_n(x)$, or one may consider the *higher order Bernoulli numbers* B_n^w. In either case, one may use the generating functions to derive explicit formulas for these numbers or polynomials. We illustrate this process in this talk.

2:25-2:40 *Stirling Numbers - Close Encounters with the First Kind and the Second Kind* (Level 1)
Kaifeng Yang and Jaimin Zhang (Skidmore College)
In this talk, we explore Stirling numbers of the first kind and of the second kind, and their generating functions. We use the generating functions to derive formulas that express one kind of Stirling number in terms of the other kind.

Computer Science — Seelye Hall 101
Chair: Taylor Stefovic

1:45-2:00 *Calculus Saves Lives!* (Level 1)
Olli Machina (Champlain College)
Vancomycin is an antibiotic drug used to treat patients with serious bacterial infections. Pharmacists use graphical, numerical and algebraic principles of calculus to determine the appropriate dosages and dosing intervals of this drug for

these patients. A TI-84 graphing calculator is a powerful tool that can be easily used in a professional environment like pharmacy and in educational environments like the classroom. This presentation covers the program created and the obstacles of a student creating a calculator application that allows users to solve vancomycin dosing problems tailored to individual patients on a TI-84.

2:05-2:20 *Shor's Algorithm and Its Impact on Present-Day Cryptography* (Level 2)
Alexandra Veliche (Northeastern University)
Factoring a given number may not seem like such a difficult task at first glance, but when the number is a few hundred digits long and is the product of two very large primes, the problem becomes infeasible. No classical algorithm for factoring in polynomial time is thought to exist, as this would solve the Millennium Prize problem of "P vs. NP". In the quantum world, however, this is another matter entirely: Peter Shor's quantum algorithm for factoring integers runs in polynomial time in terms of the size of the number being factored. Because several commonly-used cryptosystems, such as RSA, rely on the difficulty of this problem, this result poses a threat to public-key cryptography as we know it. In this project, I will be exploring the mathematics used in Shor's algorithm and analyzing its components from an algebraic perspective, with a focus on the roots of unity used. I will also discuss the impact this algorithm may have on modern-day cryptography.

2:25-2:40 *Who Needs Exceptions, Anyway? - How software engineering gets functions wrong* (Level 2)
Naomi Coffman (Champlain College)
The domain and range of a mathematical function can be declared in either mathematical or human language. "Functions" as understood in software are considerably more limited, necessitating clumsy workarounds. This talk will describe new language semantics that give software functions expressive power closer to that enjoyed by mathematical functions.

Mathematics Education

Seelye Hall 208
Chair: Tiffany Christian

1:45-2:00 *Why Common Math Core?* (Level 1)
Lindsay Day (Champlain College)
Common Core is a series of Literacy and Math standards for kindergarten through 12th grade which has been adopted by most states in the US. Recent college graduates missed seeing Common Core standards as students, and there are many misrepresentations in the media. Due to changes in state-required learning goals,

new curriculums were developed to help classroom teachers reach those desired goals. Although the methods in the math curriculum can seem impractical, they actually help build the concepts that work behind the scenes. In this talk, I will share the benefits of the changed standards and how the changed standards allow for students to have a more foundational understanding of mathematics.

2:05-2:20 *Mathematical Zendo* (Level 1)
Philip DeOrsey and Corey Pooler (Westfield State University)
Zendo is a logic game in which a secret rule is selected by the leader and students work to discover the secret rule by building and studying arrangements of prisms. The student who correctly guesses the secret rule wins. As part of a senior honors project we have expanded the game beyond prisms to various mathematical topics including shapes, numbers, and linear functions. We will discuss the game, our experiences in the classroom, and future topics for exploration.

2:25-2:40 *Integration by the Wrong Parts* (Level 2)
Vincent Ferlini (Keene State College)
When applying integration by parts, one needs to choose the functions u and v so that the new integral is simpler to evaluate. With some simpler integrals, one can make the "wrong" choice and through an "infinite" sequence of integrations by parts, still come up with the correct antiderivative of the original integral. This presentation will demonstrate the idea through examples.

Math, Games and Graphs	Seelye Hall 109 Chair: Ari Hermida

1:45-2:00 *Game, Set, Math* (Level 1)
Riley Bunker (Keene State College)
We will discuss the game SET through its mathematical properties that show ideas from group theory, magic squares, and linear transformations. We will show mathematical processes to find collections of sets and to find structurally distinct collections. We can determine the final cards needed to be a set and similarly where there will be no set.

2:05-2:20 *Encryption using the Rubik's Cube* (Level 1)
Weiqi Feng (Wheaton College)
Rubik's cubes, estimated to be the world's besting-selling toy, is a fascinating puzzle that I believe most people have attempted to solve. However, as anyone who has tried knows, Rubik's cubes are hard to solve. Cryptography shares the essence with playing Rubik's cubes; to fix the scrambled pattern. In this talk, we will discuss the advantages and challenges of using the Rubik's cube as the basis

of an encryption system. We will also see additional opportunities provided by using 4 by 4 by 4 and larger cubes.

2:25-2:40 *An Application of Integer Programming in Graph Theory* (Level 1)

Henry Wix (Western New England University)

Given a graph G, a set S of vertices is called a dominating set of G if every vertex in G−S is adjacent to a vertex in S. The domination number of G, denoted γ(G), is the minimum cardinality of a dominating set of G. In this talk, we discuss finding γ(G) by solving an integer program. We also consider the dual of the integer program and discuss what the dual program represents in terms of the graph.

Number Theory I	Seelye Hall 110 Chair: Alexis Dasher

1:45-2:00 *An Alternative Method of Computing the Decimal Expansion of a Rational Number* (Level 1)

Danielle Wiley (Keene State College)

Middle school students learn how to use long division to find the decimal expansion of a rational number. Eventually, the expansion results in the repetition of a single digit or a block of digits. Computing the block of digits proceeds from left to right. This presentation will begin with a review of decimal expansions of rational numbers. Then we will demonstrate a method that produces the block of digits proceeding from right to left and that involves multiplication of digits rather than division. This method is interesting and useful since it gives one a deeper understanding of the decimal expansion of a rational number.

2:05-2:20 *Eta-Quotients of Prime or Semi-Prime Levels* (Level 2)

Benjamin Oltsik (Hamilton College)

Modular forms are types of complex functions critical to understanding number theory. Certain modular forms may be expressed as a product of Dedekind's eta-function. These products are known as eta-quotients. In this talk, we will discuss for what particular levels of modular forms do eta-quotients exist. Specifically, we will focus on prime and semi-prime levels.

2:25-2:40 *Curves, Divisors, Riemann-Roch, and Numerical Semigroups* (Level 2)

Michael Urbanski (Western New England University)

An algebraic curve is a set of points that satisfy a system of polynomial equations. A divisor is a finite formal sum of points on a curve. With a curve and divisor there is an associated space of rational functions called the Riemann-Roch space. The Riemann-Roch Theorem relates the concepts of this space to its associated curve and divisor. In this talk we will see how the Riemann-Roch Theorem motivates the study of numerical semigroups.

Statistics	Seelye Hall 206 Chair: Kenneth Mulder

1:45-2:00 *Has Out of Competition Testing Effected Performances in Track and Field?* (Level 1)

James Burnes (Siena College)

A significant development in the efforts to eliminate the use of Performing Enhancing Drugs (PEDs) in track and field and distance running in the United States was the introduction of out of competition testing in 1989. Prior to this drug testing of United States athletes was only conducted during competitions, more specifically at high level domestic competitions such as the Olympic Trials. This study uses regression analysis to investigate performances before and after the implementation of out of competition drug testing. After considering all standard track and field and distance running disciplines for analysis. Analysis for both United States men and women over a fifty year period is presented for both the best performer from the United States each year as well as the tenth best performer, a more resistant measure. Generally, progress in all three events has decelerated after 1989.

2:05-2:20 *Comparison of Data Analysis Techniques for High Dimensional Datasets* (Level 1)

Jennifer Elder (Green Mountain College)

The goal of this study was to compare analysis methods used to identify patterns in high dimensional datasets, and to contrast their utility for hypothesis testing and prediction. Typically, statistical problems have significantly more samples than parameters, which makes it possible to fit parameters with reliable error estimates. To contrast, when there are more potential parameters than there are samples, this leads to an infinite number of possible solutions. An example of this is in analyzing microbiomes using gene sequencing data. In our case in particular, we are comparing techniques to determine the relationship of Borrelia burgdorferi, the bacterial vector of Lyme disease, to the overall structure of the microbial community of the tick. The techniques considered fall into three general categories: constrained regression, dimension reduction, and network analysis techniques. Constrained regression provides models for predicting the presence and quantity of B. burgdorferi in an unknown sample, but provides no measure of statistical significance. Dimension reduction techniques can be used to test whether B. burgdoferi influences the microbiome and potentially to predict the presence or absence of this species. Since the data is being reduced, the results are sensitive to which data transformation is used, as well as how the data is reduced. Network analysis can be used to determine a species' role in the community, however the nature of the relationship between species is not clear and there is a significant potential to identify false relationships.

2:25-2:40 *Language, Natural and Otherwise: Reconciling Statistical Authorship Attribution with the Spoken Word* (Level 1)

Michael Brown (Northeastern University)

Spoken language exists, in one sense, as an analogue signal: a continuous stream of noise we make with our mouths. However, there is another sense in which it is discrete: there are only finitely many perceptual categories that constitute meaningfully contrastive sounds (phonemes), allowing for a representation of speech as a sequence of well-ordered segments.

Although many forensic techniques in language scrutinize its analogue form-the timbre of a person's voice, for example-this project explores forensic techniques applied to language in its discrete form. In particular, we investigate applications to authorship attribution. By re-encoding literary works from different authors as a series of sound segments rather than letters, and modeling the probabilistic behavior of these sound-sequences using variable-length Markov chains and stochastic context trees, we investigate the extent to which one can meaningfully distinguish between authors based on characteristic patterns of sound.

Parallel Sessions III

Combinatorics III Seelye Hall 201
Chair: David Vella

3:15-3:30 *Counting Restricted Compositions of a Natural Number, Part I* (Level 1)
Siqi Chen and Ping Lin (Skidmore College)
A *composition* of a natural number n is simply an ordered k-tuple of positive integers whose sum is n. In our project, we consider compositions with certain restrictions on the parts, such as requiring that the last part be odd, or that all parts are odd, or that no part is greater than 2, etc. In each case, it is possible to find a formula for the number of such compositions by solving a recurrence relation. We solve the recurrence relations by considering generating functions. In this talk, we will report on some of our findings.

3:35-3:50 *Counting Restricted Compositions of a Natural Number, Part II* (Level 1)
Alex Lund and Edvin Leon Rios (Skidmore College)
A *composition* of a natural number n is simply an ordered k-tuple of positive integers whose sum is n. In part I, our colleagues considered compositions with certain restrictions on the parts. They found formulas for the number of such compositions by using a generating function to solve a recurrence relation. In this talk, we take a different approach - we write the generating function as a composite function, and use a 2008 theorem of Vella to derive our formulas.

3:55-4:10 *Catalan Numbers* (Level 1)
Philip Steudel and Stevie Yu (Skidmore College)
In this talk, we discuss the Catalan numbers C_n, one of the most important sequences in mathematics. For one thing, they are known to count many combinatorial objects, from Dyck words to binary trees to diagonal triangulations of convex polygons. For another, once can use the generating function to derive a recursive formula for these numbers. We will report on some of the things we explored in our project on Catalan numbers for our senior seminar.

Number Theory II Seelye Hall 110
Chair: Paul Friedman

3:15-3:30 *Repdigits and Arithmetic Sequences* (Level 1)
Nicholas Ahlgren (Keene State College)

An *arithmetic sequence* is an infinite sequence of positive integers of the form $a + dn$ where a and d are fixed integers and $n = 1, 2, 3, 4, ...$ An example is $3 + 5n$ which results in the sequence $8, 13, 18, 23, 28, ...$ A repeated digit, known as a *repdigit*, is a positive integer of the form $kkk...k$ where k is a single nonzero digit. The integers $33, 9999$, and 11111 are examples of repdigits. For example, the sequence $7 + 13n$ has a subset of values which contains an infinite number of repdigits where the digits are all ones. The objective of this talk is to determine conditions on a and d which determine whether the sequence will have an infinite number of repdigits, a finite number of repdigits, or no repdigits and then proving why.

3:35-3:50 *Visual Gems of Number Theory* (Level 1)
Sarah Doubleday (Keene State College)
Many of the theorems that we prove in Number Theory can be represented in a visual way. For example, we can show facts about triangular numbers using dots and forming them into a triangle. In this presentation, we shall explain some of these visual proofs and talk about how they could be used in a middle school classroom.

3:55-4:10 *Generalizing the Three Gap Theorem* (Level 1)
Alexis Dasher (Smith College)
Place the tip of a knife at the center of a circular cake and score the cake from center to edge. Rotate the cake under the knife and score it again after every rotation by angle θ until there are marks at $\theta, 2\theta, ..., N\theta$ for some fixed natural number N. After marking the cake this way, slice it along those marks. No matter the choice of N and θ, there will be slices of at most three different sizes! This result is known as the Three Gap Theorem. If we let the cake have unit circumference and angle θ has associated arc length α, then the above process is like traveling along a 1-periodic sawtooth wave making marks at $\alpha, 2\alpha, \ldots, N\alpha$. In our research, we study generalizations of the Three Gap Theorem to other periodic functions. We investigate the distinct gap sizes created by evaluating periodic functions at uniformly spaced inputs, marking these values, and studying the distinct gap sizes between nearest marks in the image. In particular, we study periodic piecewise linear and trigonometric functions.

Applied Math — Seelye Hall 101
Chair: Lucy Oremland

3:15-3:30 *Ranking Liberty League Basketball Players Using Ridge Regression* (Level 2)

Sam Cohen (Skidmore College)

In basketball, it can be hard to understand an individual's direct contribution to team success. A player that doesn't score, but plays an important role on defense, might help their team win more than the star scorer. This undervalued player might not show up in the box score, so how can we quantify their contribution? To solve this, we turn to Plus-Minus, a stat that shows the point differential between a team and their opponent when a certain player is on the floor. But even then, how can we attribute the Plus-Minus score to the undervalued player when there are 9 other players on the court? This problem is addressed with ridge regression, a form of linear modeling that accounts for multicollinearity. Using this technique with lineup data obtained from every game in the Liberty League this season, I created a model that isolates the contribution of each player. This model has considerably less error and performs much better than linear regression in ranking players.

3:35-3:50 *Win Probability and Decision Making in the NFL* (Level 1)

Andrew Perry (Springfield College)

Contemporary sports teams use quantitative analysis and mathematical modeling in a variety of the decisions they make. A modern use of mathematics by forward-thinking NFL teams is strategic decision making, for example whether attempting to convert on fourth down optimizes win probability (as opposed to punting). We will examine a mathematical model of this situation.

3:55-4:10 *Splines on Hessenberg Graphs* (Level 1)

Ari Hermida and Dayln Gillentine (Smith College)

A labeled graph is a *spline* if every edge label is divisible by the difference of the labels at its incident vertices. Splines are used across analysis and applied math, including in data interpolation, computer graphics, and engineering. One goal is to generate a "basis" that spans the set of all splines. In our research, we use an algebraic generalization of splines. We use so-called Hessenberg functions to define a family of edge-labeled graphs, and other combinatorial objects to define vertex labels. We are attempting to give a closed formula to characterize a basis of splines in this setting. We have results for small graphs; moving forward, we would like to find a more general formula.

Geometry and Topology Seelye Hall 206

Chair: Ockle Johnson

3:15-3:30 *Invariants of Colored Knots* (Level 1)

Olivia Del Guercio (Smith College)

In this work we present two methods for computing a type of knot invariant called the dihedral linking number. The (ordinary) linking number of a pair of knots measures how many times one knot wraps around another, and can be computed from a diagram of the link. The dihedral linking number is a property derived from a single 3-colored knot (rather than a link), and is equal to the linking number of a pair of knots obtained from the 3-colored knot; these two knots sit in another three-dimensional space called a branched cover. Our first method utilizes patterns in what are called twist and pretzel knots to develop an algorithm for computing the dihedral linking number in special cases. Our second method shows that the dihedral linking number for all knots can be determined from a piece of readily available information known as the Gauss Code. The dihedral linking number can be used not only to gauge whether two knots are the same, but also provide information on the ampichirality and invertibility of a given knot.

3:35-3:50 *What Percentage of Triangles are Acute?* (Level 1)

Patrick Dragon (UMass Amherst)

Suppose we generate a triangle at random. What is the probability it will be acute? Polling humans is an unreliable method for generation of random triangles, but is still worth investigation. One might conjecture that human-generated triangles will over-represent the isosceles, right, and equilateral cases. In this talk we will explore several classic approaches to the question, including both geometric methods and computer simulations.

3:55-4:10 *Differential geometry on polyhedra* (Level 2)

Andrew McIntyre (Bennington College)

One of the frustrations of a faculty member who is enthusiastic about differential geometry and global geometry is that teaching the subject requires so many prerequisites and so much struggling with foundations before reaching interesting results. However, a surprising amount of interesting geometry can actually be done meaningfully on polyhedra, or polyhedral spaces. When done this way, calculus is not needed, and students can study serious theorems (and open problems!) using only elementary geometry.

In the first part of the talk, I will describe a bit of the geometric experience of a flatlander who lives on, for example, an icosahedron. I?ll show how to use models, and elementary geometry, to make the curvature of their universe concrete, and to see, for example, how the interior angles of a triangle might not add to 180° for these flatlanders. In the second half of the talk, as an example of a global theorem, I will briefly explain the Gauss-Bonnet theorem, and very briefly indicate its meaning and proof in this context.

Math, Art and Music Seelye Hall 208
Chair: Jasmine Noory

3:15-3:30 *A Mathematical Investigation of Sol LeWitt's Wall Drawing 413* (Level 1)
Lydia Ahlstrom (Keene State College)
When one can find a mathematical concept in a work of art, it will enrich and illuminate both the mathematics and the art. Sol LeWitt was a 20th century artist whose work is closely associated with Minimalism and Conceptual art. His Wall Drawing 413, which can be viewed at the Massachusetts Museum of Contemporary Art in North Adams, MA, consists of 64 squares each of which is divided into four smaller squares. Only four colors are used to fill the small squares. This talk will begin with an overview of Lewitt's art, followed by how Wall Drawing 413 can be interpreted in terms of permutations and groups.

3:35-3:50 *Hidden Markov Model in Music Classification* (Level 1)
Xinru Liu (Wheaton College)
Music Information Retrieval (MIR) is concerned with extracting meaningful features from music (audio signal or notated music) and developing search and retrieval schemes. One of the challenges for MIR is to find music similar to listeners' preferences. This research is aimed at classifying classical piano pieces by different composers. We extract sequential features (Mel-frequency Cepstral Coefficients) of the music from the audio signal and fit Hidden Markov Models (HMMs) for different piano pieces. Model-based clustering is applied to initialize the HMM and then Balm-Welch algorithm is used for parameter estimation. We classify a variety of music by computing the "similarity" between a new piece and the fitted HMMs from different pieces.

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