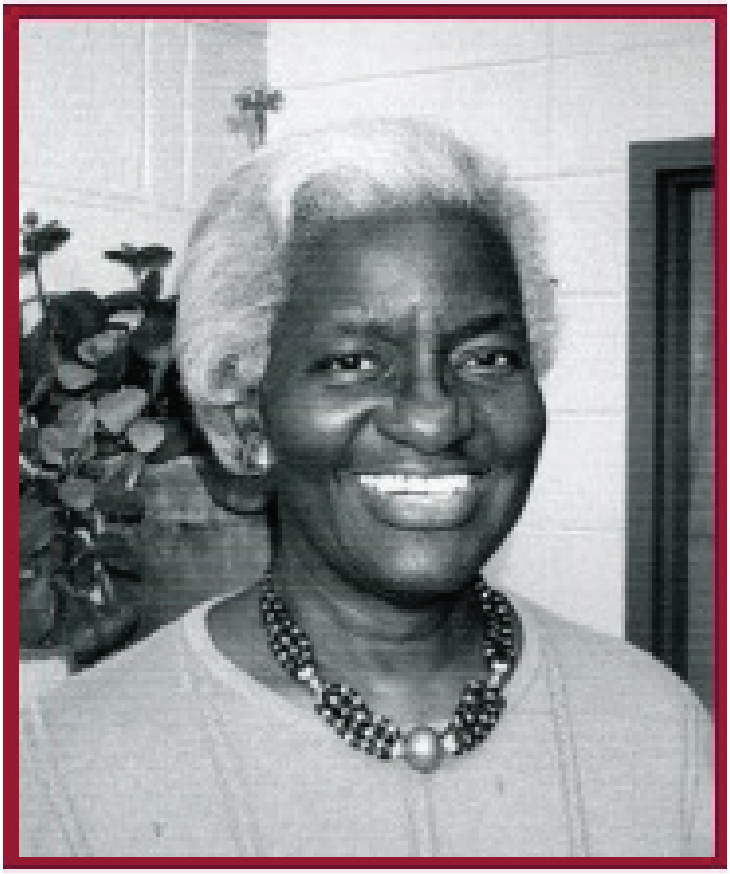
The Fourteenth Annual

Harriett J. Walton Symposium

on

Undergraduate Mathematics Research



Program and Abstracts

Saturday, April 2, 2016

The Fourteenth Annual

Harriett J. Walton Symposium

on

Undergraduate Mathematics Research

Sponsored by

The Department of Mathematics
Morehouse College

The Division of Science and Mathematics
Morehouse College

Morehouse College

Saturday, April 2, 2016

Contents

MOREHOUSE
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DIVISION OF SCIENCE AND MATHEMATICS

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March 24, 2016

Dear Student Presenters and Colleagues:

On behalf of the division of Science and Mathematics at Morehouse College as Chair, I want to welcome you to the 14th Annual Harriet Walton Symposium. To the student presenters, I would first like to congratulate you and also encourage you to continue to pursue your research. Remaining active in research is important whether you intend to pursue a research career or not. Being involved in research will enhance your skills in critical thinking, problem solving and analytical reasoning. To the faculty, as an active researcher who has been heavily involved with training undergraduate laboratory assistants, I want to express my thanks for your commitment to provide guidance and opportunities for students to engage in active learning through conducting research.

I can think of no better person to honor than Harriet Walton, who over the course of forty-two years was an outstanding mathematics teacher and valued member of the Morehouse community. I wish all of the students who are sharing the results of their research today; much continued success and that some of you will pursue a career in research. I wanted to express to the faculty that your effort and commitment to training students in research is greatly appreciated.

Sincerely,

Duane Jackson, PhD
Professor of Psychology &
Chair of the Division of Science & Mathematics

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5 April 2014

Dear symposium attendees and presenters:

We are happy to have you participate in this Twelfth Annual Harriett J. Walton Symposium on Undergraduate Mathematics Research. Since 2003, this symposium has become a highlight in the academic year for this region's mathematics students and a valuable opportunity for them to synthesize their research experiences, hone their presentation skills, and share the results of their work with each other and with the accompanying faculty and guests.

We in the Morehouse College Department of Mathematics are appreciative of the work you have done and of your travels, in many instances, to join us today. Undergraduate research like that presented at today's symposium serves to motivate and inform students about possibilities beyond the Bachelor's degree and to develop skills and habits of mind that can benefit them in graduate study and beyond.

Thank you for your participation this year, and we hope you will continue your support, joining us again in 2015 and beyond.

Duane Cooper
Assoc. Professor and Chair
Department of Mathematics

Professor Harriett J. Walton

In September 1958, Harriett J. Walton joined the faculty of Morehouse College during the presidency of Benjamin Elijah Mays. She became a member of a team of three persons in the Department of Mathematics where she worked with the legendary Claude B. Dansby who served as Department Chair. Dr. Walton and her two colleagues taught all of the mathematics for the majors as well as the mathematics for non-science students. Dr. Walton relates that two of her favorite courses that she taught during this period were Abstract Algebra and Number Theory. The three-member mathematics department did an excellent job of preparing their mathematics majors for graduate school and the other students for success in their respective disciplines. In fact it was during this period of history that Morehouse gained the reputation of being an outstanding Institution especially for African American men. As the department grew, Dr. Walton shifted her attention away from mathematics majors and began to concentrate on students who needed special attention and care in order to succeed in mathematics. She became an advisor, mentor, tutor and nurturer to a large number of students matriculating at Morehouse College. Because of the caring attitude that she had for her students, some of them to this day refer to her as "Mother Walton."

Dr. Walton has never been satisfied with mediocrity. Throughout her teaching career she demonstrated a love for learning. In 1958 when she arrived at Morehouse College she had an undergraduate degree in mathematics from Clark College in Atlanta, Georgia, a Master of Science degree in mathematics from Howard University, Washington D.C., and a second Master's degree in mathematics from Syracuse University. While at Morehouse teaching full time and raising a family of four children, Dr. Walton earned the Ph.D. degree in Mathematics Education from Georgia State University. After receiving her doctorate, Dr. Walton realized the emerging importance of the computer in education so she returned to school and in 1989 earned a Master's degree in Computer Science from Atlanta University. She is indeed a remarkable person.

Dr. Walton's list of professional activities, awards and accomplishments during her career is very impressive and too lengthy to be enumerated here. However a few special ones are her memberships in Alpha Kappa Mu, Beta Kappa Chi, Pi Mu Epsilon, and the prestigious Phi Beta Kappa Honor Society. Additionally she was selected as a Fulbright Fellow to visit Ghana and Cameroon in West Africa. Dr. Walton's professional memberships included the American Mathematical Society, the Mathematical Association of America, National Council of Teachers of Mathematics (NCTM) and the National Association of Mathematicians (NAM). She served as Secretary/Treasurer of NAM for ten years. In May 2000, Dr. Walton retired from Morehouse College after forty-two years of service.

Foreword

The Department of Mathematics and the Division of Science and Mathematics of Morehouse College would like to thank the student presenters and their advisors for their participation in the Fourteenth Annual Harriett J. Walton Symposium on Undergraduate Mathematics Research. Until this year, the Symposium had been funded partially through the generous support of the Mathematical Association of America (MAA) Regional Undergraduate Mathematics Conference Program through National Science Foundation Grant DMS-084677. The purposes of the Symposium are the following:

- to encourage students to do more undergraduate mathematics research
- to introduce students to their peers from various institutions and related fields
- to stimulate student interest in pursuing graduate degrees in mathematics and science
- to give students experience in presenting their research, both orally and in written form

To all supporters, thank you for your help to make the Fourteenth Annual Harriett J. Walton Symposium on Undergraduate Mathematics Research a success. We hope to continue this event for many years to come.

Symposium Committee

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Tuwaner Lamar
Benedict Nmah, Conference Director
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The Fourteenth Annual
Harriett J. Walton
Symposium on Undergraduate Mathematics Research
Saturday, April 2, 2016

Schedule

11:00 am - 11:20 am Welcome in Dansby Hall, Room 200

11:25 am - 11:45 am Student Presentations

11:50 pm - 1:00 pm Lunch

1:10 pm - 3:10 pm Student Presentations

3:20 pm - 3:40 pm Closing in Dansby Hall, Room 200

Session 1: Dansby Hall, Room 300

11:25 am-11:45 am **Victoria M. Latimore**
Albany State University
Finite Difference Methods for Differential Equations

1:10 pm-1:30 pm **Katherine Brooke, Denisse Saucedo and Cassie Xu**
Agnes Scott College
Second-Order Linear Recurrence Relations and Periodicity

1:35 pm-1:55 pm **Marquis Curry and Jeremy Jones**
Albany State University
Cubic Splines Polynomial Interpolation and Approximations of Integrals of Complex Functions

2:00 pm-2:20 pm **Miles Stevens**
Morehouse College
An Analogue of the Median Voter Theorem

2:25 pm-2:45 pm **Brandi Sumter**
Albany State University
Computing a Belyi Function of Degree 8 from its Branching Pattern

2:50 pm-3:10 pm **Brandon Boggess**
Georgia Institute of Technology
Splitting Varieties for Cup Products with Z/3-coefficients

Session 2: Dansby Hall, Room 302

11:25 am-11:45 am **Alayah Canteen and Alston Rice**
Albany State University
Using Regression Analysis to compute and predict Agricultural Production Estimates in Southwest Georgia

1:10 pm-1:30 pm **Chelsea Hicks, DaMarcus Green and Iris Swan**
Albany State University
Crime Data Distribution and Crime Data Analysis in some Georgia Counties from 1990 - 2015

1:35 pm-1:55 pm **Shaniqua Moore, Kadeja Scott and Savannah Perkins**
Albany State University
A Statistical Study of Small Scale Farmers in Southwest Georgia

2:00 pm-2:20 pm **Jeremy Jones, Marquis Curry and Lanina Howard**
Albany State University
Factors Affecting Student Performance and Institutional Effectiveness in Georgia: A Regional Study

2:25 pm-2:45 pm **Victoria Latimore, Sataura Jones and Jonathan Hankerson**
Albany State University
Fixed Income Investments and Retirement Annuities

2:50 pm-3:10 pm **Robert Mitchell**
Morehouse College
Modeling of an Atomic Magnetometer

Session 3: Dansby Hall, Room 306

11:25 am-11:45 am **Talon Johnson**
Morehouse College
Modeling Evolutionary Dynamics of Human Immunodeficiency Virus

1:10 pm-1:30 pm **Garrett Divens**
Morehouse College
Controlling the Space of Infinite Graphs

1:35 pm-1:55 pm **Biru Tang**
Agnes Scott College
Recursive Sequences Modulo p^2

2:00 pm-2:20 pm **Michael Wade and Keyonna West**
Albany State University
Robotics and Path Planning

2:25 pm-2:45 pm **Joseph Clark, Janika Suggs, Carlos Quarterman and Lawrence Broomfield**
Albany State University
The Network

2:50 pm-3:10 pm **Jeremy Ariche**
Morehouse College
Crowd Dynamics

Session 4: Dansby Hall, Room 308

11:25 am-11:45 am **Caleb Bugg**
Morehouse College
Committee Selection With Approval Voting and Hypercubes

Abstracts

Jeremy Ariche, Juan Claramunt and Timothy Valicenti, Department of Mathematics, Morehouse College
Title: Crowd Dynamics
Advisor: Dr. Vadim Zharnitsky, University of Illinois-Urbana Champagne

Lately, there has been growing concerns regarding the proliferation of people across the world. Specifically, under stressful conditions, dangers of stampeding effects in densely populated areas are imminent. Thus we seek an appropriate model utilizing computational methods that accurately simulate the dynamics of a panicking crowd. Specifically, we will employ a discrete physics-based model that uses fourth-order Runge-Kutta to solve for the trajectories of a finite number of people in a densely populated space. We seek to observe crowd density build-ups as well as energy growth. We also establish a relationship between density build-ups and the systems configurations.

Brandon Boggess , Department of Mathematics,
Georgia Institute of Technology
Title: Splitting Varieties for Cup Products with Z/3-coefficients
Advisor: Dr. Kirsten Wickelgren

For a functional assignment η of a cohomology class $\eta\_f \in H^*(\text{Spec } F, Z/n)$ to fields F over some ground field, k, a splitting variety is a scheme X over k which has F-points if and only if η_f vanishes. We connect Veronese embeddings to splitting varieties of cup products in Galois cohomology. We then give an algorithm for constructing splitting varieties for cup Products with Z/n coefficients, with an explicit calculation for n = 3. An application to the automatic realization of Galois groups is given.

Katherine Brooke, Denisse Saucedo and Cassie Xu, Department of Mathematics, Agnes Scott College
Title: Second-Order Linear Recurrence Relations and Periodicity
Advisor: Dr. Alan Koch

A sequence, S_n which follows a second-order linear recurrence relation satisfies $S_{n+1} = c_1 * S_n + c_2 * S_{n-1} - 3$, for some constants c_1 and c_2. For any positive integer n, we construct such a sequence with period n. By varying the initial values S_0 and S_1, a given second-order linear recurrence relation can generate at most Three distinct non-trivial periods, one of which is the least common multiple of The other two.

Caleb Bugg and Gabriel Elvin, Department of Mathematics,
Morehouse College
Title: Committee Selection With Approval Voting and Hypercubes
Advisor: Dr. Francis Edward Su

In this project, we examine elections of the following form: a committee of size k is to be elected, with two candidates running for each position. Each voter submits a ballot with his or her ideal committee, which generates their approval set. The approval sets of voters consist of committees that are "close" to their ideal preference. We define this notion of closeness with Hamming distance in a hypercube: the number of candidates by which a particular committee differs from a voter's ideal preference. We establish a tight lower bound for the popularity of the most approved committee, and consider restrictions on voter preferences that may increase that popularity. Our approach considers both the combinatorical and geometric aspects of these elections.

Alayah Canteen and Alston Rice, Department of Mathematics and
Computer Science, Albany State University
Title: Using Regression Analysis to compute and predict Agricultural Production Estimates in South West Georgia
Advisor: Dr. Robert S. Owor

This research project seeks to integrate the highly successful application of new insights of data science and predictive analytics in business, to the agricultural production pipeline in order to more accurately estimate and predict the timing, quality, quantity, efficiency, response time, frequency, distribution, compliance and consistency of the products, processes and resources inputs that go into agricultural production. This research while focusing on the specific problem of using Regression Analysis to provide a more accurate estimate of the "Cropland Rental rate" as a starting point, aims to establish a deeper relationship between the farmers of Southwest Georgia and Albany State University's Department of Math and Computer Science Data Analytics group of Researchers. From the estimation of seeding time to harvesting, farmers must contend with statistical fluctuations of weather, moisture, heat, insects and irrigation, farm implements, machinery and tools, all of whose computational requirements can benefit from new data mining and analytics techniques. Southwest Georgia is a major agricultural region in the State of Georgia. Data Mining, Data Sciences and Predictive Analytics can greatly improve the efficiency, yield, marketing, sales and distribution of agricultural produce in South West Georgia.

Joseph Clark, Janika Suggs, Carlos Quarterman and Lawrence Broomfield,
Department of Mathematics and Computer Science, Albany State University
Title: The Network
Advisor: Dr. Seyed Roosta

This project deals with an iPhone application called ***The Network***. The app is an Albany State University exclusive app (for now) and it can be used for school, networking, and fun/activities outside of school. The students can use the application to find and interact with students that share the same major with them. The app can also be used to share various social activities, including meetings, tutorial sessions, and class registration information. Furthermore the app enhances student-faculty interaction, uploading of grades by faculty in real time, and enables students to view their grades instantly. The purpose of this application is to bring convenience and versatility to everyone at Albany State University. In this presentation, we present the design of such app, the algorithms involved in the design, and various ways to make the app very popular.

Marquis Curry and Jeremy Jones, Department of Mathematics and Computer Science, Albany State University
Title: Cubic Splines Polynomial Interpolation and Approximations of Integrals of Complex Functions
Advisor: Dr. Zephyrinus C. Okonkwo

The integration of elementary functions on a given finite interval is simple especially if the function is continuous on a closed interval. But for certain classes of complex functions, such closed form solutions may not exist. The use of approximate methods for approximating the functions in the given interval are admissible. In this research, we will use cubic splines polynomial interpolation to approximate a given complex function and subsequently integrate this approximate function. It is shown that the difference between integral of the approximate function and the integral of the original function is very small.

Garrett Divens and Gregory Rodriguez, Department of Mathematics, Morehouse College
Title: Controlling the Space of Infinite Graphs
Advisor: Dr. Robert Bell

Graph theory is a fundamental area of research in mathematics that has applications to large data sets, geographic positioning, and information distribution. In this work we investigate the game of cops and robbers on graphs. The original game involves two players, one controlling some number of cops and the other controlling a robber. The players take turns moving their pieces on vertices of a finite connected graph. The objective is to analyze aspects of the game of cops and robbers on infinite graphs. We study a family of infinite graphs called spider graphs. The spider graphs are a disjoint union of n-cycles which we refer to as layers. In the center of this collection of layers is a point with n rays intersecting this vertex and the other layers surrounding them forming

the total number of vertices on each layer. The techniques used to conclude the number of cops necessary for each graph were shadowing and the sweeping method. Shadowing involves cops moving onto the same ray as the robber, preventing the robber from moving towards the center of the graph. The sweeping method involves a number of cops systematically moving through infinite graphs, cornering the robber and forcing him to another layer. We concluded during our research that three cops are sufficient to push a robber arbitrarily far from the center of a spider graph. We have also developed methods to analyze generalizations of the spider graph which resemble higher dimensional objects.

Chelsea Hicks, DaMarcus Green and Iris Swan, Department of Mathematics and Computer Science, Albany State University
Title: Crime Data Distribution and Crime Data Analysis in some Georgia Counties from 1990 - 2015
Advisor: Dr. Zephyrinus C. Okonkwo

Crime statistics helps the society to determine crime trends in order to seek ways to mitigate crime. It is well known that increase in crime, no matter the type, creates immense expenses for the greater society: properties are lost, lives are lost, there is general sense of insecurity, and people tend to move away from districts and zip codes with high crime rates. In this paper, we study crime distribution in selected counties in the state of Georgia. The test of proportions is used to determine the counties or cities with highest crime rates. Other descriptive methods will also be used to present insights to future crime trends.

Talon Johnson, Department of Mathematics, Morehouse College
Title: Modeling Evolutionary Dynamics of Human Immunodeficiency Virus
Advisor: Dr. Shelby Wilson

Human immunodeficiency virus, or HIV, is a sexually transmitted disease that weakens one's immune system by compromising the machinery and functionality of immune cells (T-cells). Ultimately, this virus results in the development of Acquired Immunodeficiency Syndrome, or AIDS. A mathematical model of nonlinear differential equations with constant coefficients highlights the dynamics between the HIV population and the T-cell population. Our model follows four populations: healthy T-cells, latent (infected) T-cells, active T-cells, and viral load. Our results show that key parameters determine whether HIV progresses to AIDS or alternatively, the immune system eradicates the virus.

Jeremy Jones, Marquis Curry and Lanina Howard, Department of Mathematics and Computer Science, Albany State University
Title: Factors Affecting Student Performance and Institutional Effectiveness in Georgia: A Regional Study
Advisor: Dr. Zephyrinus C. Okonkwo

The purpose of this research is to measure ***Institutional Effectiveness*** of high schools in Dougherty County and surrounding counties using standard attributes. Students, parents, local governments, states, and the United States government require that academic institutions be effective to justify not only the investment put in them, but also demonstrate the confidence the society ascribes to them as social institutions. In this research, we use multivariate regression method to determine ***Institutional Effectiveness***, whereby ***Institutional Effectiveness*** is the dependent variable, and certain attributes such as attendance and GPA are the independent variables. We determine the variable that has the highest correlation to high school graduation rate. The result of this study can enable high schools to enhance those attributes which increase their ***Institutional Effectiveness.***

Victoria M. Latimore, Department of Mathematics and Computer Science,
Albany State University
Title: Finite Difference Methods for Differential Equations
Advisor: Dr. Anilkumar Devarapu

In this research project our goal is to find the numerical solutions to certain linear and nonlinear system of Ordinary Differential Equations (ODE's). Nonlinear ODE's are of interest to engineers, physicists and mathematicians because most physical systems are inherently nonlinear in nature. Often, systems described by differential equations are so complex, or the systems that they describe are so large, that a purely analytical solution to the equations is not tractable. It is in these complex systems where computer simulations and numerical methods are useful. In this research project, we will discuss the implementations of the Finite Difference Method (FDM) to different class of Initial Value Problems (IVP) and Boundary value Problems (BVP).

Victoria Latimore, Sataura Jones and Jonathan Hankerson,
Department of Mathematics and Computer Science, Albany State University
Title: Fixed Income Investments and Retirement Annuities
Advisor: Dr. Zephyrinus C. Okonkwo

The purpose of this paper is to investigate the role that fixed income investments such as US Treasury Bonds, Mutual Funds, Mortgage Backed Securities, Junk Bonds, and other forms of financial instruments play in individual retirement accounts (IRA) and retirement annuities. One of the major roles of portfolio managers or hedge fund managers is to guarantee investors *Sinking Funds* which enable their anticipated periodic retirement payments feasible. In this paper, we examine various fixed income investments, their durability and immunization. We examine their pathways for growth, and the advantages and disadvantages of such investments.

Robert Mitchell, Department of Mathematics, Morehouse College
Title: Modeling of an Atomic Magnetometer
Advisor: Dr. Tuwaner Lamar and Mr. Robert Wyllie (Georgia Tech Research Institution)

There are various ways to detect magnetic fields. One of the first ones you learn about in physics is a loop wire. When the magnetic flux varies through the loop, there is an EMF induced and a counter-current is induced. The sensitivity of the sensor is limited by the

noise inherent in the detector for a loop of wire. At finite temperatures there are always thermal noise currents that flow in the wire. The voltage that drives these currents is a noise voltage called Johnson noise. Another noise limit is in whatever is used to detect and amplify the current generated by the coil. In this work, we are going to mathematically model an Atomic magnetometer and determine total noise acting on the system, using an RLC Circuit and differential equations. The RLC circuit will model a loop of coils attached to a second loop of coils and an atomic magnetometer.

Shaniqua Moore, Kadeja Scott and Savannah Perkins,
Department of Mathematics and Computer Science, Albany State University
Title: A Statistical Study of Small Scale Farmers in Southwest Georgia
Advisor: Dr. Zephyrinus C. Okonkwo

For more than one hundred years, Southwest Georgia has been known for its agricultural productions, ranging from food such as corn, peanuts, soybeans, and assorted vegetables to farm products such as tobacco, cattle, hog, and chicken plants. In fact, Southwest Georgia is home of some of the largest chicken processing plants in the United States. For more than twenty years, many small scale farmers cannot compete due to their inability to acquire land, source loans, as well as find markets for their products. In order to encourage small scale farmers to continue to produce food as well as other exportable products, it is essential to examine the challenges they have and determine how they can be helped to maximize their revenues, minimize cost and find viable markets for their products. In this study we present descriptive statistics related to small scale farmers, their products, the distribution of their incomes and other essential data which could help them improve their incomes. We describe an optimal control problem related to small scale farming, Furthermore, we analyze Liker-Type survey which was administered to the small scale farmers. Recommendations are presented for income improvement pathways.

Miles Stevens, Kyle Duke and Ethan Bush,
Department of Mathematics, Morehouse College
Title: An Analogue of the Median Voter Theorem
Advisor: Dr. Francis Su

Our objective is to develop an analogue of the Median Voter Theorem in the context of approval voting. We define median voter by considering the left and right end points of each voter's approval sets as well as by the median. From the agreement proportion, we find a formula for the pairwise agreement proportion. We use this to predict the approval winner's location relative to the distribution of sets in the spectrum and show that the median voter's approval set is guaranteed to contain the approval winner. For approval sets of equal length, we show that the median voter's approval set will contain an approval

winner if the difference in the number of sets on both sides of the approval winner is less than or equal to the size of the approval winner. We also consider the location of the intersections and define these as cliques, which allow us to ignore the lengths of the approval sets. We found that the median voter interval contains the winner if and only if the difference between the number of sets on both sides of the approval winner is less than or equal to the size of the clique containing the approval winner.

Brandi Sumter, Department of Mathematics and Computer Science, Albany State University
Title: Computing a Belyi Function of Degree 8 from its Branching Pattern
Advisor: Dr. Vijay J. Kunwar

Belyi functions are the rational functions whose branched set lies inside $\{0,1,\infty\}$. That means they ramify (i.e. have multiple roots) only above $\{0,1,\infty\}$. For this reason, we often use the branching pattern (the list of branching) to represent Belyi functions. In this presentation we will compute a belyi function of degree 8 for a given branching pattern using the Maple software.

Biru Tang, Department of Mathematics, Agnes Scott College
Title: Recursive Sequences Modulo p^2
Advisor: Dr. Alan Koch

The Fibonacci sequence mod 9 is 0, 1, 1, 2, 3, 5, 8, 4, 3, 7, 1, 8, 0, 8, 8, 7, 6, 4, 1, 5, 6, 2, 8, 1, 0, 1, 1, …, and is periodic with period length 24. Let p be a prime and let $\{S_n\}$ be a sequence of integers mod p^2 which follows the recurrence relation $S_n = c_1*S_{n-1} + c_2*S_{n-2}$, where c_1 and c_2 are in the integers and p is not divisible by c_2. Is $\{S_n\}$ necessarily periodic? The answer is no, but it is always eventually periodic. We will see that when p is not divisible by c_2, then $\{S_n\}$ is periodic. Furthermore, if $r^2 – c_1*r – c_2 = 0$ has at least two distinct solutions mod p^2 and P is not divisible by c_1, then the sequence $\{S_n\}$ is periodic and the period length divides $p(p – 1)$.

Michael Wade and Keyonna West, Department of Mathematics and Computer Science, Albany State University
Title: Robotics and Path Planning
Advisor: Dr. Seyed Roosta

The Exofabulatronixx 5200 comes with 52 blocks that includes a battery, two motors, two pivots, two flashlights, two light sensors, two distance sensors, a microphone sensor, and connection pieces that help the blocks support one another. Also, inside the box there are 140 steel balls that help connect the blocks together. The blocks are color coded to help the user to figure out where they would like each block to go. The green face blocks stands for power, the brown face block takes in data, the red face block sends out data,

and blue face block passes either data or power to the other blocks. The most important block is the double brain block, because it connects to any mobile device to be instructed to do whatever you want it to do. With all the different blocks and sensors, we should be able to complete any application. In this research, we will demonstrate the applications of this remotely controlled robots, the mathematics behind the design, and algorithms needed to improve its performance.