SEVENTH ANNUAL CAPSTONE DAY

Department of Mathematics
Georgia College

November 17, 2018
8:15 a.m. – 3:15 p.m.
Health Sciences Building

Department of Mathematics
Georgia College

Earning a college degree is a significant achievement and requires dedication and tremendous effort by each student. Several programs have been developed to help students majoring in mathematics to succeed. The First Year Academic Seminar provides an introduction to department faculty, departmental and university expectations, policies, resources and opportunities following graduation. The department conducts informal social activities and presentations by faculty and guest speakers to encourage faculty and student interaction. The department webpage serves to inform, acknowledge and encourage student majors to become involved in activities related to the major such as mathematics competitions and professional meetings. The academic honor society Kappa Mu Epsilon has been organized to encourage and provide a supporting network for the student body.

Professional schools, businesses, government and industry recognize that mathematics majors are problem solvers and are highly skilled in the use of logic and reasoning. A degree in mathematics opens many careers that are closed to those without quantitative skills. Actuarial science stands as one major example. Moreover, the demand for mathematics in education-especially in secondary schools-is tremendous. In fact, the chronic nationwide shortage of mathematics teachers is due in part to the demand in so many other areas for talented mathematics majors.

2018 Capstone Day Schedule

8:15 – 8:55 a.m. Registration and Breakfast **HSB Student Lounge (3rd Floor)**

8:55 – 9 a.m. Opening Remarks **HSB 300**

9:00 – 10:00 a.m. Session I **HSB 300**

***Applications of Monte Carlo Integrals in Python*,** Hani Al-Sharif

***Unleashing Students Mathematical Potential by Embracing a Growth Mindset*,** Sydney Cleveland

Fourier Analysis and Signal Processing, Cain Gantt

10 - 10:10 a.m. Break **HSB Student Lounge**

10:10 - 11:30 a.m. Session II **HSB 300**

***The Use of Modern Statistical Methods to Predict the Successfulness of a Kickstarter*,** Joseph Marques

***The Comparison of Japanese Mathematics Education and United States Mathematics Education*,** Maranda Fulco

***Altering the Trefoil Knot*,** Spencer Shortt

***Understanding Fractional Order Integrals and their Applications*,** Stephen K. Castleberry

11:30 a.m. - 12:30 p.m. Lunch **HSB 314**

12:30 - 1:30 p.m. Session III **HSB 300**

***Sophie Germain, The Princess of Mathematics and Fermat's Last Theorem*,** Hanna Kagele

***Fractional Calculus and its Connection to the Tautochrone*,** Matthew Dallas

***Parameter Estimations and Their Applications*,** Kyle Kibodeaux

1:30 - 1:40 p.m. Break **HSB Student Lounge**

1:40 - 3 p.m. Session IV **HSB 300**

***A Fractal Function Related to the Rudin-Shapiro Sequence*,** Bennett Haller

***Painting Polyhedra: An Application of Burnside's Formula*,** Alec Powers

***Exposing Egocentrism, Encouraging Ecocentrism - With Data*,** Megan Goetz

Effectiveness of CRA Method Implementation in Secondary and Post-Secondary Mathematics Instruction, Taylor Svehla

3 – 3:15 p.m. Closing Remarks **HSB 300**

2018 Capstone Day Abstracts

Hani Al-Sharif
Applications of Monte Carlo Integrals in Python

Monte Carlo simulation (MCS) is a stochastic process that utilizes random sampling to provide numerical approximations, the use of which varies from financial firms trying to predict the market to engineers determining how they should design their systems in regard to society's erratic nature. This research demonstrates the use of MCS in the topic of integration transforming tedious and time-consuming integrands into a body of code that provides a very good approximation to integrals.

Stephen K. Castleberry
Understanding Fractional Order Integrals and their Applications

Fractional-Order Integrals have been considered since the beginning of Calculus, but have not been truly worked on until recently. This field has gained traction as some physical systems have been found to be indescribable using traditional methods. By defining and utilizing Riemann- Louisville fractional integrals and derivatives, Caputo fractional derivatives, and several others, the process of solving these physical systems is made possible. In this paper, the focus will be on defining Newton's Second Law using fractional integrals and derivatives and utilizing this new definition to solve the fractional harmonic oscillator.

Sydney Cleveland
Unleashing Students Mathematical Potential by Embracing a Growth Mindset

The extent to which a student embraces a growth mindset has a significant impact on their belief that they can problem solve. According to Jo Boaler and others, recent neuroscience research indicates that an individual's mathematical ability to learn and grow is not predetermined at birth. That is, everyone has the ability to engage in and understand mathematics. If this is the case, then why do so many students have such an unfavorable perspective towards mathematics? In this study, we will analyze responses collected from students which reveal their perspectives towards math and what it means to embody a growth mindset. Ultimately, our goal is to understand how educators can foster a belief in their students that they have unlimited potential.

Matthew Dallas
Fractional Calculus and its Connection to the Tautochrone

Despite its brief mention in a letter written during the early days of classical calculus, Fractional Calculus remains a relatively untapped field. With most major contributions occurring in the last one-hundred years. In this paper, we will examine the fundamental aspects of Fractional Calculus and demonstrate how the modern definitions of the Fractional Integral and Derivative naturally arise from solving the classic Tautochrone problem: finding a curve such that the time it takes an object to fall along this path is independent of its initial position. We will also examine the Mittag-Leffler function, and how it arises in the solution to Abel's Integral Equation of the second kind.

Maranda Fulco
The Comparison of Japanese Mathematics Education and United States Mathematics Education

Japanese students outrank United States students in mathematics based on their standardized testing scores. My capstone explores the reasons why. I compared a typical 8th grade Japanese lesson to a typical 8th grade American lesson. A Japanese lesson typically uses problem solving based learning. It typically includes an environment that encourages productive struggle and has high levels of communication and cognitive demand. This type of lesson tends to produce higher retention. For my study, I taught U.S. students a Japanese lesson and got feedback on what they thought and how much they learned. I evaluated the levels of productive struggle, communication, cognitive demand, and retention of the lesson.

Cain Gantt
Fourier Analysis and Signal Processing

In this project, we explore Fourier analysis and its applications to various signal processing tasks. We begin by defining the space of functions under consideration and several of its orthonormal bases. We then introduce the Fourier transform and its properties. We then discuss the convolution theorem and its relationship to the physics behind problems in signal processing. Finally, we investigate the multidimensional Fourier transform; in particular, we consider the 2-dimensional transform and its use in image processing and other contexts. We include an example of a typical image processing problem and demonstrate how the convolution theorem is applied to obtain a solution.

Megan Goetz
Exposing Egocentrism, Encouraging Ecocentrism - With Data

This research includes an exploration of the survey-reported behavior that adult humans in the Georgia College community conduct towards the cats and/or dogs they live with and take care of. Models were constructed using PLS – PM (Partial Least Squares – Path Modeling), a technique utilized to form more complex models than one could with linear regression techniques. Most of the models propose that the capability the human reports to have in pertinence to their own hygiene, cleanliness, and physical health, for examples, as predictors of the efforts they have reported to make in taking care of the hygiene, cleanliness, and physical health of the nonhuman animal and that respective animal's living space. With our final model results, we can see which predictors are more significant than others, as well as understand how strongly connected both manifest variables are to their latent variables and latent variables are to each other. We are also able to identify potential inverse relationships, as well as some interesting summary statistics. The motivation for this research is rooted in interest of whether humans have egocentric or ecocentric motives in living with cats and dogs.

Bennett Haller
A fractal function related to the Rudin-Shapiro sequence

A fractal is a set that has some form of self-similarity and is seen ubiquitously in nature due to its ability to appear approximately the same at different levels. In this project, we generate and study a fractal function Psi which is related to the well-known Rudin-Shapiro sequence. Two related functions Delta and Phi are also generated as they are used to form the function Psi.

Hanna Kagele
Sophie Germain, The Princess of Mathematics and Fermat's Last Theorem

Sophie Germain (1776-1831) is the first woman known who managed to make great strides in mathematics, especially in number theory, despite her lack of any formal training or instruction. She is best known for one particular theorem that aimed at proving the first case of Fermat's Last Theorem. Recent research on some of Germain's unpublished manuscripts and letters reveals that this particular theorem was only one minor result in her grand plan to prove Fermat's Last Theorem. This project focuses on presenting some of Sophie Germain's work that has likely lain unread for nearly 200 years.

Kyle Kibodeaux
Parameter Estimations and Their Applications

The purpose of this research involves a focus on parameter estimations and their asymptotic properties for various discrete and continuous distributions and their real-life applicability. We estimated distributions of the wait time to get food, inter-arrival time, and the number of people arriving during lunch hour between 12:00 pm to 1:00 pm at the Bobcat Food Court's Chick-fil-A and Subway and calculated the estimate of their parameters. Using the same data, we compared the average wait time for any given person at Chick-fil-A and Subway.

Joseph Marques
The Use of Modern Statistical Methods to Predict the Successfulness of a Kickstarter

In this research, we analyze Kickstarter data from Kaggle in hopes of being able to predict how successful a project would be. Our goal was to predict how much money a Kickstarter would raise, the state of a Kickstarter (successful or failed) and the ratio of the amount pledged vs the goal wanted, based off of the amount of days a project was active, the category, the amount of backers, and the country of origin. The modern statistical methods used include linear regression, logistic regression, quadratic discriminate analysis, linear discriminate analysis, and tree-based models.

Alec Powers
Painting Polyhedra: An Application of Burnside's Formula

There is an activity that involves figuring out the number of different cubes a person could get if they were coloring the faces of the cube with three different colors. This activity is lengthy and tedious to most, because most people list out all the different possibilities. Is there a way to generalize this activity or change it in any way? The answer to this question can be found by looking at an abstract algebra topic, groups acting on sets. In this research, we will use Burnside's formula and groups acting on sets to find the number of distinct colorings for different shapes. We will vary parameters such as dimension and number of colors.

Spencer Shortt
Altering the Trefoil Knot

A mathematical knot *K* is defined to be a topological imbedding of the circle into the 3-dimensional Euclidean space. Conceptually, a knot can be pictured as knotted shoe lace with both ends glued together. Two knots are said to be equivalent if they can be continuously deformed into each other. Different knots have been tabulated throughout history, and there are many techniques used to show if two knots are equivalent or not. The knot group is defined to be the fundamental group of the knot complement in the 3-dimensional Euclidean space. It is known that equivalent knots have isomorphic knot groups, although the converse is not necessarily true. This research investigates how piercing the space with a line changes the trefoil knot group based on different positions of the line with respect to the knot. This study draws comparisons between the fundamental groups of the altered knot complement space and the complement of the trefoil knot linked with the unknot.

Taylor Svehla
Effectiveness of CRA Method Implementation in Secondary and Post-Secondary Mathematics Instruction

The concrete-representational-abstract (CRA) method of teaching mathematics content has shown great success in primary education. The specific sequence of tasks required in this method make for a unique learning experience that has shown many benefits for both students and teachers at lower levels, particularly in special education. This research was designed to evaluate the success of the CRA method in secondary and post-secondary mathematics, specifically Calculus I and Calculus II courses. During a pre-survey, the students' work was evaluated to gauge their content understanding and personal feelings about their own ability to follow material. After a CRA activity and post-survey, the students' responses were then compared to their pre-survey to observe potential improvements in their knowledge and notion of tangency along with their opinion on how well they were able to follow the activity. The goal of this research was to determine the effectiveness and feasibility of implementing the CRA method in upper division mathematics courses.

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