Jan 10th, 12:00 AM

13. Mathematics

University of Central Oklahoma

Abstracts from the 2013 Oklahoma Research Day

Held at the University of Central Oklahoma

05. Mathematics and Science

13. Mathematics

05.13.01 A simplified proof of the Kantorovich theorem for solving equations using scalar telescopic series

Ioannis Argyros,

Cameron University

The Kantorovich theorem is an important tool in Mathematical Analysis for solving nonlinear equations in abstract spaces by approximating a locally unique solution using the popular Newton-Kantorovich method.Many proofs have been given for this theorem using techniques such as the contraction mapping principle,majorizing sequences, recurrent functions and other techniques.These methods are rather long,complicated and not very easy to understand in general by undergraduate students.In the present paper we present a proof using simple telescopic series studied first in a Calculus II class.

05.13.02 Boundedness, Monotonicity and Convergence of a Sequence of Special Zeros Obtained from Fibonacci-Type Polynomials

Kristi Karber, Rebecca Miller,

University of Central Oklahoma

We considered a generalized Fibonacci-type polynomial sequence and studied the corresponding sequence of maximum real roots. After showing that the sequence was bounded, we created two subsequences from the original sequence and proved that each subsequence was monotonic. We then proved that the sequence of maximum real roots converges.

05.13.03 Broncho Tower - A Modification of the Tower of Hanoi Puzzle

Stephen Gregg, Britney Hopkins, Juan Orozco, Kristi Karber, Thomas Milligan, Tyler Powell,

University of Central Oklahoma

The Broncho Tower makes slight changes to the classic Tower of Hanoi puzzle, but maintains the same goal of moving one or more sorted disks between pegs. The main difference concerns the rules that govern how these disks can be sorted as the puzzle is solved. Our research has included trying to find a mathematical formula using a difference equations approach that models the Broncho Tower, and gives the minimum number of moves required to solve the modified version of the game.

05.13.04 An Iterative Approach to the Extended Broncho Tower Puzzle

Stephen Gregg, Britney Hopkins, Juan Orozco, Kristi Karber, Thomas Milligan, Tyler Powell,

University of Central Oklahoma

We explore the Broncho Tower, a modification of the Tower of Hanoi puzzle, by constructing a computer program. This program iteratively exhausts the possible moves that a player can make when solving the puzzle.

05.13.05 An Experimental Study of the Comparison of Water and Oil Flow Through Vertical Pipes.

Krystal Brantley,

East Central University

The purpose of this research is to study and compare water flow versus oil flow through vertical pipes. This experiment is set to find the difference of the fluid travel through vertical pipes based on pressure, volume and fluid viscosity. In this experiment, there are two facilities that are being used. Both of these facilities are vertical test stations with both top chambers being 2 inches in diameter and the barrels measuring 1 inch in diameter. After the water and the oil are shot through the facilities, the results measure the volume of fluid ejected over the same time period. The results indicate that oil and water travel differently through vertical pipes due to the relationship of viscosity to volume. Constant volume output over time requires greater pressure for the oil which has greater viscosity.

05.13.06 Dynamics of the Spread of Staph Infections in Hospitals

Princess Hays,

Langston University

We investigate the in-hospital transmission dynamics of two Staphylococcus aureus (MRSA) strains, also referred to as staph: hospital-acquired Staphylococcus aureus (HA-MRSA) and community-acquired Staphylococcus aureus (CA-MRSA). We hypothesize that CA-MRSA will tend to have greatest population. To predict whether or not CA-MRSA will overtake HAMRSA, a compartmental model has been established. Under the assumption that patients can only be colonized with one strain of MRSA at a time, global results show that competitive exclusion occurs between HA-MRSA and CA-MRSA strains; the strain with the larger basic reproduction ratio will become endemic while the other is extinguished. Using the extended model, we explore the effect of co-colonization on competitive exclusion by determining the invasion reproduction ratios of the boundary equilibria.Further investigation into co-colonization, trends with antibiotic methods and health risk factors will be explored.

05.13.07 Analysis of WWZ

Tobyn Large,

East Central University

We use a competing species model with growth and death rates both researched and inferred to diagnose the zombie apocalypse. Using the population of Oklahoma and hypothesized statistics for zombies, we develop a system of differential equations to find the population of both the humans and zombies at any given time, if the apocalypse were to actually happen.

05.13.08 Fourier Analysis of Musical Instruments

Sarah Schatz, Michael Fulkerson,

University of Central Oklahoma

Fourier Analysis provides a way to break up normal sound signals into components of simple sine and cosine waves. Studying this process, known as the Fourier Transform, can provide a way to "see" why instruments sound so different, even when playing the same pitch. Plotting the Fourier Spectrum of an instrument makes it easier to comprehend these differences.

05.13.09 The Game of Signs

Stephanie Duncan, Cady Murphy,

East Central University

We consider five different game situations where two players have specific operation signs to place in front of the numbers 1-20. This project examines strategies to obtain a favorable outcome for the players.

05.13.10 Multisensory Mathematics: A Tactile Approach to Concepts Found in Introductory Proofs

Kristi Karber, Courtney Simmons,

University of Central Oklahoma

Many students find the transition from computational mathematics to the rigor of proof work difficult. By introducing tangible, colorful objects into traditional lectures, instructors can engage visual and kinetic learners and help demystify perplexing topics. Using this tactile approach, we've developed a collection of objects that can be used to illustrate fundamental definitions and theorems commonly used in mathematics courses. Students will be able to discover these concepts are not as complicated as they might expect, while having fun in the process.

05.13.11 Modeling Jazz Artist Similarities Mathematically

Andres Calderon Jaramillo, Larry Lucas,

University of Central Oklahoma

This project attempts to quantitatively model similarities among jazz piano artists by building a relatively simple probabilistic system. We limit our study to monophonic melodies which we assume retain much of the essence of an artist's style. Our current model makes use of Markov chains to capture the substance and structure of a musical piece. At the initial stage, the system extracts information about attributes such as the transition of pitches, note durations, and phrase lengths. At its later stages, the model uses logistic regression to quantitatively compare a piece by one artist to the style of another artist.

05.13.12 Issai Schur

Charlotte Simmons, Jesse Byrne,

University of Central Oklahoma

Issai Schur (1875-1941) belongs "to those scattered over the earth" by the "Nazi storm," as Hirzebruch put it in his 1998 address to the International Congress of Mathematicians. This talk will examine the life and death of this remarkable mathematician whose lectures at the time of his dismissal from Berlin drew between 400 and 500 students; one student who had to be content with a seat in the back of the room reported, "I used a pair of opera glasses to get at least a glimpse of the speaker." In addition, we will also investigate the role that German emigrants such as Issai's son Georg played on the development of the actuarial profession in Israel.

05.13.13 Fibrinolysis: A Mathematical Approach

Brittany Bannish, Aaron Fogelson, James Keener,

University of Central Oklahoma

Fibrinolysis is the enzymatic degradation of blood clots. Experiments have shown that coarse clots composed of thick fibers often lyse faster than fine clots composed of thin fibers. However, other experiments have shown the opposite result. We develop a mathematical model of fibrinolysis to elucidate the determinants of lysis speed. Specifically, we are interested in identifying when coarse clots degrade faster than fine clots. Analysis of our model shows that the experimental setup can affect which type of clot lyses faster; when the number of tissue-type plasminogen activator (tPA) molecules exposed to the front of the clot is small, coarse clots lyse faster than fine. When there are many tPA molecules at the clot front, fine clots degrade more quickly than coarse.

05.13.14 A Meta-Analysis of the Use of Calculators in Mathematics Achievement

Matt Garner, Karina Chavez, Kendra Parker, Vikki Orso,

East Central University

This is a meta-analysis research study with the objective to review numerous previously published studies that addresses the research question: Does the use of calculators effect math student achievement in (1) computation skills and/or (2) reasoning profiency? The thesis for the study is that one can identify trends that indicate relationships among the use of calculators, computation skills and reasoning profiency in mathematics at the upper elementary/middle school level and the middle/high school level. Fourteen articles that addressed the question were selected at random from the literature and analyzed. The results found three general trends for results across the studies. At the upper elementary/middle school level the use of calculators improved the computation skills but had no effect on reasoning profiency. Also at this level students not using calculators improved both in computational skills and reasoning profiency. At the middle/high school level students using calculators improved in reasoning profiency; whereas, students not using calculators did not improve in reasoning profiency.

05.13.15 Using Integrals to Derive Minkowski's Inequality for L^p Spaces

Karina Chavez, Justin Cochran, Matt Garner, Pradeep Kshetri, Sarah Harris, Simeon Kachikwu, Stephen Gammill,

East Central University

By examing the L^p norm with p=1, 2, 3, 4, 5 for several different functions, we use these integrals to derive the general formula for Minkowski's inequality. This inequality is in essence the triangle inequality for L^p spaces.

05.13.16 A Network Approach to a Geometric Packing Problem

Bradley Paynter,

University of Central Oklahoma

We investigate several geometric packing problems (derived from an industrial setting) that involve fitting patterns of regularly spaced disks without overlap. We first derive conditions for achieving the feasible placement of a given set of patterns and construct a network formulation that, under certain conditions, allows the calculation of such a placement. We then discuss certain related optimization problems (e.g., fitting together the maximum number of patterns) and broaden the field of application by showing a connection to the well-known Periodic Scheduling Problem. In addition, a variety of heuristics are developed for solving large-scale instances of these provably difficult packing problems. The results of extensive computational testing, conducted on these heuristics, are presented.

05.13.17 To Remediate or Not To Remediate? That is the Question.

Sarah Schatz, Cynthia Murray, Michael Haszto, Tracy Morris,

University of Central Oklahoma

To Remediate or Not To Remediate? That is the Question. Sarah Schatz, Michael Haszto, Tracy Morris, Cynthia Murray Do incoming college freshman take remedial Math and Reading classes when necessary? At many colleges, these classes are required when a student does not score high enough on a college entrance or placement test. If not required, however, is performance on required high school tests related to the decision to take remedial classes? Also, is the ethnicity of a student related to his or her likelihood to take remedial classes? This study followed over 7,000 graduating high school students from New Mexico. These students were tested over their Math and Reading skills during their Junior year of high school and followed through their first year of college. Test scores and demographics were recorded, as well as enrollment data from the first year of college. Logistic regression was then used to construct a model for predicting whether or not a student takes these remedial classes. It was concluded that scores from the high school tests are significantly related to a student's decision to take remedial classes. There is also a noticeable difference between certain ethnicities with regard to the predicted probabilities of taking remedial classes.

05.13.18 What Can We Do for Amanda? Enhancing Student Success in Remediation

Charlotte Simmons, Jesse Byrne, John Barthell, Myron Pope, William Radke,

University of Central Oklahoma

Remediation is regarded as the biggest obstacle to President Obama's call for millions of additional graduates. This talk chronicles the challenges and successes of remediation reform efforts at the University of Central Oklahoma that have yielded pass rates of 78% over the past year.

05.13.19 Undergraduate research: the focus of the Oklahoma NSF STEP Program and UCO CURE-STEM

Wei Chen, Charlotte Simmons, Evan Lemley, Phd, John Barthell,

University of Central Oklahoma

Undergraduate research has been proven to be effective in recruitment, retention, and graduation of STEM majors. It is the focus of the National Science Foundation (NSF) funded Oklahoma STEM Talent Expansion Program (STEP), which supports students through STEM research and educational experience. The success of undergraduate research depends on the active involvement of faculty mentors. To provide a platform for faculty participation, the College of Mathematics and Science at the University of Central Oklahoma (UCO) established the Center for Undergraduate Research & Education in Science, Technology, Engineering & Mathematics (CURE-STEM). This Center provides faculty who are engaged in undergraduate research activities with reassignment time, faculty/student professional travel funds, and laboratory supplies. The STEP program and CURE-STEM provide the students with the opportunity to continue research with faculty members throughout their undergraduate experience, along with another NSF funded grant that provides scholarships (S-STEM). STEP participants have given numerous research presentations at regional, national, and international meetings, and many have co-authored peer-reviewed publications and conference proceedings papers. The retention rate and GPAs of STEP participants who are actively involved in research are significantly higher than for those who are not. The overall STEM enrollment at UCO has increased 50% over the past six years.

05.13.20 Using Integrals to Derive Hölder’s Inequality for L^p Spaces.

Cerina Stiles, Connor Keith, Kshitiz Shrestha, Robert Brown, Sanju Khatri, Stephanie Maas, Stephen Weatherby,

East Central University

By examining the L^p norm with p=1, 2, 3, 4, 5 for several different functions, we us these integrals to derive the general formula for Hölder’s inequality. This inequality states that the L^1 norm of the product of two functions is less than or equal to the product of the L^p norm of one function and L^q norm of the other function, where p and q are conjugate exponents.

05.13.21 Random Number Generation: The Linear Congruential Method

Joshua Crittenden,

East Central University

A random number is a number that is generated in a completely unpredictable way, but how is a number defined to be random. For instance, is 2 a random number? It is in fact impossible to identify a single number as being random without knowing the procedure from which it was formed. It is for this reason, when examining randomness it is necessary to instead look at sequences of random numbers. There are many types of random number generators, but the focus of this research is linear congruential generators, also known as Lehmer generators. We will use the process discussed by Donald E. Knuth in his book The Art of Computer Programming. In this process four “magic numbers” are chosen: the modulus, the multiplier, the increment, and the seed. All congruential sequences repeat themselves. The count of numbers in the sequence, before it starts to repeat, is called the period. Thus a good random number sequence will have the maximum period possible. In order to maximize the period of the sequence, we must choose our four numbers carefully, but we will be programming our recursive function into a computer. So, the choices will have to be made in a way to avoid overflow on a 64-bit machine.

05.13.22 An Algorithm for Civil Aircraft Altitude Adjustment Over Precipitous Terrain

David Stapleton,

University of Central Oklahoma

Some results are presented from an algorithm that uses Level 1 DTED (Digital Terrain Elevation Database) data to compute a database of baseline altitude adjustments over the earth that can be applied to offset meteorological risks posed to IFR aircraft over precipitous terrain. Each baseline adjustment is called a Precipitous Point Value or PPV, and the database consists of one PPV assigned per point to grid points on the earth’s surface. At each grid point the algorithm considers statistics of nearby points and constructs a best fit plane. The height adjustment for a given segment of a given procedure is obtained by scaling the largest PPV in the flight segment. The purpose of the algorithm is to develop a database of offsets for civil aircraft flight procedure designers that improves upon current algorithms.

05.13.23 Mathematical Models of Synchronizations of Yeast Cell Glycolytic Oscillations.

Nathan Pezant, Brittany Bannish, Sean Laverty,

University of Central Oklahoma

Glycolytic oscillations of yeast cells in particular environments have been observed for some time. Recently it has been shown that yeast cells in this environment that are out of phase with one another, if put into contact, will synchronize their oscillations. Models have been constructed to simulate this observation. Our research is on the sensitivity of parameters in the existing two-cell model and expansion of the model to include three or more cells.

05.13.24 Bound Smoothing using Euclidean Squared Distance Matrices

Heather Magee,

University of Central Oklahoma

A distance matrix A which encodes squares of pairwise distances in matrix form is known as a Euclidean Squared Distance Matrix (ESDM). Bordered ESDMs are useful in determining the embedding dimension of points in space. We investigate known methods that use these bordered ESDMs to improve the bounds on unknown distances of four points in three dimensional space (using the tetrangle inequality) and extend these ideas to five points.

05.13.25 The Effect of Temperature on Glycolytic Oscillation Synchronization in Yeast Cells.

Mark Wissler, Brittany Bannish, Sean Laverty,

University of Central Oklahoma

Previous research has been conducted on Saccharomyces Cerevisiae, a species of yeast, to examine the rate at which glycolytic oscillations between two populations of yeast cells will synchronize. It has also been shown experimentally that temperature affects steps of the metabolic pathway of this species. However, no mathematical models address temperature's effect on the procession of glycolytic synchronization between two populations of yeast. It is hypothesized that temperature will expedite the synchronization process within a range of biologically sensible temperatures. We will derive rate constants based on temperature, then compare the behavior of models with published figures in biologically relevant papers. Additionally, special interest will be placed on autonomous temperature forcing functions and their effect on the system.

05.13.26 Linking immunology and epidemiology with mathematical models: effects on individual disease and public health

Sean Laverty,

University of Central Oklahoma

We use a mathematical model that includes the dynamic nature of the host immune response, and explore the interactions between the immune system of the individual and the spread of infectious disease in the population. In particular, we identify features of the host immune response that yield the emergence of 'disease cycles' in the host population. We show that the immunogenicity of the pathogen and the rate at which immunity wanes in the host are key determinants of oscillations. Using the human rhinoviruses as a model system, we explore the dynamics of a diverse collection of co-circulating viruses, whose transmission in the population is mediated by the immunological history of the individuals.