

## Sheet1

Aydin, Ahmet Kaan , Western Kentucky University, Graduate student

Title: Robust-Filtering of Sensor Data for the Finite Difference Model Reduction of a Sandwich Beam

Abstract: The set of partial differential equations describing vibrations on a three-layer Mead-Marcus beam model, consisting of piezoelectric or elastic outer layers constraining a compliant viscoelastic layer, is considered. This model fully describes uniform transverse vibrations (bending) of the perfectly bonded beam as well as the shear due to the compliant layer. The eigenvalues, and in particular, the uniform gap among the eigenvalues of the model with hinged boundary conditions is proved to be written in terms of the ones of the single-layer Euler-Bernoulli beam model. Therefore, the three-layer beam model can be considered as a perturbation of the single-layer beam model. Ingham's inequality is utilized to show the uniform observability result of the model with a single boundary sensor. Space-discretized Finite-Difference approximations of the model do not retain the uniform observability due to high-frequency spurious eigenvalues generated by approximations. To obtain a uniform observability result, for the same sensor design, the spurious eigenvalues of the approximated model are filtered by the so-called Direct Fourier filtering method. After filtering, the approximated solution space uniformly converges to the whole infinite-dimensional solution space as the mesh parameter goes to zero. The preliminary results of the sandwich beam with arbitrary number of layers will also be discussed. This research is funded by KY NSF EPSCoR grant #3200002692-22-08

Barnard, Kristen M. , Berea College, Faculty member at a college or university

Title: Learning Based Grading in Mathematics

Abstract: Learning-Based Grading (aka Contract Grading, Mastery-Based Grading, Standards-Based Grading) was not something I thought could be effective in Mathematics courses until a presentation at an AACU conference convinced me otherwise. I began using LBG with my Introduction to Proofs course in Spring 2020, and because of it my students were able to be successful after the Covid-19 pandemic forced our schools to close halfway through the semester. I started using LBG in all my courses when we went to virtual instruction for the 2020-2021 academic year and have continued to use it in my courses now that we have returned to mostly face-to-face instruction. I will share my experiences with Learning-Based Grading in classes at multiple levels--including student feedback--as well as resources to help you begin using LBG in your classes.

Chatham, Doug , Morehead State University, Faculty member at a college or university

Title: Arrangements of mutually non-attacking chess pieces of mixed type

Abstract: We present placements of mutually non-attacking chess pieces of mixed type that occupy more than half of the squares of a rectangular board. If both white and black pawns are allowed as separate types, there are arrangements, which we also present, that occupy at least two-thirds of the board squares.

Eskew, Sarah , Eastern Kentucky University, Faculty member at a college or university

Title: Increasing Transparency in First Semester Calculus (and Beyond)

Abstract: The Transparency in Learning and Teaching (TILT) framework was created to promote equitable teaching and learning practices in higher education. In this talk we will introduce the general framework and give ideas on simple ways to increase transparency in all courses. Further, we discuss how this framework has been implemented in creating a small number of group activities for first semester calculus students and plans for future assignments and changes. Increases in transparency in other courses will also be mentioned briefly.

## Sheet1

Farmer, Emily , Thomas More University, Undergraduate student

Title: The Frobenius Number of a Numerical Semigroup

Abstract: Let  $N$  denote the set of non-negative integers. A numerical semigroup is an additive submonoid of  $N$  that has a finite complement in  $N$ . It is known that a numerical semigroup can be generated by a finite set of natural numbers such that all elements of the semigroup are non-negative integer combinations of these generators. The elements that are not contained in the numerical semigroup are called the gaps. The largest gap of the numerical semigroup is called the Frobenius number of the numerical semigroup. Calculating the Frobenius number of a numerical semigroup is a classic problem in Number Theory that dates back to at least 1884 when J.J. Sylvester showed how to calculate it when the numerical semigroup has exactly two generators. Wilf's algorithm is one method of solving for the Frobenius number, which this MATLAB program uses to calculate the Frobenius number and number of gaps when any number of generators of a numerical semigroup are entered.

Flehood, Sydney , Asbury University, Undergraduate student

Title: Space Mining

Abstract: Our definition of global equity was created after research on what the word equity means in both business and sociological circles, understanding that its meaning may depend on its context. We defined global equity the state in which every global participant has reachable access to the same opportunities and resources in order to achieve an equal outcome. Global equity is achieved by lowering the gap between extreme parties and allocating resources to the parties in need. Using this definition, we constructed a model that would be able to measure global equity. We sought to measure this by using global poverty rate data over time. We chose poverty as a measuring factor because it gives insight into how resources are being allocated globally and tells us what kind of resources people have access to. We show global equity as having an inverse relationship with poverty rates by global regions. By measuring the gap of poverty rates globally, it gives us an idea of where resources need to be allocated more. We also explored asteroid mining and different scenarios of how this process might look in the future. For us to have the freedom to do this exploration, we had to first assume that asteroid mining is both possible in the future and financially beneficial. This topic is one that is new in the idea market of science and one that does not have much data backing it with these assumptions. Throughout the paper we lean into the unknown and the endless possibilities. Taking all the data we collected and possibilities that we explored, we put our model to the test to see how it might be affected by the different possibilities that asteroid mining would bring. We made predictions of specific outcomes. We also explored policies and changes that would need to occur for global equity to rise.

We concluded that due to the limited resources, our relatively new exploration of space, and our inability to currently enact global equity, it is impossible to realistically determine whether asteroid mining will be a positive endeavor regarding global equity. After much research and debating, we acknowledge that the teamwork, policy, and careful examination that will be required might be too great of a burden. For global equity to go up because of asteroid mining, places and individuals with most power would have to be give more resources to others with less. But if we humans cannot reach global equity with the resources near to our fingertips, how can we guarantee that those outside of this planet will help us achieve that?

Gaubatz, Nicholas , Murray State University, Undergraduate student

Title: Friends in  $Z_n$

Abstract: For a positive integer  $n$ , the abundancy index  $I(n)$  is equal to the sum of the positive divisors of  $n$  divided by  $n$  itself. Two positive integers  $m$  and  $n$  are said to be friends if their abundancy indices are equal; for example,  $I(6) = 2 = I(28)$ . For integers  $n > 1$ , the  $n$ -abundancy index, analogous to the abundancy index on the positive integers, is defined on the ring  $Z_n \setminus \{0\}$ . Some basic results, founded on basic results about divisor sets in  $Z_n$ , are obtained, including the result that if  $n$  is a prime power, then the  $n$ -abundancy index is one-to-one on  $Z_n \setminus \{0\}$ .

## Sheet1

Gaubatz, Nicholas , Murray State University, Undergraduate student

Title: Quantum Dimension Polynomials: A Networked-Numbers Game Approach

Abstract: The Networked-Numbers Game—a mathematical "game" played on a simple graph—is incredibly approachable and yet surprisingly rich in content. On the other hand, Quantum Dimension Polynomials (QDPs)—enumerative expressions traditionally understood through root systems—are complicated to derive and often inaccessible to undergraduates. Based on an in-progress Honors Thesis, an overview of the Networked-Numbers Game, closed-form expressions of some QDPs, and uses of QDPs to count combinatorially significant structures are provided.

Hanssen, Willem , Asbury University, Undergraduate student

Title: A Solution to Optimize a Portfolio

Abstract: In this paper, we develop a model for maximizing the market evaluation of our portfolio made up of cash, Gold and Bitcoin, which are two famous volatile assets. This portfolio had an original value of \$1000 total. Firstly, our model takes the data found in the given csv files, which are the closing prices of Bitcoin and gold from 9/11/16 to 9/10/21, and uses the data analytic software, NinjaTrader 8, to chart the data and overlay a 'technical indicator' called the Moving Average Ribbon. Based off the chart data, and three specific 'Signals', which are part of the Moving Average Ribbon, we were able to determine when to buy, sell, or hold, while minimizing transaction cost. Depending on the indication of the three 'Signals', three 'Scenarios' were determined to exist. These three 'Scenarios' and their unique set of equations were then used to determine how to move the total dollar value of our portfolio into the momentum of the market to maximize profit. At the beginning of every year, a different set of equations corresponding to each 'Scenario' were used to redistribute the total dollar value of our portfolio, in order to minimize risk and diversify our portfolio, while keeping up with the market fluctuations. Our model is quite practical and intuitive. Reading the charts and understanding the 'Signals' and 'Scenarios' is very easy. The equations used to maximize profit, redistribute funds and the like, require basic Algebra skill. However, each part works together in complex ways. The model is truly sophisticated. It is also extremely effective. When back tested on the data that was given, the market value of the portfolio was \$530,017.13 at the end of the 5-year trading period. That is about a 53000% increase over 5 years!

Jose Contreras , Ball State University, Faculty member at a college or university

Title: The Thrill of Investigating Special Problems with Dynamic Geometry Software

Abstract: The formulation of conjectures and problems are fundamental processes of mathematical activity. In this presentation, I illustrate how we can use dynamic geometry software to investigate special problems related to the following problem: The vertices of quadrilateral EFGH are the points of intersection of the consecutive angle bisectors of the angles of a quadrilateral ABCD. What type of quadrilateral is EFGH? Justify your response.

Kristen Barnard , Berea College, Faculty member at a college or university

Title: Using Combinatorial Games to Teach Mathematical Principles

Abstract: Combinatorial Games are two-player games with no elements of chance. Inquiry-based investigation into a series of combinatorial games—with the purpose of finding a strategy to win each game—can not only help students learn principles of games, but also introduce them to general principles of mathematics. These games are especially great for math courses for non-STEM majors as they give students an opportunity to approach mathematics as a mathematician does.

Lin, Allen , Carol Martin Gatton Academy, High school student

Title: Values of Dirichlet Series

Abstract: We study several classes of Dirichlet series, some of which were studied by Shimura, Choi, and others. We prove the meromorphic continuation of the series. We generalize results of Choi by relating values of some series to values of other, related series. We prove closed formulas of these Dirichlet series and relate them to combinatorial numbers.

Lin, Allen , Carol Martin Gatton Academy, High school student

Title: Properties of Pólya's Circular Symmetrization

Abstract: Circular symmetrization, a procedure first introduced by Pólya and Szegő, has applications to isoperimetric problems in various settings because it is known to reduce perimeter of a region. The original proof that this symmetrization procedure reduces perimeter uses calculus of variations. We present an elementary proof (without using calculus of variations) that circular symmetrization reduces the diameter of a shape in the Cartesian plane. We also present the images of certain shapes after circular symmetrization. This research was conducted at the Research Science Institute (RSI) during the summer of 2021.

McGee, Daniel , NKU, Faculty member at a college or university

Title: Case Studies of Professional Noticing in Calculus 1

Abstract: Professional noticing presents an organizational framework for aiding students that do not fully understand mathematical concepts. It requires that a non-unique learning progression be identified for the associated mathematical concept. It then (i) creates a discussion designed to navigate the learning progression with a student, (ii) uses the discussion to determine where the student's understanding lies along the learning progression, and (iii) provides effective intervention focused on the now identified needs of the student. This study uses a metric for understanding that is based on a multi-representational perspective developed along the APOS (Action-Process-Object-Schema) framework. This metric provided guidance for developing classroom activities for Calculus 1 and for assessing student understanding. A professional noticing framework is then used to help students that are still struggling after the initial classroom activity. This presentation presents preliminary results for case studies of students for whom professional noticing was used in Calculus 1.

Nathan Hartmann , Murray State University, Undergraduate student

Title: Sangaku in Multiple Geometries: Examining Japanese Temple Geometries Beyond Euclid

Abstract: During the Edo period of Japan, when the country was closed from the rest of the world from 1603 until 1867, the field of mathematics developed in a different way from how it developed in the rest of the world. One way we see this development is through the sangaku, the thousands of geometric examples hung in various Shinto and Buddhist temples throughout the country. Written on wooden tablets by various people, all these problems hold true within the Euclidean geometric plane. During the 1800s, while Japan was still closed, non-Euclidean geometries began to developed, so the isolated nation was entirely unaware of these new systems. Thus, we will explore the sangaku in two of the other well-known systems, namely the neutral and hyperbolic geometric systems. Specifically, we will highlight how these traditionally- solved problems change under the varying definitions of line parallelism.

Poynter, Matthew Crouch, Trey , Western Kentucky University, Undergraduate student

Title: Numeric filtering vs. non-filtering: Boundary Control of Vibrations on a String

Abstract: A one-dimensional wave equation, describing vibrations on a clamped-free string, is considered. The corresponding partial differential equation (PDE) is known to be fully controllable by a boundary feedback controller (force) applied at the tip of a string. However, it is well-known space-discretized approximations (a system of difference differential equations) by Finite Differences or Finite Elements are not fully controllable without proper filtering of the numerical scheme. It is simply due to the artificial high-frequency vibrational modes caused by the blind use of these approximations. To avoid the discrepancy, an indirect filtering technique is adopted to retain the controllability, mimicking the PDE-counterpart. Moreover, an alternate order-reduced numerical scheme, utilizing a clever use of Finite Differences without filtering, is also introduced for comparison. Approximate solutions are built to where all control parameters can be controlled. All these parameters can be manipulated via a Mathematica program (called a Wolfram Demonstration Project). We are able to find that the results from the numerical schemes happened to match what was happening in the real world. All three approximation techniques are compared side-by-side in terms of their computational costs during the presentation. This work is fully funded by the KY NSF EPSCoR grant #3200002692-22-08.

Sheet1

Qualls, Joshua , Morehead State University, Faculty member at a college or university

Title: Semiclassical Mastermind

Abstract: Games are often used in the classroom to teach mathematical and physical concepts. Yet the available activities used to introduce quantum foundations are often overwhelming even to upper-level students. Further, the "games" in question range in focus and complexity from superficial introductions to games where quantum strategies result in decidedly nonclassical advantages. In this talk we introduce a straightforward newly-developed "Semiclassical Mastermind" based on replacing colored pegs in the popular board game with possible orientations of four qubits. Due to superposition and collapse, the game becomes probabilistic and requires repeated measurements to determine the states in the "solution". We report on the mathematical analysis of three strategies for play and conclude by previewing how a "quantum" player could outperform even optimal "classical" players.

Richmond, Tom , Western Kentucky University, Faculty member at a college or university

Title: Lattice Points and Visibility

Abstract: A lattice point  $(m,n)$  in  $\mathbb{Z}^2$  is visible from the origin if there are no other lattice points on the segment  $(m,n)$  to  $(0,0)$ . Equivalently, a nonzero lattice point  $(m,n)$  is visible from the origin if and only if  $m$  and  $n$  are relatively prime. What percentage of the lattice points are visible from the origin? If trees at the nonzero lattice points have radius  $t < 1$ , how far from the origin will you have an unobstructed view in a given angle? The Basel problem and Minkowski's theorem are used to provide some answers.

Robinson, Ian , Murray State University, Undergraduate student

Title: Strange Weak Solutions of First Order PDE with Impulse Forcing Functions

Abstract: We will investigate the interesting properties of first order PDE (Partial Differential Equations) with two-dimensional Dirac Delta forcing functions. Some background regarding the field of PDE will be given and we will develop an understanding of what it means to be a weak solution of a PDE as well as why it is helpful to think of the Dirac Delta "function" as a distribution instead. We will look at a few examples of such problems as well as graphs of their solutions, which can sometimes be rather exotic.

Robinson, Mark , Western Kentucky University, Faculty member at a college or university

Title: Numerical Integration Rules and the Solution of Initial Value Problems

Abstract: Numerous applications involve the numerical solution of initial value problems in ordinary differential equations. Many difference methods used in practice can be derived from numerical integration rules. Examples and applications are presented.

Sheet1

Schiffman, Jay , Retired, Rowan University , Retired University Faculty

Title: Families of 3 X 3 Prime Magic Squares Comprising a Neat Pattern

Abstract: There are several prime magic squares including Rudolph Ordrejka's (1928-2001) consisting of the nine entries below:

178971  
113595  
4729101

This paper considers two companion prime magic squares. The first consists of the nine prime entries as follows:

5953101  
1137129  
418983

The second was discovered by Harry Nelson in 1988 whose entries consist of nine consecutive primes in the array below:

148002815914800281531480028201  
148002821314800281711480028129  
148002814114800281891480028183

We explore each of these magic squares, observe a palatable pattern shared by these magic squares and determine the smallest constant required to add to each of the entries to obtain new magic squares consisting of nine primes as well as nine consecutive primes respectively. The problem takes on several flavors which will be discussed in the sense that each of the entries will be congruent to either 1 or 2 modulo 3 and the constants added to each entry in the original magic squares to produce new ones will be congruent to either 0 or 2 modulo 3.

Thompson, Jessie , Asbury University, Undergraduate student

Title: Gold and Bitcoin

Abstract: In recent years, we have seen a spike in the value and frequency of cryptocurrency - most prominently, Bitcoin. Our paper seeks to reflect the trends of price between gold and Bitcoin over the course of five years and determine which would the yield the greatest return for an investor looking to maximize their potential profit.

Tidwell, Will , Morehead State University, Faculty member at a college or university

Title: Elementary Pre-service Teachers' Praxis II Math and Science Performance: Early Results

Abstract: Educational Testing Services designed the Praxis II Elementary Education Mathematics and Science tests were designed to assess whether entry-level elementary teachers have the subject matter knowledge and skills that are "important, necessary, and needed" for successful P-5 science and mathematics teaching. The purpose of this study is to identify longitudinal trends in the performance of Morehead State University students, as measured by their Praxis II mathematics and science sub-scores. Variables of interest include ACT scores, high school and college graduation GPA, graduation year, KCTCS transfer status, grades in pre-requisite courses, and the number of Praxis II attempts. This analysis is expected to result in curriculum reform to improve Praxis II passing rates for Morehead State University students.

## Sheet1

Wells, Flannery , University of Louisville, Graduate student

Title: Majority Rule on the Condorcet Domain

Abstract: The Condorcet alternative is the alternative that beats any other alternative by majority rule. The set of profiles in which there is always a Condorcet alternative is called the Condorcet domain. Donald Campbell and Jerry Kelly proved with some assumptions that the only anonymous, neutral, and strategy-proof voting rule on the Condorcet domain is majority rule. But their research left open the question whether these three properties characterize majority rule on the Condorcet domain for the case where there are a multiple of four voters and exactly three alternatives. This talk will expand on their research to present a characterization of majority rule on the Condorcet domain.

Wells, Holden , University of Louisville, Graduate student

Title: Super and Sub Additivity on the Space of Distribution Functions

Abstract: The space of distribution functions, referred to as  $\Delta^+$ , has a natural partial ordering and can be equipped with an operation allowing it to become a semi group. As a result, it is possible to discuss sub additive and super additive functions over  $\Delta^+$ . This talk will examine properties of these functions especially in the case of order automorphisms.

Whitaker, John, Shawnee State University, Faculty member at a college or university

Title: Winning at Nim

Abstract: In this talk, we will introduce the two-person game of Nim and give the few rules of the games. Attendees will be invited to play a few rounds of Nim with the presenter. Each game should take less than a minute to play. Then we will go over finding a winning strategy of the game for the person who plays first by using a solving a simpler model approach. We will quickly form some easy to derive theorems for the game that will be used to find the winning strategy. This talk is based on the work by John Conway.

Whittlesey, Marshall , California State University San Marcos, Faculty member at a college or university

Title: Using quaternions to prove theorems in spherical geometry

Abstract: It is well known that the complex numbers can be used to do transformation geometry in the plane. In particular, rotation by angle  $x$  about the origin is accomplished via multiplication by the complex number  $e^{ix} = \cos(x) + i\sin(x)$ . It is less well known that the quaternion algebra (consisting of expressions of the form  $a + bi + cj + dk$  with  $i^2 = j^2 = k^2 = -1$ ) can be used to do similar transformations in three dimensional space. In this talk we show how to use quaternions to prove a significant classical theorem in spherical geometry. These methods are featured in the speaker's new book with CRC Press "Spherical Geometry and its Applications", which the author hopes will be attractive for use in topics courses in geometry.

Wildstrom, D. Jacob , University of Louisville, Faculty member at a college or university

Title: Transitions of Frieze Patterns

Abstract: There are seven symmetry patterns which can be present in a strip of material or "frieze", but if one wants to exhibit multiple symmetries in a single strip of material, transitions between them are necessary in order to showcase all available symmetries without abrupt changes of design. This talk will explore the viable transformations among the seven conventional frieze patterns and also discuss the applicability of the same ideas to the seventeen wallpaper groups and the seventeen frieze patterns which make use of color-reversal symmetries.

## Sheet1

Zheng, Lukun , Western Kentucky University, Faculty member at a college or university

Title: Deep learning for video game genre classification

Abstract: Video game genre classification based on its cover and textual description would be utterly beneficial to many modern identification, collocation, and retrieval systems. At the same time, it is also an extremely challenging task due to the following reasons: First, there exists a wide variety of video game genres, many of which are not concretely defined. Second, video game covers vary in many different ways such as colors, styles, textual information, etc, even for games of the same genre. Third, cover designs and textual descriptions may vary due to many external factors such as country, culture, target reader populations, etc. With the growing competitiveness in the video game industry, the cover designers and typographers push the cover designs to its limit in the hope of attracting sales. The computer-based automatic video game genre classification systems become a particularly exciting research topic in recent years. In this paper, we propose a multi-modal deep learning framework to solve this problem. The contribution of this paper is four-fold. First, we compile a large dataset consisting of 50,000 video games from 21 genres made of cover images, description text, and title text and the genre information. Second, image-based and text-based, state-of-the-art models are evaluated thoroughly for the task of genre classification for video games. Third, we developed an efficient and salable multi-modal framework based on both images and texts. Fourth, a thorough analysis of the experimental results is given and future works to improve the performance is suggested. The results show that the multi-modal framework outperforms the current state-of-the-art image-based or text-based models. Several challenges are outlined for this task. More efforts and resources are needed for this classification task in order to reach a satisfactory level.