Welcome to the 26th Annual Retreat of the UW-Eau Claire Mathematics Department. This year we feature mathematical talks given by faculty and students in the morning. In the afternoon, the 9th Andrew Balas Lecture, *Probability Without Calculation*, will be presented by Dr. Peter Winkler of Dartmouth University. This is followed by an electrifying, heart-breaking, brain-splitting mathematics competition for students!
Contributed Talks

8:00 – 8:40   Room:  HHH 308     Level: Advanced
Ai Lie Ching, Grant Keane, Christopher Magyar, Haotian Wu, Lucas Buchanan
Faculty Mentor: Michael Penkava
Construction and Deformation of Z2 Graded Complex Associative Algebras

A Z2 graded complex associative algebra possesses a well defined even-odd parity property among its elements. We build upon the research of previous students by using the Fundamental Theorem of Finite Dimensional Associative Algebras to construct higher dimensional graded algebras. Once we've discovered all the complex associative algebras in a Z2 graded space, we map the deformations, or small changes to the multiplication structures, in order to visualize the structure of the moduli space.

8:00 – 8:20   Room:  HHH 315     Level: Intermediate
Luogen Xu and Taren Leitzke
Faculty Mentor: Chris Ahrendt
Green’s Functions and Quantum Mechanics

Green’s functions are a class of functions which solve boundary value problems in the field of differential equations. Quantum mechanics is a highly mathematical branch of physics which studies the elementary components of the Universe. Quantum mechanical systems are often described using wave functions, however, they can also be described using Green’s functions, which can better facilitate understanding of certain problems. We focus on Green’s functions’ properties and application to the quantum mechanical free particle.

8:00 – 8:20   Room:  HHH 320     Level: Elementary
Clara Lambrecht and Cass Sechtig
Faculty Mentor: Jennifer Harrison
The Logic of Logic Puzzles

Join us for a presentation and discussion about methods for solving grid logic puzzles. There will be opportunities for each person to complete their own puzzle and have some fun learning about problem solving.
8:00 – 8:20   Room:  HHH 322     Level: Elementary

Jenna Balsiger
Faculty Mentor: Fariba Khoshnasib-Zeinabad

The Wage Gap in Professional Occupations

Comparing two sample set of means: men versus women’s weekly salaries from 1997 to 2015 for physicians and men versus women's weekly salaries from 1997 to 2015 for lawyers. Showing the evidence of the wage gap through time.

8:30 – 8:50   Room:  HHH 309     Level: Intermediate

Jacob Johnson, Dan Becken, Allison Brunner
Faculty Mentor: Abra Brisbin

Modeling Optimal Housing Development in Eau Claire

The city of Eau Claire is unsure of where and what sizes of houses to build and develop. To determine the desirability of a house we used price per square foot per day on market. By using factors such as year built, square footage, and number of bedrooms in a linear regression we are able to analyze how that variable increases, decreases or has no effect on desirability.

8:30 – 8:50   Room:  HHH 315     Level: Intermediate

Nicholas Lydeen, Connor Feltman
Faculty Mentor: Chris Ahrendt

Symplectic Integration Methods in Classical Mechanics

Analyses of systems in classical mechanics typically reduce to solving ordinary differential equations. These equations typically do not possess closed-form solutions and in practice are solved numerically. However, general-purpose numerical methods often lead to physically unacceptable approximations. One may obtain superior approximations from symplectic integrators, methods that better preserve fundamental physical properties such as energy conservation. We discuss two methods in particular, Leapfrog and Verlet integration, and relate these methods to problems in mechanics.
The following presentation introduces and explains basic and key concepts on which Algebra and Arithmetic used to solve “The Hundred Fowls”, by Quijan Zhang. Algebraic equations are planted and later on arithmetic thinking is needed to give a precise response. Algebraic and arithmetic thinking are both essential tools in Mathematics and its combination is crucial to obtain an accurate solution to this problem from ancient China.

Statistics on sales made on a weekend versus a week day and tips that correspond with the sales.

For many years the Eau Claire Public Library had an illuminated map of the world showing where it was day and where it was night. I often thought that it would be interesting to figure out the equation of the terminator, the boundary between day and night. Recently, I finally did it. I will derive parametric equations for the terminator using techniques from my junior high mechanical drawing class, elementary geometry, and right triangle trigonometry.
9:00 – 9:40   Room:  HHH 203   Level: Intermediate
Geoffrey Glover, Austin Holmes, Tennie Jacobson
Faculty Mentor: Colleen Duffy
**Algebras associated with the Hasse graphs of polytopes**

Our goal for this year is determining the structures of the graded algebras associated to the Hasse graphs of the 600-cell. The algebra is formed by looking at paths between distinct vertices in the graph. For each 600-cell symmetry, we consider the Hasse subgraph consisting of fixed k-faces. The number of paths between the levels in the subgraph determines the generating function for the sub-algebra, which helps describe the algebra. We are programming in Maple.

9:00 – 9:40   Room:  HHH 301   Level: Elementary
Molly Petersen, Dawn Paukner and Jonah Amundsen
Faculty Mentor: Carolyn Otto
**The Colorability of Rational Tangles**

Our research team has investigated the colorability of rational tangles. A rational tangle is comprised of two strings with free ends. We examined the relationship between the colorability and a tangles rational number. The rational number is a complete invariant, which means it helps us distinguish between two tangles. The rational number is a collapsed form of tangle fraction which incorporates information on the number of twists in each component of a rational tangle.

9:00 – 9:20   Room:  HHH 308   Level: Elementary
Emily Gullerud and Claire Arneson
Faculty Mentor: James Walker
**A Graphical User Interface for Mathematical Art**

Symmetric rosettes, wallpapers, and friezes are created in MATLAB using complex valued functions to map pixels from a source image onto the complex plane. By appending multiple images, we have created animations that show effects of rotation and growth. We have constructed a Graphical User Interface (GUI) to allow users, including high school students, to make their own designs without any advanced mathematical knowledge. Future work will expand upon this research using non-Euclidean geometries.
9:00 – 9:20  Room: HHH 309  Level: Intermediate

David Bachmeier, Alec Putnam, Mario Sanchez, Bradley Wesely
Faculty Mentor: Abra Brisbin

**Modeling the Eau Claire County Housing Market**

Each of us can call Eau Claire County home in some way. We’ll take a look at how the county can continue to allow us and others to call it home by diving into the housing market and the potential for its growth in the near future.

9:00 – 9:20  Room: HHH 311  Level: Advanced

Nicole Anderson, McKenzie Scanlan
Faculty Mentor: Manda Riehl

**The intersection of all Largest Hairpin Family Matchings**

RNA forms bonds with itself and this partially determines how the RNA functions. We investigate some models for this RNA secondary structure using a mathematical object called a matching. Many different models have been created to approximate which matchings are likely to show up in RNA and which aren’t. By analyzing C&C matchings combined with earlier work on L&P matchings, we have revealed traits common in all largest hairpin family matchings.

9:00 – 9:20  Room: HHH 320  Level: Elementary

Brenna Hughes
Faculty Mentor: Jennifer Harrison

**Eliminating Possibilities**

When problem solving, we often look for strategies to make the search for the solution easier. One of these methods is Eliminating Possibilities. It is an extremely common technique that many people have used before in everyday life. However, there are also many types of puzzles and problems that use this method as well, including some that are a lot more popular with those of us seeking a cognitive challenge.

9:00 – 9:20  Room: HHH 322  Level: Elementary

Matt Hembel
Faculty Mentor: Fariba Khoshnasib-Zeinabad

**Boys vs. Girls, Non Profit Fundraising**

My presentation will be an examination of Madison Youth Choirs annual fundraising event. I will compare performance of boys and girls and other groups. I will also draw conclusions and make suggestions on how this data can be used to benefit the organization.
Möbius Theorem and Transformations

Möbius transformations send circles and lines to either circles or lines. It preserves symmetry and is a composition of translations, rotations, magnifications, and inversions. The Möbius transformation is generally defined as \( M(z) = \frac{az+b}{cz+d} \), with \( ad-bc \neq 0 \). There are several different applications that Möbius transformations are used for, like brain mapping and spherical graph drawing.

Analysis of Combining Musical Scale Vectors

We utilized mathematics to represent musical scales, chords, and intervals as linear combinations of each other. These note collections were converted into scale vectors so that matrices could be used to solve systems of linear equations in MATLAB. Focus was placed on the octatonic scale, the diatonic scale, and the interval of a major third. We took our results to music professor Dr. Gary Don to find examples of these combinations in musical literature.

Statistical Analysis of Adoption Patterns in Four US States

Adoption has provided stability to millions of children in the US. To identify factors which influence adoption rates, we analyzed data from the 2014 American Community Survey in Wisconsin, Minnesota, Texas, and California. We used tests of proportions to investigate associations between adoption rates and ethnicity and income. Additionally, we used a permutation test and found evidence that in California, but not Wisconsin, neighboring regions have more similar adoption rates than expected by chance.
Ana Petarius, Jingtai Liu, Taren Leitzke
Faculty Mentor: aBa Mbirika

The Monster Group

The Monster group is the largest of a class of groups known as sporadic simple groups. It contains about eight hundred thousand trillion trillion trillion trillion elements. It is also commonly known as the Fischer-Griess Monster and the Friendly Giant. We focus mostly on discussing the Monster group’s properties, but will also briefly discuss its history and give a broad overview of its applications.

Michael McDonnell & Claudia De Valk
Faculty Mentor: Chris Ahrendt

The Foucault Pendulum

The first Foucault pendulum went on display in Paris in 1851, and they can be found throughout the world today. A Foucault pendulum consists of a weight suspended from a pivot that is allowed to swing back-and-forth, or oscillate, freely. If the pendulum is allowed oscillate continuously, the plane of oscillation will begin to rotate with the rotation of the Earth. The Foucault pendulum is therefore a simple experimental proof of the Earth’s rotation. In this talk we will delve into the rich history and mathematics of the Foucault pendulum.

Daphne Kroells, Lexi Haug
Faculty Mentor: Jennifer Harrison

Lemonade Stand Problem

We are going to demonstrate various ways to evaluate a pattern and form an equation for the pattern.

Ethan Hartwig
Faculty Mentor: Fariba Khoshnasib-Zeinabad

Global Climate Change

Will be presenting information regarding to how temperature medians have changed over the years. This can range from year to year as well as decade to decade etc.
Mandelbrot Fractal

The Mandelbrot set is a set of complex numbers that generates a beautiful, self-similar fractal. We will discuss its definition, as well as its importance in complex analysis and other areas of math. Finally, we will demonstrate how to programmatically generate this fractal.

Display the Beauty of Mathematics Through Quilts

This presentation will display several beautiful math and art projects. Our research project integrated aspects of the mathematical principle of symmetry, artistic imagination, and color theory. Each student made an individual quilt prior to the final collaboration to become familiar with the techniques of sewing and creative designs. The designs were made using Adobe Illustrator to ensure perfect symmetry, accurate measurements and proper perspective. The quilts involve Fibonacci sequence, financial modeling, flowing blocks, circular convergence, nested cubes, 3D triangles, and a multi-layered star. Dr. Tong will present her most recent mathematical quilts.

The paradox of the "missing fundamental"

The relation between frequency and pitch is a subtle one. In this talk, we show that pitch corresponds to a correlation between the audible frequencies in musical tones, rather than the frequencies themselves. An example from a musical recording will be examined in detail. In this example, none of the audible frequencies directly correspond to the pitch of the singer’s voice, but their correlation leads to a frequency that does match the pitch.
10:00 – 10:20   Room:  HHH 309     Level: Elementary
Brendan Kwick, Ian Turk, and Troy Chavez
Faculty Mentor: Abra Brisbin
Modeling Housing Demand in Eau Claire County

This presentation will analyze the demand for housing in Eau Claire County and model trends moving forward. By using multiple linear regressions of characteristics from recent home sales and examining the demographics of the people in the county, we will define which areas are the most desirable for new housing development as well as determine the proportion of new buildings that should be single family or multi-family homes.

10:00 – 10:20   Room:  HHH 311     Level: Elementary
Tennie Jacobson, Abigail Schwichtenberg, Michaella Burg, and Zach Walbrun
Faculty Mentor: Carolyn Otto
Introduction to Braid Theory

This project is aimed at explaining the definition of a braid and how they relate to knots and links. During this presentation, our group will be discussing the group they form and how to depict them in space. Finally, there will be an introduction to braid moves, consisting of adding and multiplying braids together along with applications.

10:00 – 10:40   Room:  HHH 315     Level: Elementary
Thao Tran, Danielle Brushaber
Faculty Mentor: Jessica Kraker
Lunar Effects on University of Wisconsin Eau Claire on-campus Housing Incidents

The purpose of this project is to examine patterns in incidents of student misconduct in UWEC residence halls across time, with particular investigation of possible lunar effects. On-campus housing incidents from August 2012 to December 2016 were analyzed using two statistical approaches: non-parametric tests and time-series analysis. Understanding the patterns of on-campus incidents over time will contribute meaningful insights for hall directors, resident assistants, and entities who support and protect students.
10:00 – 10:20       Room:  HHH 318       Level: Elementary
Jacob Stuttgen and Rachel Johnson
Faculty Mentor: Jennifer Harrison

*Probability*
We are looking at interesting and challenging probability problems to help people gain a better understanding of probability and become more comfortable with it.

10:00 – 10:20       Room:  HHH 322       Level: Elementary
Emilie Froidcoeur, Shauna Parish
Faculty Mentor: Fariba Khoshnasib-Zeinabad
*Statistics of GDP and income*
Hypothesis testing on mean GDP and mean household income of two states, and the correlation of income and GDP.

10:30 – 10:50       Room:  HHH 301       Level: Advanced
Sam Henningsen, Joe Westenberg
Faculty Mentor: aBa Mbirika
*Compass-Ruler Constructions*
The ancient Greeks explored utilizing basic ruler and compass constructions such as (1) squaring the circle, (2) doubling the cube, and (3) trisecting an angle. These objects, which can now be created easily using our technology, continued to puzzle mathematicians for over 2,000 years. We will utilize topics from Abstract Algebra II (Math 426) to show that these things are actually impossible to do.

10:30 – 10:50       Room:  HHH 308       Level: Elementary
Kyle Geib, Charles Lindberg
Faculty Mentor: James Walker
*The JPEG Compression Algorithm*
Ever wondered what that “.jpeg” means on a file? This presentation will describe the basics of JPEG compression, a process that is used each and every time someone saves or transfers a digital image. This process is broken down into eight easy to follow steps: acquisition, matrix level shift, discrete cosine transform, quantization, differential compression, organization, Huffman compression, and output.
10:30 – 10:50   Room:  HHH 309     Level: Intermediate
Jordan Koski
Faculty Mentor: Marie-Claire Koissi

**Pricing mortality-linked securities with R**
The R software is a very powerful statistical tool used in various areas of actuarial sciences. In this presentation, we will show how R is used to price mortality-linked derivatives such as swaps and short-term catastrophe bonds.

10:30 – 10:50   Room:  HHH 311     Level: Advanced
Dawn Paukner, Courtney Patri, Grant Keane
Faculty Mentor: Carolyn Otto

**Knot Concordance Groups**
We will talk about the group of topological concordance classes of knots in S3. Topics include: an introduction to the subject; the basic definition of the concordance group; various properties of the group; why the group is useful; and some of its applications. Explanation of these subjects will be given at an intermediate level and we will cover multiple examples to aid in the explanation.

10:30 – 10:50   Room:  HHH 318     Level: Intermediate
Kole Hartwig
Faculty Mentor: Jennifer Harrison

**Pascal’s Triangle**
A look into the sequences of Pascal’ s triangle, and how to use it mathematically.

10:30 – 10:50   Room:  HHH 324     Level: Intermediate
Rita Post, Geoffery Glover, Emily Gullerud
Faculty Mentor: Fariba Khoshashib-Zeinabad

**Stereographic Projections**
We present definitions on stereographic projections and the Riemann sphere. We relate its connections to homeomorphisms and topological spaces. We present formulas for calculating points on the Riemann sphere as well as its corresponding points on the Cartesian plane and demonstrate how a light source can project a point from the sphere to the plane. We discuss applications of stereographic projections, including the cartographic use of the spherical-shape of the Earth to 2-D paper.
In this presentation, we will cover the use of matrix multiplication in cryptography or also known as the art of writing codes. We will define “matrices” as well as other important terms and detail the process of multiplying matrices of various dimensions in order to build up to using this process to decode a message.

A discussion that will explore the topics of groups, D4, and the group actions of D4 in relation to a tic-tac-toe board.

Mathematical and musical ideas are used for analyzing the harmony, rhythm, and form of Charles Ives’ famous composition, “Variations on America.” Spectrograms are useful for analyzing the acoustic features of the musical sounds in the piece. The Tonnetz, a network of major and minor chords, was used to analyze the logic of the chords and keys in the piece. Circle diagrams aided in analyzing the rhythmic structure of the piece.
11:00 – 11:40   Room:  HHH 309     Level: Advanced
Christopher Davis
*Links and their C-complexes*

Knots can readily be studied by looking at a surfaces they bound and coming up with a matrix for each surface, called a Seifert matrix. It is even understood how badly this technique will fail to classify knot theory. Two knots which cannot be distinguished by their Seifert matrices are related by a sequence of simple local moves. An important step in proving this is the fact that any two knots will bound Seifert surfaces which are the same, at least as topological spaces. In a recent project with Grant Roth (A then student at UWEC) we found that this is not the case for a generalization of the Seifert surface to links, called C-complexes. We find links which do not bound any topologically equivalent C-complexes.

11:00 – 11:20   Room:  HHH 318     Level: Elementary
Dani Vierbicher and Kylie Bluske
Faculty Mentor: Jennifer Harrison
*Open-Ended and Open-beginning Math Strategies*

This presentation explores mathematical strategies involving open-ended, open-beginning, and both ends-open problems. We will be targeting people who are interested or considering a future in elementary education.

11:00 – 11:20   Room:  HHH 322     Level: Intermediate
Connor Feltman, Nicholas Lydeen, Luogen Xu
Faculty Mentor: Fariba Khoshnasib-Zeinabad
*Complex Circuitry*

Most cases of modern circuitry involve the use of oscillatory input voltages, which in turn require the use of complex numbers and their methods to model conservation laws. In addition, Fourier analysis and information theory are two mathematical techniques used to generalize inputs into systems and analyze their outputs. We discuss the fundamentals of complex circuit analysis and how mathematical models provide insight into the actual physical systems.
11:30 – 11:50   Room:  HHH 301     Level: Intermediate
Rita Post, Jingtai Liu
Faculty Mentor: aBa Mbirika
Involutions and Orientation-preserving Symmetries in the Hyperoctahedral Group

We study a variety of involutions and orientation-preserving symmetries in the hyperoctahedral group. We examine the involutory elements and their corresponding conjugacy classes and present formulas for calculating both the size of each involutory conjugacy class and the number of involutory conjugacy classes in this group. We explore some combinatorial aspects, namely, the size of the intersection of conjugacy classes of the alternating group elements, the orientation-preserving symmetries, with the conjugacy classes of involutory elements.

11:30 – 11:50   Room:  HHH 308     Level: Elementary
Li Jin
Faculty Mentor: James Walker
Digital images

Digital images are used everywhere now, on our phones, computer, TVs. But how are those colors displayed? How are the images converted into 1 and 0 that the computer can understand and process? This is a presentation introducing the processing of digital images.

11:30 – 11:50   Room:  HHH 315     Level: Intermediate
Nicholas Lydeen
Faculty Mentor: Chris Ahrendt
An Application of Neural Networks to a Non-Deterministic Game of Imperfect Information

Neural networks have been successfully employed in the development of artificial intelligence agents designed to play deterministic games of perfect information. A relatively recent example is Google's AlphaGo, which plays Go on par with the world’s most skilled players. AlphaGo was trained with a database of over 30 million board positions, drawing from 160,000 actual games. We investigated the application of neural networks to the game Lost Cities, a non-deterministic strategy game of imperfect information, without providing such "expert information" as known successful strategies or sample gameplay. We discuss several training methodologies, and compare and contrast the resulting agent's play against several metrics. These metrics include the agent's performance against an agent that plays randomly, an agent that selects its moves by Monte Carlo tree search, and other instances of the same agent. We also graphically analyze the evolution of the neural network's weights as the agent plays to gain insight into how the agent is learning.
11:30 – 11:50   Room:  HHH 318     Level: Elementary
Ali Barrie and Taylor Saunders
Faculty Mentor: Jennifer Harrison
Evaluating Finite Difference Techniques

Evaluating Finite Differences is a way to solve a problem that involve linear, quadratic, cubic, and quartic functions. We have selected a number of problems we wish to display to help us inform how to evaluate finite differences. We also have provided the base equation chart to use as well.

11:30 – 11:50   Room:  HHH 322     Level: Intermediate
Darian Sowers, Joowon Kim, and Austin Angell
Faculty Mentor: Fariba Khoshnasib-Zeinabad
Harmonic Functions

The presentation will be about harmonic functions and different types of harmonic applications.

11:30 – 11:50   Room:  HHH 324     Level: Elementary
Cole Pankratz
Faculty Mentor: Chris Hlas
Stress and Time Management in High School Students

Stress levels are high; there are newfound responsibilities; and there is finally a sense of independence which makes way for budding social lives in high school. Our study looks to find correlations between perceived student stress levels and their time management with family, school, and social lives in order to better advise students in finding a healthy balance between these factors in the future.

12:00 – 12:20   Room:  HHH 301     Level: Advanced
Emily Gullerud, McKenzie Scanlan, Rita Post
Faculty Mentor: aBa Mbirika
Fermat’s Two Squares Theorem

We present Fermat’s theorem on the sum of two squares. We define maximal, prime, and principal ideals along with fields and modular arithmetic and discuss their connection to the sum of two squares being prime. We also discuss how an integer can be expressed as a sum of two squares if and only if it has a nontrivial factorization in the set called the Gaussian integers, a principal ideal domain.
12:00 – 12:40   Room:  HHH 308     Level: Elementary
James Walker  
*Mathematics of Musical Harmony*

Using the mathematical tool of spectrograms, we can plot the
fundamental pitches and overtones of musical sounds, and see
how they change as the music plays. This provides a clear
explanation for how musical harmony works and allows for
creating new musical instruments and musical sounds.

12:00 – 12:20   Room:  HHH 309     Level: Intermediate
Nicolas Larson  
Faculty Mentor: Abra Brisbin  
*A Statistical Analysis of the Effect of R on Student Learning in Probability*

How can we help students learn math? One way is introducing technology into the classroom to help
students better understand what they are learning. We tested the effect of a statistical computing
program called R on students’ performance and confidence. We gathered data from 11 pairs of
homework problems in a course on probability. One problem in each pair required the use of R. We
used linear regression to test the effects of R on students’ confidence levels and on their scores, with
and without effects of each homework assignment and of each student’s baseline performance. Results
were inconclusive, suggesting a need for larger sample sizes. There was some indication that students
grew more confident in their use of R as the semester progressed.

12:00 – 12:20   Room:  HHH 315     Level: Intermediate
Michael Breunig and Hunter Hermes  
Faculty Mentor: Chris Ahrendt  
*Lotka-Volterra Equations and Their Use in Modelling Predator/Prey Relations*

The study of differential equations has had countless real-world applications. One set of such equations
are the Lotka-Volterra equations. These equations are a pair of first-order, nonlinear differential
equations. They have applications that have substantial impacts on studying a wide variety of
disciplines. For this presentation, we will focus on their analysis of predator-prey relationships in
biological systems. These equations, under certain conditions, study the dynamics of how two species
interact. The main goal of this presentation is to teach others on where these equations came from, a
basic understanding of the equations, and to give examples on how these equations are used.
Use and Exploration of Algebra in Venn Diagrams

Introduction to Venn Diagrams and use of algebra to solve and show relationships within the data.

The parent funded sport of lacrosse

We compared the average amount of money a lacrosse player is willing to spend in high school compared to someone in college.
The tools of probability theory are so powerful that many problems can be solved without pencil and paper—or computer. The idea is that perhaps, when you figure out how to solve a problem "in your head," you can better understand why the answer is what it is. We'll examine some intriguing probability puzzles to see if we can get to their solutions by pure reasoning.