Prior to the demolition of Scot Lanes, Math/CS and Physics battled out the final Taylor Bowl for the permanent possession of the giant slide rule trophy. Math/CS came out on top and will retain the trophy for all eternity.

<table>
<thead>
<tr>
<th>Data</th>
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<th>Physics</th>
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Avi Vajpeyi (Computer Science & Physics Major from Kolkata, INDIA)

Studying Universality with Physics Engines: Accelerating Granular Flow on GPU with OpenCL and CUDA (advised by Denise Byrnes & John Lindner)

Experiments with a granular beadpile have shown that the pile can model critical systems such as avalanches. In the experiments, a bead is dropped on the apex of the pile of beads. Eventually, one such bead causes several beads of the conical bead pile to avalanche. The experiments have studied the distribution of avalanches and how the distribution is affected by altering the bead type, bead cohesion, and bead drop height. In this study, two computational simulations of the experiment are presented. The simulations model each bead as an independent particle with their own position and velocity. Due to the independentness of the particles, we can use parallelism to thread various processes of the particles to a personal computer’s graphical processing unit. This allows the simulations to run faster than real-time while still having more than 10 thousand particles on the pile. The first simulation’s data matched the laboratory beadpile’s data at the low drop height regime, but failed to do so at higher drop heights. The second simulation, made using a much simpler model, requires friction to be included in the model to make the simulated beadpile comparable to the laboratory beadpile. With these simulations it is possible to learn new information that may have been challenging to study with the actual experiment. For example, we can vary the shapes and numbers of the beads. With the simulation it is also possible to record the velocity of each particle both on the surface and inside the pile.
Shiwani Varal (Math & Political Science Major from Pokhara NEPAL)

WWTS: Inclusion of Blocking Power for a Complete Voting Power Analysis in the IMF (advised by Jim Hartman & Matt Krain)

The International Monetary Fund (IMF) calculates the voting power of a country by dividing the total of one member’s votes by the total of all members’ votes. This method of calculating the power of a state judges power as voting weight. However, voting weights are the total number of votes a country has in an institution, while voting power is the influence a country has on a policy decision. A better approach to calculate this voting power within an institution is by using voting power indices. However, literature only calculates the winning power, while voting power is defined as the ability of an actor to obtain a desired outcome. Thus, literature has only analyzed half of the voting power. This paper addresses this gap in the study of voting power literature by making a case for blocking power. In this paper, we have shown hypothetical examples to illustrate that blocking power is an important component of power, and the concept of voting power of a country cannot be fully understood without looking at the blocking power. We have also made improvements to the current models that discuss voting powers of members within an institution, and tested the new amended model on the voting data obtained from the IMF’s website and explained observed results.
Thomas Matlak (Math & Computer Science Major from Worthington OH)

Algorithmic Music Composition (advised by Nathan Sommer & Nathan Fox)

Algorithmic music composition is a popular area of research in computer aided music; it is the application of computer algorithms to create music. One subtopic of this area is the automated creation of pleasing melodies. This paper explores two matching learning approaches to algorithmically creating melodies: Markov chains and genetic algorithms. Markov chains can generate a rough imitation of the corpus of music upon which they are based. Though Markov chains can generate a rough approximation of musical style, we want to refine the music to bring it closer to the desired target style. To accomplish this we use genetic algorithms to take an initial population of melodies and tweak and remix them to create better melodies. Genetic algorithms have been used extensively in previous research, but this paper proposes the use of a long short-term memory artificial neural network to act as a surrogate fitness function, rather than defining a set of rules for good music and penalties for breaking those rules.

Sonia Malik (Math Major from Karachi PAKISTAN)

Fractals and Fractal Time Series (advised by Jim Hartman)

Classical geometry has, for a long time, been used to shape our understanding of the natural world. Geometrical properties such as length, area and volume aid us in analyzing objects around us in a way that is tangible to us. The discovery of fractals and the introduction of fractal geometry added a new dimension to our understanding of natural phenomena. Fractals, or irregular objects, can be found everywhere from galaxies to coastlines and the applications of fractal geometry extend into many other scientific fields.
Nicholas Hagopian-Zirkel (Math & Computer Science Major from Ann Arbor MI)
Analyzing and Solving the Nurse Scheduling Problem (advised by Nathan Fox & Robert Kelvey)

From large to small, most every workplace requires some sort of scheduling. Nowhere perhaps is this more critical than in hospitals, where, in addition to all the normal labor restrictions for scheduling, it is a matter of life or death that hospitals be sufficiently staffed at any hour of the day. The nurse scheduling problem (NSP) is the problem of creating a schedule that satisfies all the wants and needs of a hospital and its nurses. With current methods, the problem cannot be solved directly in reasonable runtime and its large number of constraints mean that any feasible solution may be difficult or even impossible to find. This problem's difficulty, real-world application, and its unique relationship to its constraints have solidified the NSP’s importance in the field of computational complexity theory. In this paper the NSP is analyzed and methods for solving it are discussed. Additionally select methods and constraints are showcased in corresponding software.

Zhirui Zhang (Math & Computer Science Major from Qingdao Shandong CHINA)
Artificial Intelligence with Reinforcement Learning in First Person Shooter Games (advised by Sofia Visa & Nathan Fox)

This project uses Unity3D as the game engine for building a first person shooter game, the Zombie Hunter. To train the AI bot (the zombie) we use reinforcement learning. In this game the bot becomes smarter and smarter as the player advances to upper levels. In the Zombie Hunter game, the zombies perform differently in response to the player’s individual behavior.
Erik Barroso (Computer Science Major from Ann Arbor MI)

BioScript: A Web Application for Biological Researchers (advised by Sofia Visa)

Genomic sequencing has become a popular process present in academia, health care, and private industry. Before the results of genomic sequencing can yield any results, the sequenced data must be trimmed and checked for quality. Traditionally the trimming process has been handled by a third party resource like a computer scientist or a bioinformatician, because it requires a strong familiarity with super computing systems. The large demand for genomic data has created a bottleneck at the point of trimming. To solve this, we provide a web application called BioScript that assists biological researchers through the trimming process. BioScript guides the user through to selection and software download, provides the user an interface to input information about their super computing system, and helps them select trimming options. For the development of this application we investigate the Rube on Rails application framework and the Passenger application server.

Jianqiu Bai (Math & Computer Science Major from Zhengzhou CHINA)

Connecting Five Stones: Artificial Intelligence Implementation for Go-moku in Unity (advised by Sofia Visa & Robert Kelvey)

This project studies how to 1) develop a 3D Go-moku game using C# in Unity and 2) implement AI into the game. The paper briefly introduces the Go-moku game and discusses the game implementation. Next, the paper explains three AI playing strategies: the Greedy, the Minimax and the Neural Network strategies. After implementation, the project investigates the optimal strategy by letting the computer play against itself in combinations of any two of the three strategies.
Sarah Padrutt (Math Major from Alexandria VA)

An Investigation of Markov Chains and Their Application to Hospital Patient Flow (advised by Marian Frazier)

Markov chains can be used to model patient flow in hospital settings. In this study, six Markov chain models are constructed to model patient flow in the emergency department of Wooster Community Hospital. The Markov chains are used to predict long term patient movement within the department. Additionally, sensitivity analysis suggests hospital efficiency may be improved by reducing the time between each patient’s report is sent and when the patient leaves the emergency room. A compartmental model is presented as an additional way to model patient flow and is constructed to model patient flow throughout the hospital.

Than Phuong Nguyen (Math & Business Economics Major from Hanoi VIET NAM)

Understanding Municipal Bond Ratings Using Ordered Multinomial Logistic Regression (advised by Jim Hartman & James Burnell)

Municipal bonds are used by cities in the U.S. to raise funds for public projects. Cities are concerned with how they can improve their credit ratings so that they can borrow funds at lower cost. In this study, we examine the determinants of municipal bond ratings for three rating agencies: Moody’s, Standard and Poor’s, and Fitch. We construct predictive models that associate cities’ characteristics with bond ratings. Our goal is to understand what cities need to improve so they can achieve better credit ratings. As a basis for this research, we provide an understanding of ordered multinomial logistic regression theory. This regression method also leads us to other topics in mathematics such as maximum likelihood estimation and the Newton-Raphson iteration method. This project focuses on learning about the determinants of municipal bonds’ credit ratings and how to measure the effects of these determinants on the ratings. We learn about maximum likelihood estimation and the Newton-Raphson method to understand how ordered multinomial logistic regression works, and apply this knowledge to build models that can answer our questions.
Tommy Bacher (Computer Science Major from Uniontown OH)
A Study of Dynamic Difficulty Adjustment for Video Game Balance (advised by Nathan Sommer)

When developing a video game, it is important that the game be balanced in the sense that it is neither too difficult nor too easy. Dynamic difficulty adjustment is a form of video game balance where the game is adjusted while the user is playing it based on the user’s performance. This study explores the process of creating a dynamically adjusted game and whether users prefer a dynamic version of a game over a static version of the same game. By the end, the reader should have a solid understanding of the previous work done in the field of dynamic difficulty adjustment and the software developed for this paper. The reader should also understand the difficulty of creating a dynamically adjusted game and recognize that dynamic difficulty adjustment provides a potential benefit in terms of user enjoyment and performance.

Todd Brockelman (Computer Science Major from York ME)
Interactive Sound Synthesis: Procedurally Generated Audio Based on User Drawn Waveforms (advised by Nathan Sommer)

This study focuses on the creation of software with the goal to introduce the concepts of timbre, audio synthesis, and sampling through the use of virtual reality (VR) as a medium. First describing the physics of sounds, synthesis, and sampling, we discuss the software methods used to accomplish our goal of teaching users about the relationship between timbre and wave shape through the use of the Unity game engine. The software allows a user to draw a waveform and have the unique timbre that corresponds the output back to the user. Complex and unique waveforms can be modeled in this manner to be analyzed for distinct tone qualities that are otherwise difficult to recreate. We observe users’ understanding of wave shapes before and during a software test to ascertain any improvement in understanding.
Maxwell Taylor (Computer Science & Math Major from Columbus OH)

Logic -> Proof -> REST (advised by Denise Byrnes and Robert Kelvey)

REST is a common architecture for network application. Applications that adhere to the REST constraints enjoy significant scaling advantages over other architectures. But REST is not a panacea for the task of building correct software. Algebraic models of computation, particularly CSP, prove useful to describe the composition of applications using REST. CSP enables us to describe and verify the behavior of RESTful systems. The descriptions of each component can be used independently to verify that a system behaves as expected. This thesis demonstrates and develops CSP methodology to verify the behavior of RESTful applications.

Sabrina Tobe (Math Major from Oakland CA)

Something Fishy: A Comprehensive Analysis of Terror Plots Subject to Binomial and Poisson Distributions (advised by Pamela Pierce)

In 2017 alone, over 22,000 terror attacks were committed worldwide and many more planned. To combat the development of terror plots and attacks, undercover government agents are sent out to detect and intercept them. The purpose of this research paper is then to redevelop a model that predicts the probability of some number of unknown terror plots and busy undercover agents and to then find the steady state probability of different combinations of these two factors. Additionally, given a variety of parameters that impact the probability of unknown and known plots, this research seeks to understand how varying these parameters affects the number of terror plots. In order to redevelop this model, we utilized concepts from both univariate and bivariate distributions in probability; the distributions ultimately used were binomial and Poisson distributions. Using MATLAB, a simulation of the distribution was created to understand the long term probabilistic behavior of difference combinations. The given parameters were altered and reapplied to the simulation to replicate sensitivity analysis. As a conclusion, bounds were found for each parameter and the simulation and distribution were approved with minimal error.
Mary-Hannah Boyer (Computer Science Major from Wooster)
Recognizing Sarcasm Using Machine Learning (advised by Nathan Sommer)

The purpose of this study is to utilize machine learning techniques to recognize sarcasm in social media comments, in order to more accurately understand their content. In the age of social media, it has become more difficult to predict the interests of younger generations through focus grouping. The use of social media to gauge how users feel about a topic using machine learning algorithms has recently become a way to replace them. However, social media comments are often heavily sarcastic, meaning that the sentiment being expressed is the opposite of what the comment explicitly says. Accurately determining the opinion of users based on comments therefore requires taking sarcasm into account. Using a corpus of comments from the social media website Reddit, which are tagged as either sarcastic or not, and the scikit-learn Python library, this study investigates various machine learning approaches to text classification, such as naive Bayes classifiers, decision trees, and random forest classifier. Other similar studies are also investigated.

Kelly Steurer (Math Major from Tallmadge)

The aim of this study was to determine what affects aggregate crime rates around the world. This thesis used mathematical modeling techniques to build generalized linear models for homicide rates and burglary and housebreaking rates using the following predictive factors: economic indicators, education rates, government quality indicators, ethno-linguistic fractionalization, GDP per capita and its growth, drug consumption rates, and age and gender ratios. We used a series of factor selection techniques including linear and stepwise regressions, principal component analysis, and regression analysis to select factors to use to build final models of homicide and burglary and housebreaking.
Aidan Brown (Math & Russian Studies Major from Fredericktown OH)
The First Spacewalk: An Exploration of the Mathematical and Cultural Implications of the Space Race (advised by Jennifer Bowen and Tatiana Filimonova)

The purpose of this thesis is to explore the mathematical and cultural implications of the first spacewalk and how it has been perceived over time. The historical perception of this mission is established through discussion of Soviet propaganda practices and the analyzation of initial press coverage after the launch. Modern perceptions are explored through analysis of recent film dramatization of the mission and how Russian audiences respond to this film. Focus is also given to the theory of orbits and ground tracks to establish a more technical understanding of the complications faced by the cosmonauts involved.

Robert Gates (Math Major from Princeton NJ)
The Earth-Moon Problem: A Study in Topological Graph Theory (advised by Jennifer Bowen)

Graph theory is the study of a class of mathematical objects known as graphs. Unlike the graphs referred to in common speech, mathematical graphs are not a diagram. Rather, they are a typically finite collection of vertices along with a collection of edges connecting those vertices. We examine topics in topological graph theory, a branch of graph theory which deals with embeddings of graphs into surfaces. In particular we will be examining the unsolved Earth-Moon problem, as well as related problems in this field. We attain bounds on the Earth-Moon problem, and we also find exact solutions for some of the related problems. In order to attain the desired results, we often use results from fields such as topology and combinatorics.
Paige McKean (Math Major from Groveland MA)
She Shoots, She Scores: Creating a Mathematical Model to Predict Expected Shot Values in Women’s NCAA Division III Basketball (advised by Drew Pasteur)

This thesis aims to create a model to predict the expected value of a given shot in women's NCAA Division III basketball. For each shot taken, we collect information on several variables relating to the shot. Some of these variables include whether the offensive team was the home team or away team, the type of shot (i.e. off rebound, post move, off pass, etc), distance from the basket, and offensive and defensive shooting percentage. The resulting data set contains approximately 2200 data points from 20 games in the 2016-17 season. We then use two-fold cross validation and forward stepwise regression to create several models based on court location that predict expected shot value. Division III women’s basketball coaches will find this research particularly useful, as it will help with implementing offensive and defensive research. We conclude by examining common scenarios that may occur during a game and calculating the expected shot value in those scenarios.

Colby Jeffries (Math & Computer Science Major from Wooster)
Sports Analytics with Computer Vision (advised by Drew Pasteur & Sofia Visa)

Computer vision in sports analytics is a relatively new development. With multi-million dollar systems like STATS's SportVu, professional basketball teams are able to collect extremely fine-detailed data better than ever before. This concept can be scaled down to provide similar statistics collection to college and high school basketball teams. Here we investigate the creation of such a system using open-source technologies and less expensive hardware. In addition, using a similar technology, we examine basketball free throws to see whether a shooter's form has a specific relationship to a shot's outcome. A system that learns this relationship could be used to provide feedback on a player's shooting form.
Ralph (Ruifeng) Xu (Math Major from Dalian CHINA)
On Hausdorff Dimension and Julia Sets (advised by Pamela Pierce & Ondrej Zindulka)

In recent years, geometric measure theory has become a very heated topic in mathematics. According to H. Federer, “[the advances of geometric measure theory] have given us deeper perception of the analytic and topological foundations of geometry, and have provided new direction to the calculus of variations”. In other words, a good understanding of the theory is essential to the study of modern mathematics. In Real Analysis II, we learned some foundations of basic Measure Theory. In this project, we include a further investigation of Measure Theory and the application of it in fractal geometry. Some notions of measure theory, such as $\sigma$-algebra, Borel sets, and measurable sets are included as a foundation. Then we introduce Lebesgue measure, Hausdorff measure, Hausdorff dimension and their properties. Lastly, we focus closely on Julia sets, visualize the connection between Hausdorff dimension and complex dynamics, and eventually state some main results from Shishikura’s paper which talks about the Hausdorff dimension of the boundary of Julia sets. Due to the complexity of the proofs, readers who are especially interested shall refer to more advanced literatures, and the original proof is not duplicated in this project.
Scarlett (Junyi) Chen (Math & Philosophy Major from Province CHINA)

Understanding Human Well-Being (advised by Marian Frazier & Garrett Thomson)

The project is motivated by our concern for the problematic conceptual framework and approach Joshanloo assumes in the article “Revisiting the Empirical Distinction Between Hedonic and Eudaemonic Aspects of Well-Being Using Exploratory Structural Equation Modeling.” First, we aim to (1) give a summary of Joshanloo’s conceptual framework of well-being and his analysis approach, and (2) offer a philosophical critique of Joshanloo’s account. In addition, we propose that a framework of well-being needs to be comprehensive and integrated. Next we set the purpose of the mathematical section as to explore whether the dataset Joshanloo uses in his study has a pre-given structure. Then, we introduce the needed background knowledge, viz., linear regression and factor analysis. Next we perform Exploratory Factor Analysis on the dataset and find that it has a presumed structure, which is the same framework that Joshanloo adopts in his study. In the philosophical discussion, we show that a hedonistic concept of well-being is false, because conceiving pleasure as the only non-instrumental value of life denies other inherently valuable activities that constitute human life. We argue that an eudaemonic account of well-being is erroneous, because it fails to explain in what sense performing the uniquely human function is good or desirable, such that it constitutes well-being. Finally, we offer an account of reconciling with a rough past in a way that renders the painful experience constitutive of well-being. We hope to use this chapter to demonstrate what an integrated account of well-being might look like.
Jennifer Shepheard (Student Designed Public Health Epidemiology major from Hagerstown MD)

The Shot Heard Around the World: Determining the Influence and the Spread of the Anti-Vaccination Ideology on Measles Outbreaks Using Epidemiological Models (advised by Drew Pasteur & Stephanie Strand)

Through vaccination campaigns, the measles virus was eradicated in the United States in 2000. After the media promoted the disproven Andrew Wakefield paper that claimed that the Measles, Mumps, and Rubella vaccine was linked to autism, distrust rose towards vaccines and areas of unvaccinated communities began to appear in the United States. There are a variety of beliefs as to why people are choosing not to vaccinate, which can be categorized by religious, philosophical objections, safety concerns, and lack of education. It was determined that the main vectors spreading the anti-vaccination ideology are the media, friends and family, government, and religion. In order to understand the spread of the ideology, epidemiological models can be used to predict the spread through communities.

The Ohio 2014 outbreak was used in order to test my model and display changes in communities varying in vaccination rates. The two communities that were modeled were the Amish community, which had a low vaccination rate, and the English (general population) which had a high vaccination rate. Through manipulating an SEIR model of the measles and creation of theoretical ideology models it was found that increasing vaccination rates in communities by a small amount can have an impact on how the measles will spread through the community. Additional research is needed in order to quantify the influence of each of the vectors in order to model the spread of vaccination ideology.
Vedica Jha (Math & Biology major from Mumbai INDIA)

Dispatches from the Fly Killer: A mathematical model that studies the correlation between sleep fragmentation and longevity in *Drosophila melanogaster* (advised by Drew Pasteur & Seth Kelly)

Sleep fragmentation has been linked to various negative effects such as decrease in immune response and impaired daytime functions in organisms such as rodents, fish and humans. Our study focused on building a mathematical model to analyze the correlation between sleep fragmentation and longevity in *Drosophila melanogaster*. We collected sleep data using Drosophila Activity Monitors and feature generated seven sleep parameters: Night sleep, Day sleep, Night bout number, Day bout number, Night average bout length, Day average bout length and Waking activity. Then, we built a linear regression model in R to analyze the data. By assessing our model, we found night bout number, waking activity and total sleep time during the day to be significant predictors of lifespan. Furthermore, our findings helped us conclude that sleep fragmentation has a negative correlation with lifespan, as we hypothesized. These results can help us further understand the harmful consequences of sleep fragmentation and provide direction for future studies trying to understand both the underlying causes and effects of fragmented sleep.

Lauren Burke (Math Major from Lewis Center OH)

Are We There Yet? A Traveling Salesman Approach to Road-trip Optimization (advised by Drew Pasteur)

This project attempts to optimize a beloved American pastime: the road trip. The Traveling Salesman problem (TSP) is a well known combinatorial optimization problem categorized by complexity theory as NP-hard. Using a TSP approach, we aim to minimize the overall travel cost accumulated along a specific route. The complexity of TSP makes exact methods inefficient solution location. To determine the ideal method, we apply three heuristics to an instance of the problem involving 40 U.S. National Parks.
Ethan Myers (Math & Business Economics major from Columbus OH)

A Behavioral Approach to CAPM (advised by Robert Kelvey & Matthew Histen)

Financial models serve to capture an accurate prediction of a stock's price. Because these models assume the efficient market hypothesis, they fail when not accounting for irrationality in the market. Using a time series regression analysis, this paper contributes to the literature by modeling irrationality through a price momentum variable. The novelty here is proxying for this price momentum with social media trends, which prove to be statistically significant in financially modeling price changes across multiple sectors.

Khoa Le Tue Nguyen (Math & Computer Science Major from Ho Chi Minh, VIETNAM)

Pretending to Be Human: An Automated Tool to Writing Mathematical Proofs (advised by James Hartman & Sofia Visa)

This project explores the theories of automated theorem proving and lambda calculus, and seeks to improve upon a current implementation of an automated theorem prover that produces human-like output. This software component is based on a published article titled “A Fully Automatic Theorem Prover with Human-Style Output” by M. Ganesalingam and W.T. Gowers, which outlines a program called robotone containing a first-order logic system (with a few modifications) able to automatically write simple direct proofs. It is designed to mimic different strategies that a human mathematician would use when facing a problem, and to write human-style proofs. The current prototype can solve and write eighteen proofs, seven of which are developed from this project with the addition of a mathematics library customized for the course MATH-332 Real-Analysis I at The College of Wooster. Future work includes further investigation on how human mathematicians construct their proofs, and a possible implementation of a more dynamic tactic mechanism to emulate humans’ thinking process better.
HONORS & AWARDS

Latin Honors

Summa cum laude
Junyi Chen
Colby Jeffries
Khoa Le Tue Nguyen
Avi Vajpeyi

Magna cum laude
Aidan Brown
Shiwani Varal

Cum laude
Thao Nguyen
Kelly Steurer
Maxwell Taylor
Sabrina Tobie
Ruifeng Xu

Phi Beta Kappa
Junyi Chen
Colby Jeffries
Avi Vajpeyi

T. Marll MacDonald I.S. Award
Colby Jeffries
Giorgio Tramonto
Shiwani Varal

The Jonas Notestein Prize
Avi Vajpeyi

The Foster Prize in Mathematics
Maxwell Taylor

The Elizabeth Sidwell Wagner Prize in Mathematics
Shiwani Varal

The William H. Wilson Prize in Mathematics
Khoa Le Tue Nguyen
Pi Mu Epsilon is a non-secret organization whose purpose is the promotion of scholarly activity in mathematics among students in academic institutions. It aims to do this by 1) electing members on an honorary basis according to their proficiency in mathematics, 2) engaging in activities designed to promote the mathematical and scholarly development of its members, and 3) taking any other measures which will further the purpose stated above.

Chapter advisor: Dr. Robert Kelvey
2017-2018 PME Officers: Mijiti Mierkamili, Paige McKean, Dylan Orris, Haven Wagner

**New Inductees**

**Class of 2018**
Thomas Matlak
Sabrina Tobe
Phuong Vu
Justine Walker

**Class of 2019**
Christian Betre
Christopher Good
Colin Ford
Joseph MacInnes
Erin Rajewski

**Class of 2020**
Minjoo Kang
Jordan Kirsch
Maya Lapp
John Nugent
Aedan Pettit
Henry Potts-Rubin
Eli Samuelson
Regan Szalay
Hieu Tran
Isaac Weiss
Daniel Zuchelkowski

**Current Members**

John T Bacher
Hwan Bae
Bhargav A Bhalodi
Savannah V Binion
Emma B Brinton
Aidan E Brown
Junyi Chen
Allison L Clough
Haidar Esseili
Wan Hang Hui
Colby T Jeffries
Margaret K McGuire
Paige E McKeen
Jack S Mershon
Mijiti Mierkamili
Khoa LT Nguyen
Callie M Oglend-Hand
Dylan M Orris
Matthew J Pleshinger
Kory R Sansom
Kelly M Steurer
Maxwell H Taylor
Avi Vajpeyi
Shiwani Varal
Benjamin P Verschell
Haven C Wagner
Afton H Widdershins
Ruifeng Xu

**Faculty**
Dr. Jim Hartman
[Skate to stage]

As a boy who grew up in Kolkata, India, I would have never thought that I would have been able to do what I just did -- skating was only something for Marty McFly.

Coming to Wooster made me realize that EVEN I was capable of learning how to skate

AND now my Independent Study has made me realize that even I, like all of you, am capable of contributing to humanity.

Before I begin, I’d like to thank my professors, coaches, friends, and family, especially my Ma -- she is she has flown half-way across the world to celebrate this weekend :D  Ma, I know I didn’t call as often as I should have these past four years, but every morning, I thank you in my mind, because I know that I AM the person I AM -- because of you.

Well, Class of 2018, we’ve made it! We have survived:

the terrifying two minutes of power outage of 2017 (RIP squirrel),
the great floods of Andrews-Gault library,
the rise and fall of YikYak,
and even made it through I.S. orals, something that I had been nervous about ever since my first year at Wooster, when I heard about the grueling stories from upperclassmen.

Before I get into I.S. orals, Id like to talk a bit about our first year at Wooster—which is a bit like learning to ride a skateboard.

Initially, when you get on a skateboard, it can feel chaotic and somewhat terrifying -- the landscape around you seems to guide the skateboard rather than you steering it.

I remember the start of freshman year feeling like this: I had absolutely no idea what was going on.

In fact, during international orientation, I was so confused with everything, I managed to lose my way while walking from Bornhuetter to Lowry. Eventually, a kind Drug Mart cashier, who seemed very concerned, gave me some directions.
Yes, I was a confused individual my first year. I kind of had an idea that I wanted to study neuroscience -- but I wasn’t sure.

But then at ARCH, a professor helped me pick classes: he mentioned that as a neuroscience major I would have to take physics at some point, so after talking to some people at ARCH, I registered for Physics 111.

Wooster’s environment nudged me towards a path and this guidance ended up being exactly what I needed: I really loved the intro physics classes and labs. I also really struggled in them -- but that only made me like the subject even more!

Very quickly, these classes helped me realize that I wanted to study physics and computer science instead of neuroscience!

The hours I struggled with friends on HW sets eventually paid off -- I was able to get a summer research opportunity in the Physics Department here at the College!

I read the acceptance email during a sociology class and masked my whoop of excitement with a bout of coughing. I honestly thought I had been pretty slick at containing my happiness -- but right after class, a classmate asked me why I was grinning so much, in a class on gender inequality.

By the time our class reached sophomore year, we were all getting the hang of steering our skateboards and choosing the environments to roll towards. We got more involved with clubs, became better at getting ready for class in ten minutes, and found the best places to study on campus. And I am proud to say that I managed to memorize Lowry’s location in the GPS of my brain.

What I also find amazing about Wooster is that it has exposed me to so much more than just academics. I had never run track before coming to college, yet the coaches and track team readily accepted me. I was able to join different clubs, and eat meals with people from all over the world -- from Paraguay, Lebanon, Brazil and China, sometimes even at the same table! I have been so grateful for having the chance to speak to people from such diverse backgrounds on a daily basis these past four years.

By the end our sophomore year, each of us even figured out our majors! I think this was one of the most incredible steps in our journey here.

And just like that we became upperclassmen. At this point, we knew where we were going, and we began guiding our skateboards with complete control. We became such pros that we even knew when to avoid the long lines at Lowry during admissions events. The experience we gained and the courses we took helped us choose the area we felt passionately about for our junior and senior independent studies.

For me, the area I wanted to investigate was the study of criticality. I worked on creating a simulation of an avalanching system. What I find ridiculously awesome is that by studying this simple system, we can better understand much more complex phenomenon such as real sized avalanches, forest fires and even stock markets!

Through IS, all of us were able to take what we learned and direct our skateboards to previously unexplored areas, and push the boundaries of our fields just a little further.

And now back to I.S. orals. If we compare this to our skateboard analogy, orals are kind of like the X Games. None of us were too keen to participate, but we also wanted the opportunity to show what we had found and learned in our explorations to our mentors.
Before my orals, I was nervous. I thought about the stories I had heard about them from previous survivors. Then I complained to everyone how frustrating it was that the Physics Department was so extra -- orals for the Physics Department last for two HOURS and in addition to our first and second readers, the entire physics faculty is present! What the heck!?

All my physics professors were sitting in front of me, waiting for me to talk about my work… and they were all smiling. Immediately, I was at ease -- this was going to be fun!

Yes, I know that sounds weird, but yeah, I really enjoyed IS orals! I think it was my favorite experience at the college.

I could tell that all my professors were listening to me, and just by that itself, I felt that my work had value. I felt so energized and honored. Our professors at Wooster are amazing individuals, and they are willing to give us so much of their time. Not just during orals, but countless hours outside class, including playing in occasional intramural sports. I can say without hesitation that this is something unique to Wooster.

My professors have not only helped me find my passion--they have helped me figure out the kind of person I aspire to be. I think Wooster does this for each and every one of us.

Whether it be a coach, a professor, a friend, or Al from dining services, each is helping guide us on our path. Due to this close environment here at Wooster, we have learned more about ourselves and how we aspire to grow and change.

Before I close, I'd like us to reflect for a moment. If we look over the course of human existence, we see flash points of change driven by people who seek information and knowledge--challenging existing belief systems to further ethical and scientific progress.

Class of 2018: the three hopes I have for our class are that…

First, that we be the flash points of change and continue to push the boundaries of knowledge like we did for I.S.;

Second, we impact the life of at least one person, like the professors and coaches have done for us.;

And finally, teach one person how to skate!

Thank you and CONGRATULATIONS TO THE CLASS OF 2018!

View from the mezzanine of the Scot Center indoor track, prior to commencement ceremonies.
1. Student Summer Research Experiences, 26 September
   Thomas Matlak - programming intern @RawVoice
   Khoa Nguyen - security engineer intern @Intuit San Diego
   Thao Nguyen - capital markets analyst @Montgomery Scott LLC Philadelphia
   Shiwani Varal - code graphs and multicast networks @Clemson University

2. Colin Dawson, Oberlin College, “When adding moving parts can yield simpler inferences” 1 November
3. George Exner, Bucknell University, “Infidelity, Gambling, and Squirrels” 29 March
4. Danielle Shepherd, Wooster Math & Physics ’14, “From IS to IndyCar” 15 February
5. Marie Snipes, Kenyon College, “Fun with Fractals and Metric Space Embeddings, 19 April
Jennifer Bowen, Associate Professor of Mathematics and Chairperson

**TEACHING**

Transition to Advanced Mathematics (x 2)  
Abstract Algebra  
Abstract Algebra II  
2 Senior Independent Study advisees  

Dr. Bowen continues to be passionate about her work with the STEM Advisory Board relating to the Mathematical Sciences and her grassroots textbook program for STEM students in need. She is currently co-facilitating a Hewlett-Mellon funded Faculty Learning Community: What Now? Strategies for Female Associate Professors. She remains engaged in the greater mathematical community, serving on the Mathematical Association of America’s Problem Books Series Editorial Board until 2021. She also serves as the Posse Mentor for the Class of 2021.
James Hartman, Professor of Mathematics

TEACHING
Linear Algebra (x 2)
Problem Seminar
Transition to Advanced Mathematics
Probability and Statistics II
3 Senior Independent Study advisees

Dr. Hartman, the “senior” member of the department, has taught at Wooster since 1981. He continues to do one-day workshops for the College Board, direct and teach in the Advanced Placement Summer Institute, and serve as a Question Leader for the AP Calculus exams.

John Ramsay, Professor of Mathematics
on sabbatical 2017-2018

Even though Dr. Ramsay was on leave this past year, he continued to co-direct the AMRE program and even organized an AMRE 25-year reunion that took place during Alumni Weekend this past June. The events at the reunion included a picnic in the park, an ice cream run to Hartzler’s Dairy, a colloquium with a four-person AMRE alumni panel, and a networking lunch. Dr. Ramsay looks forward to returning to full-time teaching this fall.

Pamela Pierce, Professor of Mathematics

TEACHING
First Year Seminar “Tough Choices”
Multivariate Calculus (x 3)
Tutorial in Functional Analysis
Transition to Advanced Mathematics
Real Analysis I
3 Senior Independent Study advisees

With Dr. Bowen, Dr. Pierce co-organized a session at the Joint Meetings of the AMS/MAA in January 2018. The session (Incorporating Mathematical Themes into a First Year Seminar) gathered a lot of interest, and they are planning to co-edit a volume for the MAA book series on this theme. Dr. Pierce presented “Decisions, Decisions: Incorporating Mathematics into a First Year Seminar” at the same session.
Drew Pasteur, Associate Professor of Mathematics

**TEACHING**
- First Year Seminar “Amateur Athletics Then and Now”
- Differential Equations
- Math Modeling
- Problem Seminar
- 7 Senior Independent Study advisees

Dr. Pasteur published a research article with three recent alumni co-authors (Emily Howerton ’17, Preston Pozderac ’17, Stuart Young ’17) titled “A Flight-Based Metric for Evaluation of NFL Punters” in the *Journal of Sports Analytics*. Also, he is serving as chair of the newly-founded Sports SIGMAA, a special-interest group within the Mathematical Association of America, which deals with sports analytics research and related applications in the classroom.

Marian Frazier, Assistant Professor of Mathematics

**TEACHING**
- Calculus & Analytic Geometry I (x 2)
- Probability & Statistics I
- Basic Statistics (x 2)
- 4 Senior Independent Study advisees

This year we welcomed Marian Frazier to the Department. She earned her B.A. from Kenyon College and M.S. and Ph.D. from The Ohio State University. She taught at Gustavus Adolphus College in Minnesota before coming to Wooster. She is particularly interested in improving upon existing sequential design techniques used on non-stationary surfaces, or data with non-stationary qualities. Her research focuses on achieving an accurate global fit of such surfaces. She also has an interest in statistics education research and curricular design.

Ronda Kirsch, Math Center Coordinator and Instructor

**TEACHING**
- Calculus with Algebra I (x 3)

Ms. Kirsch was excited to be selected as a reader for the Advanced Placement Calculus Exam and traveled to Salt Lake City in June to do so. On campus, she taught the math component of the Youngstown Early Intervention Program.
Denise Byrnes, Associate Professor of Computer Science

**TEACHING**

Computer Graphics
Theory of Computation
Data Structures & Algorithms (x 2)
Algorithm Analysis
Virtual Reality Computing & Technology tutorial
2 Senior Independent Study advisees

Dr. Byrnes had two senior I.S. advisees who had papers accepted at the Proceedings of the 2017 Midstates Conference on Undergraduate Research in Computer Science and Mathematics. One of these received the Best Paper award. One I.S. advisee, Avi Vajpeyi (CS and Physics), presented his senior research at the National Meeting of the American Physical Society in Los Angeles.

Sofia Visa, Associate Professor of Computer Science

**TEACHING**

First Year Seminar “Computers: A Blessing or a Curse?”
Scientific Computing
Data Structures Lab
Computer Networking & Communication
5 Senior Independent Study advisees

In summer 2018, Professor Visa worked for eight weeks with CS students Erika Goetz and Angelo Williams on a bioinformatics project. Briefly, they used Lumpy and their own Python scripts to identify structural variants such as inversions, deletions, and insertions in 254 tomato fruit genomes. In October, assisted by CS students Thuy Dinh and Hieu Tran, she offered a 2-day workshop on programming with Ozobots to 50 4th grade students at the Melrose Elementary.

Nathan Sommer, Assistant Professor of Computer Science

**TEACHING**

Imperative Problem Solving (x 2)
Data Structures Lab
Software Engineering-Databases
Principles of Computer Organization
Problem Seminar
4 Senior Independent Study advisees

Professor Sommer’s students in his Problem Seminar competed in the ACM ICPC East Central North America Regional Contest at Youngstown State University.
Robert Kelvey, Visiting Assistant Professor of Mathematics

**TEACHING**
- Calculus & Analytic Geometry II (x 4)
- Introduction to Topology
- Abstract Algebra II
- 4 Senior Independent Study advisees

Dr. Kelvey and Dr. Bowen team taught a second course in abstract algebra. He advised three teams in the CoMap Math Modeling Competition. He is faculty advisor for Wooster’s chapter of Pi Mu Epsilon, the mathematics honorary society, and advisor to the Math Club. Dr. Kelvey served as a judge at the undergraduate poster session at the Joint Math Meetings in San Diego. In June, he participated in the Washington DC Inquiry Based Learning Workshop sponsored by the Academy of Inquiry Based Learning.

Nathan Fox, Visiting Assistant Professor of Mathematics & Computer Science

**TEACHING**
- Calculus & Analytic Geometry I (x 2)
- Multimedia Computing
- Combinatorics & Graph Theory
- Scientific Computing
- 3 Senior Independent Study advisees

Dr. Fox came to Wooster fresh out of graduate school at Rutgers University. His research area is combinatorics; specifically, problems relating to integer sequences. Dr. Fox is working to develop a replacement for the Jython Environment for Students (JES) platform, traditionally used in CSCI 102 Multimedia Computing. In the Spring, Dr. Fox had a Sophomore Research Assistant, Hieu Tran, working with him on the project. The codebase can be found at [https://github.com/nhf216/cs102-wooster](https://github.com/nhf216/cs102-wooster). This version will be used in the upcoming fall semester.
The American Statistical Association (ASA) DataFest is a celebration of data in which teams of undergraduates work around the clock to find and share meaning in a large, rich, and complex data set. With support from an APEX mini-grant, AMRE, and the Math & CS department, Dr. Pasteur took ten students to this event at Miami University’s Center for Analytics and Data Science on April 6-8, 2018. The size of the data set (17 million rows) was much larger than many students had ever worked with, making it challenging to handle.

The Miami contest involved each team giving a six-minute oral presentation to a group of judges from academia and industry, followed by brief questioning from the judges. With about 35 teams presenting, the two highest-ranked teams in each room moved on to a final round later in the day, with all of the corporate representatives (most of whom were professional data scientists themselves) determining the winners. While neither of the Wooster teams were among the eight finalists, feedback from judges was quite positive, leaving the impression that both narrowly missed making the cut. Throughout the weekend, our students earned the respect of the organizers, some of whom had been initially skeptical about liberal arts college students’ ability to hold their own.
Maxwell Taylor, Math & CS ’18, *The Use and Creation of Concurrency Primitives Conducive to Parallel Architectures*

Avi Vajpeyi, CS & Physics ’18, Denise Byrnes and John Lindner, *Chaotic Scattering in Hill and Valley Systems*

Two teams participated in the ACM ICPC East Central North America Regional Contest at Youngstown State University. The contest consisted of 10 programming problems, and teams were to solve as many problems as possible over the course of 5 hours. Wooster Gold (Jemal Jemal, Junzhe Liang, Hieu Tran) solved two of the problems, and Wooster Black (Khoa Nguyen, Thomas Matlak, Mijiti Mierkamili) solved one.

**MCM**: The Mathematical Contest in Modeling

**ICM**: The Interdisciplinary Contest in Modeling

**MCM Successful Participant:** Team of Will Koenig, Daniel Manfrediz, and Aedan Pettit
Team of Vedica Jha, Giorgio Tramonto, Salim Dohri
Team of Thuy Dinh, Hieu Tran, Tam Nguyen

**ICM Honorable Mention:** Team of Shiwani Varal, Haidar Esseili, Hwan Bae

**ICM Successful Participant:** Team of Isaac Weiss, Mijiti Mierkamili, Morgan Thompson
Team of Wan Hang Hui, Maya Lapp, Jordan Kirsch

**Game Jam I**

CS majors Avi Vajpeyi and Joe MacInnes to organized Wooster’s first Game Jam, in conjunction with Ludum Dare, one of the world’s largest and longest running game jam events. Six teams went the distance and completed games. The finishers included the team of Vajpeyi, MacInness, Thomas Matlak, and Alex Iudice ’17, who created a turn-based driving game they dubbed Time Turner. At the end of the weekend they submitted it for play and rating by the Ludum Dare community.
Western Reserve Group

Analyzing Causes of Personal Auto Premium Changes

Student Team: Tianyi Cai, Tammy Dinh, Jordan Kirsch, Margaret Odero

Advised by: Jennifer Bowen and Nathan Fox (Mathematics)

A local insurance company performed a rate revision, and some customer segments experienced unexpectedly large changes in their premiums. The AMRE team was given a set of data, which they then cleaned and analyzed. The team clustered the data into customer segments with similar characteristics and determined which segment was most affected by the rate revision. They also identified the factors that caused the most change in this revision, and analyzed the profitability of these customer segments. They used the techniques: k-means Clustering, Gower's distance, Partitioning Around Medoids (PAM), Boruta feature selection, and Random Forest. The team presented their findings to the company for further analysis and decision making.

Progressive Insurance

Line of Business Decision Making

Student Team: Christian Betre, Eric Gabriel, Major Kadonzvo, Callie Ogland-Hand

Advised by: Rob Kelvey and Marian Frazier (Mathematics)

This Fortune 500 insurance company wanted the AMRE team to explore a specific market. The AMRE team was given three data sets to clean and analyze in order to answer the company's questions. The team additionally conducted research independent of the data. Some findings include non-trivial differences between customer groups and numerous pros and cons of investing in this business. Analysis methods included; Decision Trees, Clustering, Logistic and Linear Regressions, Statistical Summaries, Frequency Tables, Choropleths (Geographical Heatmaps), and Cost-Benefit Analysis.
AMRE
APPLIED METHODS & RESEARCH EXPERIENCE
2018 PROJECTS

Pure Math Research

Knot and Links on the Klein Bottle
Student Team:  Henry Potts-Rubin and Isaac Weiss
Advised by:  Jennifer Bowen and Rob Kelvey (Mathematics)

This project was an evolution of previous AMRE work that looked into knots and links on the Klein bottle. We expanded this research by studying links on the real projective plane (RP2), something that had not been previously explored. Our main results include the discovery of equivalencies between certain classes of RP2 links, as well as some generic braid words.

The College of Wooster Experiential Learning

APEX Application System
Student Team:  Miquilina Anagbah, Jemal Jemal, Katie Reese, Scott Stoudt
Advised by:  Cathy McConnell (APEX) and Nathan Sommer (Computer Science)

The purpose of this project was to understand the problems of the APEX Fellowship application system and design and implement a system that was streamlined and simplified for both APEX EL and students as well. The team carried out research and the final proposed product was Formstack (an online form-builder that is easily customizable and user-friendly), together with a PDF Merger web application (developed by the computer programmers on the team). This web application allows APEX EL to easily generate master PDFs of all the submitted applicant’s information and documents for review by external officers. The team conducted evaluation on the Fellowship application by sending questionnaires to APEX fellows and some faculty to identify redundant steps and reduce the complexity of the process.

This research culminated in two papers which will be submitted for publication and two presentations at MAA MathFest in Denver in August. Both Isaac and Henry won Pi Mu Epsilon Speaker Awards at MathFest for their presentations of this research.
Geology Tree Ring

Using Tree Rings to Date Historical Structures and Extract Climate Information from Old Growth Forests

Student Team: Kendra Devereux, Alexis Lanier, Juwan Shabazz
Advised by: Greg Wiles and Nick Wiesenber (Earth Sciences)

This AMRE project was a unique addition to the program as it was the first time that AMRE worked in collaboration with the Earth Sciences Department. The team used data collected from living trees to update local chronologies and date historical structures. Throughout the course of the program, they worked with a multitude of clients, including David Burke of Holden Arboretum and Ray Leisy, project manager of Sonnenberg village. The team primarily focused on coring living trees and measuring their ring widths in order to update living tree chronologies and analyze past climate data throughout northeast Ohio. Throughout the program, the team interpreted their data to compose multiple reports for their clients and will present their findings at a nationwide geological conference in the fall.
Adaptive Sports Program of Ohio

Identifying future resources for funding and creating a strategic plan for the advancement of the sports program to reduce health inequity and disparities among individuals with disabilities

Student Team: Jordan Griffith and Annabelle Hopkins
Advised by: Angie Bos (APEX, Political Science)

In year two of the AMRE social science focuses project, the Adaptive Sports of Ohio (ASPO) team was one of three teams that researched topics related to social science. For this project, the team was tasked with finding policy solutions for ASPO that would provide their organization with additional public funding options that would allow them to scale up their programming across the state. As part of this project, the Team looked into a variety of state laws and funding sources that ASPO could use to get more funding. The biggest source the team looked into was Ohio Revised Code 4511.69 that allows for fifty percent of the fine paid for parking in a handicapped spot to be redistributed to organizations and public entities that would assist citizens with disabilities. The team then looked to use this law statewide to funnel the funds generated to ASPO. The team assembled a database of Ohio municipal courts, cold called the different courts, and generated a report of how much revenue could be gathered from a change in the law. The team also looked into other funding sources from the Ohio Lottery Fund, the BMV, and the Ohio Department of Education. The team then presented a comprehensive report on funding sources to Senator Frank LaRose and Representative Scott Wiggam. By the end of their time working for AMRE, this team constructed an official report, containing a recommendation that ASPO receive a line item in the Ohio biannual budget.
Community Re-entry Program (Collaboration of several entities including NAACP, WEDC, Fund for Our Economic Future, and Behind Bars and Beyond)

Workforce Re-Entry

Student Team: Mary (“Emma”) Cotter and Halen Gifford
Advised by: Nate Addington (CDI’s Office of Civic and Social Responsibility) and Cameron Maneese (Former Director of Wayne County Family and Children First Council)

The 2018 AMRE Workforce Reentry Team was one of three social science projects completed this year. They looked into workforce reentry after a period of incarceration in Wayne County, Ohio. The Workforce Reentry Team had a number of different community clients: The Wooster/Orrville NAACP, The Noble Foundation, The Wayne Economic Development Council, The Fund for Our Economic Future, The College of Wooster’s Office of Civic and Social Responsibility, and Behind Bars and Beyond. The need for this project came out of the low unemployment rate in Wayne County (3.1%) which makes it difficult for employers to find employees, and the perceived unemployability of those who have returned to the community following a period of incarceration. The Team endeavored to meet a number of different deliverables, including completing case studies on other reentry systems in other Ohio counties, studying supportive employment models, researching The College of Wooster’s hiring policies, gathering returning citizen interviews, and generating a database of employers in Wayne County who will hire returning citizens.

In regard to the database, the Workforce Reentry Team cold-called over 400 businesses and were able to identify 60 businesses that will hire returning citizens in Wayne County. The Team successfully completed each of these deliverables and presented them at two final presentations open to the community, the first of which had over 70 attendees.
Goodwill Industries

The Search for a Profitable and Long-term Solution to Goodwill’s Excess Textile Salvage: A Market Analysis of Future Strategic Partnerships

Student Team: Gio Tramonto and Kiera Parker-Emerson
Advised by: Brooke Krause (Economics)

The goal of our AMRE project was to find alternative solutions to best repurpose secondhand clothes or garments (textiles) for four North-East Ohio Goodwill Thrift stores. Currently, around 20% of the donations given to Goodwill are not sold and then these donations are packaged and sold overseas to vendors. Due to international markets closing their boarders to secondhand textiles, Goodwill’s revenue stream from their left over donations, called salvage sales, was at risk. The AMRE team was given four data sets on Goodwill’s past unsold donations and a list of priorities for conducting future business. The final result was a two-pronged solution that included a short, and long-term plan. In the short-term, 3-5 years, Goodwill would partner with larger organizations to increase the global diversity of their overseas buyers. As the time passes, Goodwill will stay up to date with new companies that are reusing and recycling excess clothes across various industries, using organizational databases. In the long term, Goodwill will look to partner with a technology company that is able to take secondhand textiles at scale, break them down to the molecular fiber level, and build them back up into virgin fiber to be sold to large textile manufactures and brands.
ProMytheUS

Creating a Culture of Talent

Student Team: Ibrahim Abdullah, Jacob Abramo, Alex Huang, Phillip Wells
Advised by: Peter Abramo (Entrepreneurship) and Marina Rosales (APEX)

The ProMytheUs project team worked with a startup company that uses artificial intelligence (AI) and data systems to identify, grade, map and market “Human Talent” across a wide range of career fields and organizational needs. The AMRE student consultants worked in two general areas: marketing and technical product development. The students performed market research on talent indicators, contacted schools, businesses and non-profit organization in the region to market the product, and assisted with preparing a pitch and connecting to investors for fund-raising. The team also worked on updating the website, performed data analytics, and explored user interface design options.

AMRE Lunch on President Bolton’s Patio