Hello! Thanks for reading the second annual department newsletter. A quick glimpse on Wooster’s website indicates that we have recently been named the Premier College for Mentored Undergraduate Research, and we are very proud of this distinction. It seems appropriate, then, to highlight the increasing number of student research projects that keep our department busy throughout the year. The AMRE program is growing and thriving, and this continues to provide summer research opportunities for many of our majors. In October of 2010, Professors Bowen, Pasteur, and Ramsay took five students to Wittenberg University to present research completed over the summer of 2010. Professors Pasteur and David, together with their students, had several publications and conference presentations stemming from their exciting work in Sports Prediction using Artificial Neural Networks. This spring, Professor Visa took five students to the Midwest Artificial Intelligence and Cognitive Science Conference, where students shared their research results with experts in the field. Of course, there is a lot more research going on, because 23 seniors all completed I.S. projects in a variety of areas. Congratulations to all of our seniors!

We recently bid farewell to John David, who completed a two-year post-doctoral position in the department and has accepted a job at Virginia Military Institute. We wish him well in his new position. Jon Breitenbucher is also leaving the department, as he has accepted a full-time position in the Instructional Technology Department at Wooster. Happily, he remains in Taylor Hall, so we can still seek him out for help and advice with innovative teaching technologies. This fall we are happy to welcome visiting instructor Ronda Kirsch and computer science intern Peggy Winkler ’06 to the department.

One of our goals for this year is to begin keeping an accurate database of our alums and what they are doing, so if you fall into that category please drop us a line and stay integrated with the department😊 ~Pam Pierce (PPierce@Wooster.edu)
In addition to her teaching and chair duties, Professor Pierce served on the College’s Financial Advisory Committee, Health Benefits Advisory Committee, Controller Search Committee, Ad Hoc Committee on Faculty Salaries, and the Department of Education Internal Advisory Board. She was also a referee/reviewer for the *College Mathematics Journal* and the *Real Analysis Exchange*, and served as a consultant/mentor for the MAA’s Project NExT, a professional development program for junior faculty in mathematics. Her students in Real Analysis II held their very own “Lebesgue Conference” and presented projects pertaining to the work of French mathematician Henri Léon Lebesgue. In June, Professor Pierce attended the Summer Symposium in Real Analysis XXXV (“The Symposium on the Danube”) at the Alfréd Rényi Mathematical Institute in Budapest, Hungary.

Professor Ramsay is director of the College’s Applied Mathematics and Research Experience which this past summer employed a record 25 students working on 10 projects. Throughout the year, he served on the Bringing Theory to Practice Task Force. This task force is putting together the foundation for a “robust” experiential learning program at The College of Wooster. He was also a board member for the Center for Entrepreneurship and the College Faculty Athletics Representative to the NCAA. Last fall, Dr. Ramsay, along with Dr. Pasteur, Dr. Bowen, and five of their students, attended the MidStates Conference for Undergraduate Research in Computer Science and Mathematics at Wittenberg University where they presented two papers (see MCURCSM 2010).
Professor Hartman continued his involvement with College Board activities in the area of Advanced Placement. In addition to being a BC exam leader, he conducted teacher training workshops in Livonia, MI and at Triton College. He was also an instructor at Wooster’s AP Summer Institute. Dr. Hartman co-authored the article “Preservers of Eigenvalue Inclusion Sets” with Aaron Herman and Chi-Kwong Li, Linear Algebra and Its Applications, Volume 433, Issue 5, October 2010, pp. 1030-1051. He was an invited speaker at Oberlin College where he gave the talk “Powers of Magic Matrices”. He was also an invited speaker at Columbus City Schools’ 7th Annual AP Calculus Tournament. On campus, he served on the College’s Financial Advisory Committee. He attended the National AMS/MAA Joint Meeting in New Orleans and served as a judge at the undergraduate poster session.

Professor David had the following publications appear this past year:

- J. David, J., D. Pasteur, M. Janning*, S. Mohammed*, NFL Game Winner Prediction through the use of Artificial Neural Networks, Journal for Quantitative Analysis in Sports: Vol. 7: Iss. 2, Article 9, 2011
- J. David, H. Tran, H.T. Banks, Receding Horizon Control of HIV accepted for publication and available online in Optimal Control, Applications and Methods, October 2010
- Robert L.V. Taylor*, (advised by J. David), Strange and Chaotic Attractors, SIAM Undergraduate Research Online Volume 4, June 2011

*undergraduate co-authors

He gave presentations at the Future Directions in Applied Mathematics Workshop in Raleigh, NC, at the National AMS/MAA Joint Meeting in New Orleans, at the Northern California Symposium on Statistics and Operations Research in Sports in Menlo Park CA, and the SIAM Annual Meeting and Life Science Conference in San Francisco. Two of his students, Bridget Kraynik and Saif Ahmad, presented their work at the MAA Ohio Sectional Meeting in Youngstown, OH.

Dr. David has accepted a position at the Virginia Military Institute, Department of Mathematics, beginning Fall 2011. We have immensely enjoyed having him (and his sense of humor!) with us for the past two years and wish him all the best.
Professor Pasteur taught First Year Seminar for the first time last fall semester. His section was entitled “A Town, A Team, and a Dream: High School Athletics and Small-Town America”. With support from the institutional HHMI grant he developed and taught (with Stephanie Strand of the Biology Department) a new course, Introduction to Mathematical Biology, which enrolled 38 students.

At the Northern California Symposium on Statistics & Operations Research in Sports in Menlo Park, CA, Dr. Pasteur presented “NFL Prediction Using Neural Networks” (presented jointly with John David) and “Monte Carlo Simulation for High School Football Playoff Seed Projection”. He attended the Midstates Conference for Undergraduate Research in Computer Science and Mathematics (MCURCSM) at Wittenberg University where two of his students presented a paper. He also went to the Ohio MAA spring sectional meeting in Youngstown where three of his research students (two senior I.S., one summer research) gave talks and he chaired a contributed paper session (see Ohio MAA).

In addition to the article that Dr. Pasteur published with Dr. David on NFL rankings, he also co-authored the following article with his 2010 summer research student:


On campus, Dr. Pasteur served as chair of the Library, Information Resources and Technology Committee and was a steering committee member of the Junior Faculty Caucus. He was faculty advisor for two teams of students in the international Mathematical Contest in Modeling / Interdisciplinary Contest in Modeling. He was faculty advisor for the Wooster Christian Fellowship. He and his wife Heather sang a beautiful and much appreciated rendition of the national anthem at several Wooster Scots basketball games.

As a result of a grant from the President’s Office Hewlett Mellon Funds, Professor Bowen and Angie Bos (Political Science) convened the Quantitative Literacy Faculty Learning Community this past fall. She served on the Educational Policy Committee and was Faculty President for Phi Beta Kappa. She also served on the MAA National Committee for Early Career Mathematicians.

She was a reviewer and editor for Rogawski’s *Calculus* Solutions Manual. At the Joint AMS/MAA meeting in New Orleans, she gave the invited presentation “Centroids of Jordan Superalgebras over Superscalars.” She also accompanied students to the Ohio MAA Section Meeting at Youngstown State and the Midstates Conference for Undergraduate Research at Wittenberg University (see Ohio MAA and MCURCSM 2010). Dr. Roche, along with Dr. Mary Jo Kreuzman, rewrote the mathematics placement exam given to incoming students. She served as faculty advisor to the Ultimate Frisbee Club and conducted a workshop in mathematics for the Expanding Your Horizons program for middle school girls. This summer she was a “Mathematician in Residence” at Carleton College and an AP Calculus reader.
Professor Visa taught First Year Seminar for the first time last fall semester and her section was entitled “Computers changing the world we live in – my refrigerator talks to my microwave”. She was co-organizer of the Midwest Artificial Intelligence and Cognitive Science Conference in Cincinnati. Nine students from her Machine Intelligence course were co-authors of papers presented at this conference (see MAICSC 2011). Dr. Visa presented two papers at the 3rd International Conference on Future Computer and Communication in Iasi, Romania:

S. Visa, M. Ionescu, A. Ralescu “Edge Coincidence Based Technique for Image Segmentation”

*student co-author

Professor Byrnes also attended the Midwest Artificial Intelligence and Cognitive Science Conference in Cincinnati and served as a councilor for CUR’s (Council on Undergraduate Research) division of Mathematics and Computer Science. Dr. Byrnes was the lead representative for the computer science 10-year self study and the curricular redesign of computer science offerings. She also worked on populating the computer science program’s new curricular matrix with assessment measures. On campus, she served on the Classroom Stewards Committee and on the Assessment Committee. This past summer, she was advisor for two AMRE projects (see AMRE 2011).

Dr. Visa attended the Virtualization Workshop at Oberlin College and the Annual Tomato Fruit Shape Research Meeting at the OARDC in Wooster as part of her continuing collaboration with the NSF research group there.

This past summer, Dr. Visa did HHMI-funded bioinformatics research with Tristan Vrolijk ’12, Matthew Lambert ’13, and Stephanie Strand (Biology). The project involved a genomic comparison of two strains of the fungus Histoplasma Capsulatum.
In addition to teaching mathematics courses, Dr. Breitenbucher administered the College's Moodle and WordPress Multisite installations. He also wrote a couple of WordPress plugins for Jacob Dinkelaker's IS project (Archaeology/History) which was the first completely digital IS and developed themes for The Wooster Voice and SGA.

MARY JO KREUZMAN
Visiting Assistant Professor of Mathematics
BS Xavier 1980
MA, PhD Notre Dame 1982, 1985

Courses taught 2010-11
Calculus for the Social Sciences
Calculus I (2 sections)

SCOTT MEECH
Adjunct Teaching Staff
BA Wooster 1995
MS Akron 2001

Courses taught 2010-11
Math in Contemporary Society (2 sections)

JACKIE MIDDLETON
Administrative Coordinator

LINDA BARBU
Math Center Coordinator
BS Univ of Findlay 1971
MAT The College of Wooster 1975
Bertolt Brecht and David Hilbert: A Connection through Formalism

Abstract: This thesis establishes the connection between mathematical and literary formalism by examining the works of the mathematician David Hilbert and the playwright Bertolt Brecht. Specifically, this involves the discussion of Brecht’s *Threepenny Opera* (and his theory on theater) and Hilbert’s theory on Hilbert Spaces.

Fish On: A Study of Nonlinear Elasticity and Tensors

Abstract: It is the purpose of this paper to explore how the theory of nonlinear elasticity can describe the deformation of a fishing rod under constant tip force. The mathematical foundation upon which this stands involves a study of tensor calculus. Tensor calculus forms the basis for the material on elasticity. Elasticity is the study of elastic materials, which can be described as any material that returns to its original shape after all external forces have been released. A nonlinear theory differs from a linear theory by allowing for large deformations in the object. We do not therefore make small angle approximations as would occur in linear theory.

For a linear theory the outputs follow directly from the inputs but nonlinear theories lack this direct relationship. Therefore nonlinear theories are inherently more difficult to solve and evaluate. This sacrifice is necessary for it allows us to form a more accurate study of the material. My particular study uses a nonlinear theory of elasticity to model the deformation of an elastic beam with uniform width. To do this I start by forming a study of tensors so that when the study of nonlinear elasticity is introduced, there is a firm basis from which to start.
**Going Inside the Rubik’s Cube**

Abstract: The mathematics behind the Rubik’s Cube can be broken down into different sections of permutations, groups of rigid motion, order, subgroups, congruency and cosets, normal subgroups, and finally isomorphisms and homomorphisms. First I explored each of these topics and then I applied them to the Rubik’s Cube. While doing this, I gave examples and illustrated how this worked in order to give the reader a visual and to help them better understand the concepts.

**XIAORU BAO**
Mathematics
Advised by John Ramsay

**The Derivation of the Black-Scholes Model and Its Application in Hedging**

Abstract: A financial derivative is a financial instrument that offers a return based on the return from another financial asset. In today’s financial market, financial derivatives play a very important role by helping investors to control and hedge risk. However, the pricing of financial derivatives has been a tough task for many years, especially for options. The value of an option to buy or sell a share depends on the uncertain price movement from the underlying stock, which is beyond the demand and supply of the option itself.

Fisher Black and Myron Scholes (1973) discovered a differential equation that prices European options. The discovery shocked the world and ultimately resulted in a Nobel Prize. In contrast to some traditional pricing formulas that emphasize premium, the Black and Scholes model transformed the option pricing problem into the task of solving a partial differential equation. The main idea is to construct a riskless portfolio consisting of cash, option, and the underlying stock. This technique is widely used in the analysis of other derivative securities such as loans, preferred stocks, and structured debts that depend on the return of other securities as the way that options depend on underlying stocks. In this paper, we focus on deriving the Black-Scholes model and its application in the delta hedging strategy. We start with the introduction of option and the efficient market hypothesis. Then we introduce the Wiener process and Ito’s lemma, which are background knowledge for deriving the model. Then, we construct a riskless portfolio and derive the Black-Scholes differential equation. In contrast to the “heat function” that Black and Scholes used, we choose to solve the Black Scholes differential equation based on a probability distribution function. The last section extends the derivation of the model to the use of a delta hedging strategy.
ANNE SOMERS
Mathematics

Paradox

Abstract: We explore nine different mathematical paradoxes. For each paradox we determine what makes it a paradox, the mathematics behind it, and any possible solutions. The paradoxes cover various branches of mathematics, including calculus, game theory, set theory, probability, geometry, and mathematical logic.

PAMELA WALES
Mathematics & Chemistry
Advised by R. Drew Pasteur (Mathematics) and Karl Feierabend (Chemistry)

Exploring the Effects of Initial Conditions on the Kinetics of the Decomposition of Dichloroacetic Acid through a Hydrogen Peroxide and Ultraviolet Radiation Oxidation Process

Abstract: Dichloroacetic acid (DCA) and other chlorination disinfectant byproducts are water contaminants that have grown to be a public health concern due to their potential carcinogenic effects. As a result, advanced oxidation techniques, which enable the complete mineralization of the pollutant, are being developed to treat DCA and other contaminants. Consequently, kinetic studies are needed to better understand and improve these decomposition techniques. Past kinetic studies of one advanced oxidation technique, which utilizes the ultraviolet irradiation of hydrogen peroxide, have proposed a mechanism and related rate constant for the decomposition of DCA. However, these studies did not thoroughly explore the effect of initial pH and DCA concentration on the kinetics of the system. To test the effects of changes in these conditions, a merry-go-round photoreactor was used to conduct each photodecomposition reaction while high performance liquid chromatography and UV-visible spectroscopic methods were used to monitor the respective changes in concentrations of DCA and H₂O₂ as the reactions proceeded. Using the acquired experimental information, a system of differential equations, which was established by Zalazar et al., was solved in MATLAB to determine kinetic constants for each set of initial conditions. Attempts to mathematically model the kinetic constants with respect to their initial conditions using an artificial neural network provided inclusive results. However, the general trend of the calculated kinetic parameters implies that as the initial [DCA] increases, the initial rate of reaction and the rate constants increase except when the initial pH of the system is over 8.

DEREK WYMAN
Mathematics (Education minor)
Advised by Pamela Pierce

The Impact of Calculators on Students’ Test Scores

Abstract: I administered the Stanford Achievement Test to a group of 7th grade students. There were 120 students enrolled in 7th grade at the time, 72 males and 48 females. Most of the students’ ethnic background was white, but there were also African-American and Asian. There were eight students who had learning diversities, such as emotional disturbance, hearing impairment, or specific learning disabilities. Also, there were 13 students identified as English as second language learners. The school was in a rural setting and a majority of the students came from low-income households. The students were given the mathematics portion of the test on two separate occasions. Initially, they took the tests without a calculator, and the second time they were able to use one. The goal of this study was to determine how much of a difference the calculator made in test scores. Additionally, I interpreted the data that I have collected through analysis of the scores of specific problems. Following the analysis, I made inferences about the possible reasons for the scores on these problems by making conjectures about how effectively the students utilized the calculator.
ITAI NJANJI
Mathematics & Computer Science
Advised by Denise Byrnes (Computer Science) and John Ramsay (Mathematics)

Exploring the Branch-and-Cut Algorithm
Abstract: Integer Linear Programming has been a growing area of study since the development of modern economies. This project explores the Branch-and-Cut algorithm, one of the methods used to solve large Integer Linear Programming problems. The Simplex method and the Dual Simplex method, the basic computational machines in the Branch-and-Cut algorithm, are discussed. The Branch-and-Bound algorithm and the Cutting Plane algorithm that form the Branch-and-Cut algorithm are also explored. In addition, Gomory’s Finiteness proof for the Cutting Plane is outlined. Parallel computing using MATLAB is investigated. Shared memory parallel computing, distributed memory parallel computing, and computer classifications are some of the main concepts of parallel computing that are explored. A Parallel Branch-and-Bound algorithm is implemented in MATLAB. The performance of a parallel Branch-and-Bound algorithm is compared to that of a sequential Branch-and-Bound algorithm and the results are recorded.

LOGAN GARRITY
Mathematics & English
Advised by Pamela Pierce (Mathematics) and Debra Shostak (English)

Infinity
Abstract: I am a twenty-two year old college senior. This is my IS. This is math I have researched and stories that I have written at this point in my life. I am not trying to capture any universal truths. All I know is that I like math and I like stories. This IS attempts to bring them together. I have specifically chosen to focus on the topics of infinity and college aged male ennui. Mathematically, I work through some of what it means to be infinite, as well as go into discussions of the problems we face when dealing with this topic. That is, I write about some of the paradoxes that arise when looking at infinity. My stories are all informed by the mathematical concepts that I have researched. From a content perspective, they deal primarily with a world very similar to my own.

SEAN TWINING
Mathematics
Advised by John Ramsay

Printed Circuit Board Layout Optimization
Abstract: Printed Circuit Boards are a piece of technology that will never become obsolete. They are the building block for almost all technology being developed today. Therefore, it is important to try to make these Printed Circuit Boards as efficient as possible considering the growing complexity of technology. This IS focuses on a few different techniques that can be used to work on making Printed Circuit Boards more efficient and applicable for new age technology.
WENYUAN WU
Mathematics & Economics
Advised by James Hartman (Mathematics) and Lisa Verdon (Economics)

Bayesian Statistics: An Alternative Method to Insurance Pricing Practice
Abstract: This independent study explores how asymmetric information shapes the insurance market and its pricing practice. I investigate the market equilibrium with the existence of asymmetric information and discuss how economists analyze insurance pricing with linear regression models. However, I argue that Bayesian statistics is a better alternative to analyzing insurance pricing. In order to test for this hypothesis, I compare the premium forecast accuracy between simple linear pricing models and Bayesian pricing models. My result shows that Bayesian’s prediction on premium is closer to what the insurance company charges. Moreover, the accuracy increases as more Bayesian updates are employed. As a result, I conclude that the Bayesian method for insurance pricing is superior to the simple linear regression approach. I also suggest that economists should adopt Bayesian statistics in the study of insurance pricing.

JACOB HANING
Mathematics
Advised by Jennifer Bowen

The Interpretation of Homology Groups
Abstract: The concepts involved with this topic stem from some more general areas of mathematics. Homology groups are a unique mesh between fundamental concepts of abstract algebra and some essential ideas from topology. More specifically, from abstract algebra we will review or perhaps introduce such things as binary operations, homomorphisms, and groups. With topology, we will begin to better understand such notions as equivalent topological spaces and what it means to mathematically define geometrical observations for a graph. The tools discussed will allow us to understand a new kind of algebra used when dealing with homologies. It is described as chain algebra and it is the key to the manipulation and mathematical understanding of homology groups. The motivation for exploring these subjects has come from a fascination with this topic that evolved from a research paper in an undergraduate abstract algebra course.
PRACHI SARAOGI
Mathematics & Economics
Advised by Drew Pasteur (Mathematics) & James Warner (Economics)


Abstract: This study hypothesizes that lack of financial literacy, irregular and insufficient income, high transportation costs and excessive social capital (financial access) constrains the efficiency of a household’s portfolio. Various geometric representation of portfolio theory exhibits the impact financial access has upon the optimal portfolio. Especially, in the case of low-income households, along with the financial access constraints there exists other exogenous factors that make their portfolio risky. Thus there is a stronger need to provide a secure portfolio that can battle the variance in income and unforeseen circumstances. Via empirical analysis of financial diaries of households in South Africa, we find that education level, belonging to the male gender, and transportation cost all have significant impacts on the household’s portfolio allocation.

HANNAH KURTZ
Mathematics
Advised by Drew Pasteur

An Introduction to Game Theory and its Application to Biology

Abstract: This thesis presents an introduction to game theory and how it can be applied to biology. Presented is a brief history of how game theory arose as a branch of mathematics and how it became widely used within other areas such as economics, psychology, and political science. The basics of game theoretic analysis are outlined with an explanation of the purpose of game theory and then an introduction of the key concepts and the most common two-person game scenarios and their respective solutions. How game theory can be applied to other disciplines with a focus on how it can apply to biology is described. The use of game theoretic analysis with a biological problem concerned with the survival of feral cats is demonstrated. Relevant information is presented regarding the biology and social system of the feral cat and the problem to be analyzed (optimal survival) is introduced. The structure of the model is presented, starting with the choices available to each player, their possible costs and benefits, and relevant assumptions. Payoffs are then calculated and analyzed to determine optimal strategies for each player. The conclusion discusses the significant findings of the model and outlines its limitations and possible options for further work.

DAVID SMALL
Computer Science & Philosophy
Advised by Denise Byrnes (Computer Science) and Garrett Thomson (Philosophy)

Understanding Sense: Word Sense Disambiguation

Abstract: Understanding is a feature characteristic of those capable of intelligence. This is demonstrated in the understanding of ambiguities that can occur in language. This thesis is a joint research venture into the philosophical and computer science aspects of strong artificial intelligence and its facilities for understanding. Philosophically, this thesis delves into the arguments for and against strong artificial intelligence, examining the a priori features needed to effect understanding in its fullest sense. Programmatically, a word sense disambiguation program, written in Python, is used to disambiguate “bank” in two senses (or classes): in terms of money and as a geographical water feature. This process of classification is achieved using the Naïve Bayes Classifier (from Python’s Natural Language Toolkit). The Naïve Bayes Classifier is based on Bayes’ Theorem.
JASON VAN HOUTEN
Mathematics & Biochemistry / Molecular Biology
Advised by Drew Pasteur (Mathematics) and Dean Fraga (BMB)

An Evolutionary Study of Multimeric Phosphagen Kinases Using Ancestral Protein Reconstruction and the Prediction of Phosphagen Kinase Substrate Specificity Using Artificial Neural Networks

Abstract: Phosphagen kinases (PKs) are found throughout all of the animal kingdom as well as some bacterial and protozoa species. They catalyze the reversible transfer of a high energy phosphory-group from ATP to a guanidino group on an acceptor molecule. PKs are known to play an important role in energy homeostasis by forming phosphorylated guanidine compounds, called phosphagens, to store high-energy phosphates that can be utilized to form ATP from ADP during periods that require a high level of energy. These enzymes can adopt two basic quaternary structures, monomeric and multimeric. Arginine kinases are the only PKs to fall in the monomeric category while the multimeric group consists of creatine, taurocyamine, hypotaurocyamine, glycocyamine, lombricine, and arginine kinases. A current proposed path of evolution for these PKs is that an ancestral monomeric arginine kinase evolved to form dimeric arginine kinases. These dimeric arginine kinases later developed into creatine kinases, which then gave rise to the other PKs. The aim of this study was to better elucidate the path of evolution of PKs by investigating substrate specificity of four theoretical ancestral dimeric PKs predicted by ancestral protein prediction software (ANCESCON). An additional aim of this study was to use artificial neural networking to recognize patterns in arginine kinases that may contribute to substrate specificity and create a model that could predict when a PK was an arginine kinase. The network was trained separately with inputs of three different amino acid properties (hydrophobe moment, isoelectric point, and molecular weight) at each amino acid position in the sequence. The networks were analyzed on the accuracy to predict whether or not a protein was an arginine kinase. Training with molecular weights of amino acids in the entire sequence illustrated the best accuracy of 88.64%. Also, by training the network with segments of 10 consecutive amino acids, regions that may better predict arginine specificity were identified. These results illustrate a proof of concept that neural networking may be used to predict substrate specificity in PKs.

DUSTIN EISELE
Mathematics & Psychology
Advised by Drew Pasteur (Mathematics) and Gary Gillund (Psychology)


Abstract: A common limitation of psychology and law is that psychologists are only able to examine a few variables at a time before the analysis becomes too complex. Research has shown that eyewitness testimony, DNA testimony, and expert testimony, as well as the race and gender of the plaintiff, defendant and juror all affect the outcome of a criminal case. But, the effects are not necessarily independent. This study involved 750 participants, each viewing a different combination of case information. To examine the interactions among the variables, a committee of artificial neural networks was used to make mock-juror guilt predictions, given a certain set of parameters. Minor differences in guilt predictions were seen when manipulating plaintiff, suspect, and juror composition, but evidence appears to be the key driver of guilt predictions.
Go with the Lava Flow

Abstract: This thesis investigates and produces a model for the simulation of a flow of basalt lava. The inherent properties of volcanoes and lava are examined first, with a focus on determining the critical aspects to model. Basalt lava is chosen for its properties and abundance in nature and the properties of heat transfer, viscosity, and particle flow are focused upon. The implementation for heat transfer uses the heat equation to determine temperature values at mesh points in a discretized space. Building upon the mechanics for heat transfer, a velocity implementation using a simple Navier-Stokes equation is added to facilitate the movement of the lava flow. Using these constructs as a base, a simple method for particle movement is constructed, based on Newton’s laws of motion. Simulations are run for each mechanism to test its validity, culminating in a simulation of spherical particles moving down a simulated hill in accordance to the temperature and velocity values over the area of simulation. This simulation represents a flow of basalt lava, moving across an area of space over time.

Boom! How the Human Population Explosion Affects Our Future

Abstract: Mathematics is an important tool for scientifically analyzing aspects of our daily lives. I focus my research on that of human population growth and how it will affect our world. I use mathematical models and real population data to analyze human population growth and incorporate factors such as development status, fertility and mortality rates, and age distribution. I first model how population growth affects resource usage and hypothesize how changes in oil consumption rates in the major consuming countries will affect the long-term usage of oil globally. Lastly I estimate how the changing age distribution with in the United States will affect the future of Social Security. I conclude with a summary of my results and stress the importance of using mathematics to gain a better understanding of the world around us.
Tighten Up: A Preliminary Study of Knots

Abstract: Knots are a common occurrence in everyday life, so common, in fact, that they are often taken for granted. Knots are able to make one string out of two, without any adhesive, simply by entangling the strings' ends in a certain way. Some weaker knots may slip, but strong knots will outlast the string, forcing the string to break before the knot slips. This thesis outlines the initial steps in creating a solid basis for studying knots, both mathematical and physical. The basics of the mathematical field of knot theory are explored. Two preliminary simulations modeling the motion of knots slipping are discussed; the first simulation uses Newtonian mechanics to describe the motion of the strings, while the second uses Lagrangian mechanics. Exploratory experiments studying the behavior of a knot tied with two pieces of perciatelli pasta are also examined. This study lays the groundwork for further research into the properties and benefits of mathematical and physical knots.

Selection Pressure on a Selfish Herd: Evolution of Ecological Relationships in an Agent-based Model

Abstract: This study investigates the role of the environment on the evolution of collective behavior by modeling an evolvable boid population (flocking, silicon-based birds). The underlying claim of this project is that the specific collective behaviors evolved by a population of boids is dependent on the particular set of environmental forces present in their habitat. Simulations support this claim by demonstrating differences in flocking tendencies as the sparsity of their primary energy source is varied. Furthermore, the model reveals an intriguing set of unanticipated emergent properties that may illustrate fundamental processes in the natural world.
Latin Honors

*Summa cum laude*
- Itai David Njanji

*Magna cum laude*
- Robert Leslie Vincent Taylor
- Wenyuan Wu

*Cum laude*
- Xiaorui Bao
- Hannah Jane Kurtz
- Joshua Ethan Thomas

Campus Council Leadership Award

- Dustin Christopher Eisele

Phi Beta Kappa

- Itai David Njanji
- Wenyuan Wu

Foster Prize in Mathematics

- Louisa Gabrielle Catalano

Whitney E. Stoneburner Memorial Prize in Education

- Derek Michael Wyman

Procter & Gamble Economics Prize

- Wenyuan Wu

William H. Wilson Prize in Mathematics

- Wenyuan Wu

Vivien Chan Prize in Interdisciplinary Sciences

- Jason M. Van Houten

The Endowed Faculty Scholarship

- Robert Leslie Vincent Taylor

Elizabeth Sidwell Wagner Prize in Mathematics & Computer Science

- Robert Leslie Vincent Taylor

Barry Goldwater Foundation Scholarship

- David Freund '13

Sophomore David Freund was honored by the Goldwater Foundation for excellence in mathematical and scientific research. David was chosen for his research in Knot Theory — the study of various properties of mathematical knots, which differ only slightly from the typical conceptualization of a knot. The objective of his research is to explore properties of Klein knots, a new type of knot.

“When I found out I won the award I was thrilled because I know how selective the program is,” said Freund. “Wooster has given me the opportunity to challenge myself mathematically, particularly through the Applied Mathematics and Research Experience during the summer. That’s when I began my preliminary investigation of Knot Theory.”

Pam Pierce, professor of mathematics at Wooster, commended Freund for his natural curiosity about deep mathematical questions. “David is an insightful problem-solver with a real passion for learning,” she said. “I am thrilled that he has been awarded a Goldwater Scholarship because he is clearly a talented and deserving student who shows exceptional promise in mathematics.” (excerpt and photo from CoW Office of Public Information)
A Preliminary Study of Klein Knots
Jennifer Bowen, John Ramsay, David Freund,* Louisa Catalano,* Rutendo Ruzvidzo*

A Non-elliptical Model for Steel Cord Cross-sections
Andrew M. Licking*, Kemar Reid*, R. Drew Pasteur, John R. Ramsay

BitTorrent-Enhanced Distributed Internet Caching (BEDIC):
Applying Peer-to-Peer Protocols to Enhance Performance and Scalability of Browser-Accessible Internet Resources
Max Rafferty* and Sofia Visa
*student co-author

MCURCSM
Wittenberg University
November 2010

Andrew Licking, Louisa Catalano, Kemar Reid, Rutendo Ruzvidzo, Dr. Ramsay, Dr. Bowen, Dr. Pasteur, David Freund

*student co-author

“New Features and Many Improvements to Analyze Morphology and Color of Digitalized Plant Organs Are Available in Tomato Analyzer 3.0”
Gustavo Rodriguez, David Francis, Esther van der Knaap, Jaynie Strecker, Itai Njanji*, Josh Thomas*, and Atticus Jack*

“Attribute Selection and Classification for Tomato Fruit Data - That’s a RELIEF!”
Matthew Lambert*, Bennjanim Snyder* and Sofia Visa

“Feed Forward Artificial Neural Networks Applied to Tomato Data Classification”
Joshua Thomas*, Jacob Haning*, Yanlong Hu*, and Sofia Visa

“Learning Morphological Data of Tomato Fruits-Analysis of Variance and k-Nearest Neighbors”
Michael Janning*, Mohammad Ahmad* and Sofia Visa

*student co-author
The Life and Work of Henri Lebesgue
Robert Taylor ’11

Borel Sets and Baire Functions: An Introduction
David Freund ’13

Integration: The Real Story
Wenyuan Wu ’11

Norm and Trig, a Love Story
Trisha Fultz ’12

Convergence and More Convergence
Evan Radkoff ’12

The Real Way to Look at Probability
Willem Daniel ’11

Henri Léon Lebesgue was a French mathematician whose generalization of the Riemann integral revolutionized the field of integration. Toward the close of the 19th century, mathematical analysis was limited effectively to continuous functions, and artificial restrictions were necessary to cope with discontinuities that cropped up with greater frequency as more exotic functions were encountered. The Riemann method of integration was applicable only to continuous and a few discontinuous functions. Influenced by the work of Émile Borel, Camille Jordan, and others, Lebesgue formulated a new theory of measure and framed a new definition of the definite integral, which he presented in his doctoral thesis at the Sorbonne in 1902. The Lebesgue integral is one of the great achievements of modern real analysis, and Lebesgue integration was instrumental in greatly expanding the scope of Fourier analysis. (eh.com)
The East Central North America Regional Programming Contest (ECNA RPC) draws students from colleges and universities throughout western Pennsylvania, Ohio, Michigan, eastern Ontario, and Indiana. Winners selected from the ECNA RPC advance to the ACM International Collegiate Programming Contest (ACM-ICPC) World Finals. Last October, two teams of Wooster computer science students competed in the 2010 ACM-ICPC East Central North America Regional Programming Contest in Youngstown, Ohio. There were 112 teams from 56 colleges in the competition. Although larger universities took most of the top spots, among the 16 smaller colleges and universities, the WOO++ team of Robert Taylor ’11, Trisha Fultz ’12 and Evan Radkoff ’12 placed 5th. Also participating in the contest were Spencer Hall ’13, Matthew Lambert ’13 and Jacob Haning ’11.

Dr. Pasteur’s math modeling students competed in the CoMap Mathematical Contest in Modeling (MCM) and the Interdisciplinary Contest in Modeling (ICM). The MCM team was composed of Robert Taylor ’11, Wenyuan Wu ’11, and Kemar Reid ’12. They worked on a radio repeater problem. Their honorable mention selection puts them roughly in the upper half (but not the top 15%) of teams from all over the world that participated. The Interdisciplinary Contest in Modeling (ICM) team worked on a problem in environmental science which resulted in successful participant status. This team included Melissa Venecek ’12, Saif Ahmad ’12, and Tristan Vrolijk ’12. Both contests run for four days in February annually and are the most significant competitions for undergraduates in math modeling.

The Student Mathematical Association of America Chapter (SMAAC), also known as Math Club, held its annual high school math contest in the spring. In the individual contest, students from Revere High School won first and third places and a student from Western Reserve Academy won second place. Results of the team contest were:

1st Place Western Reserve Academy, Hudson OH
2nd Place Revere High School, Richfield OH
3rd Place North Ridgeville High School, North Ridgeville OH
4th Place Central Christian High School, Kidron OH

Other schools participating: St. Vincent Saint Mary High School, John Hay High School, Ravenna High School, Cloverleaf High School, and Oberlin High School.
April 7
Newton's Clock: Chaos in the Solar System by Ivars Peterson, Director of Publications and Communications at the Mathematical Association of America, Washington, D.C.

March 31
Regret-Minimizing Representative Databases or How to Buy a Rocket Ship by Ashwin Lall, Assistant Professor of Computer Science, Denison University

March 3
Surgical Solutions in Differential Equations by Charles R. Hampton, Johnson Professor of Mathematics, Emeritus, The College of Wooster

January 18
On Writing Numbers by Tom Garrity, Professor of Mathematics, Williams College

November 2
METAGENOMES: What they are and how to tell them apart by Imre Tuba, Department of Mathematics, San Diego State University

October 26
Summer Research Internships by Bridget Kraynik ’11, Itai Njanji ’11, and Nancy Tinoza ’12

October 20
Simpson's Paradox by Jeff Witmer, Professor of Mathematics, Oberlin College

October 12
Careers, Start-ups, Silicon Valley: Create your opportunities, maximize your life experiences, plan your success by Mitch Haile, CTO and VP Product Management, Pancetera Software, (CoW Computer Science 2002)
2010 - 2011 Officers
Joshua Thomas
Nancy Tinoza
Aakarsh Gottumukkala
Kevin Nicholson

Advisor: Dr. John Ramsay

Events

Sunday 1 May 2011: Taylor Box XXII
Saturday 16 April 2011: High School Math Contest
Saturday 9 April 2011: Trip to M.C. Escher Exhibit, Akron Art Museum
Friday 3 December 2010: Math Club Game Night, Taylor 3rd Floor
Friday 22 October 2010: Math Club Game Night, Taylor 3rd Floor
Sunday 3 October 2010: Fall Picnic at Professor Ramsay's place
Thursday 23 September 2010: Pizza and Video of Arthur Benjamin: Mathemagician

In April, the Math Club and several other campus groups traveled to the Akron Art Museum to witness M.C. Escher: Impossible Realities. The exhibit featured 130 works by master printmaker Maurits Cornelis Escher, including woodcuts, lithographs, mezzotints, sculptures, and rare preparatory drawings that provided an in-depth view of the artist's creative processes. The exhibition came from the Herakleidon Museum in Athens, Greece. Akron was one of only two North American venues for this extraordinary loan.
Translation of two-dimensional information from microscopy images to realistic three-dimensional representations

Client: The Goodyear Tire and Rubber Company

Team: Benn Snyder, Josh Thomas, Ruth Steinhour

Advisors: John David (Mathematics) & Denise Byrnes (Computer Science)

This AMRE team developed a new image analysis tool for Goodyear Tire and Rubber Company. This project had two main goals. The first was to develop a three-dimensional rendering of particles from a two-dimensional sample image. The second goal was to produce a three-dimensional rendering of cylinders from a two-dimensional image featuring ellipses and non-spherical particles. Several properties of a given rubber sample, such as the rubber’s toughening efficiency and impact resistance, are related to particle size, shape, and location. This tool enables Goodyear to analyze two-dimensional images of rubber samples more effectively by providing new insight into the samples’ three-dimensional characteristics.

AMRE AT A GLANCE...

◆ 180 students have participated in the program. 45 of these students participated twice and 5 participated 3 times!
◆ AMRE has been in existence for 18 years.
◆ AMRE had a record 25 students complete 10 projects in the summer of 2011.
◆ We have completed 91 projects with 27 different clients.
◆ The Goodyear Tire and Rubber Company has sponsored 14 projects!
◆ The Prentke-Romich Company and Progressive Insurance have each sponsored 7 projects.
Efficiency Analysis in MHD Workstations

Client: Bekaert Corporation, Orrville OH

Team: Andrew Licking, Huachen Li, Kemar Reid

Advisors: John David and Drew Pasteur (Mathematics)

The purpose of this AMRE project was to analyze, collect data for, and improve the workload model established by Bekaert’s corporate office. A further goal of our project was to observe operations and to determine what, if any, inefficiencies existed and to find a way to avoid these inefficiencies in the future. The AMRE team was contracted to study ‘one area of the plant specifically – the Multi-Hole Drawers (MHD) section.’

Integrating Theory and Practice: Developing an Assessment Framework For Experiential Learning Programs at The College of Wooster

Team: Ashley Dawes, Ana Godonoga, Promise Kamanga

Advisors: Theresa Ford (Educational Assessment) and Dr. Amy Jo Stavnezer, Psychology Department

This project involves the development of an assessment framework for theory-to-practice (also known as experiential learning (EL)) experiences at The College of Wooster. One of the current strategic priorities at the College is “Integrating Theory and Practice” with the goal of increasing “opportunities for students to connect theory and practice through campus life and ‘real world’ projects and experiences that strengthen the quality of student learning”.

Our study therefore provides an opportunity to identify where and how much “Integrating Theory and Practice” occurs on campus; to examine program similarities and differences in practices, goals, and outcomes; and to develop a broad assessment framework and an agile assessment plan of “Integrating Theory and Practice: Experiential Learning” (EL) experiences at the College.
Surface Absorption of Selected Rubber Chemicals onto Model Surfaces

Client: The Goodyear Tire and Rubber Company

Team: Andy Young and Norman Chamusah

Advisor: Sarah Schmidtke (Chemistry)

This project was developed as a computational chemistry project to compute the relative sorption energies and model the structures of selected rubber chemicals on filler surfaces. The compounds are used in the vulcanization process for producing tires. The chemicals have an effect on the rubber crosslink density, filler surface and aging characteristics of the rubbers. The main goal was to use the sorption energies to make predictions of the relative strengths and favorability of the interactions between the given chemicals and fillers. A series of milestones were accomplished in this study: chemicals were optimized on new filler surfaces and protocols were developed to minimize computational cost for this step, energies were evaluated at different levels of theory to capture primary components of the interactions energies for the two different types of fillers, and results were analyzed to gain a deeper molecular level understanding of the impact of chemical structure on sorption properties.

Sports Predictions using Neural Networks

Team: Andrew Blaike and Gabriel Abud

Advisors: Drew Pasteur (Mathematics)

This project was a continuation of a 2010 AMRE/HHMI project dealing with artificial neural networks (ANNs) as a tool for predicting NFL football games. We built multiple ANN models to predict both college and professional football games. ANNs have many uses in today's scientific fields and are an efficient way to model complicated systems. We devised our most efficient model by analyzing several years of game statistics, using methods including correlation, principal component, derivative-based, and linear regression analysis. Predicting college football was a more difficult problem due to the wide variety of team abilities and schedule strengths, so the results were not as accurate as they were for the NFL model. Additionally, we collected large amounts of data on other sports for future research.
**Summer 2011 Projects**

**Undergraduate Research in Knot Theory**

Team: Sarah Smith-Polderman and David Freund

Advisors: Jennifer Bowen (Mathematics) and John Ramsay (Mathematics)

We continued previous research in the study of Klein links. We drew and untangled 48 distinct Klein links to provide a catalogue from which to observe patterns in their construction and the resulting links. We also created digital versions of a small subset of these links and wrote a paper that will be used to introduce the Klein links to future researchers. Lastly, we proved a number of theorems, including a result that allows us to count the number of components in an arbitrary Klein link, and have prepared our results for publication.

**Analysis of Actuarial Data Supporting Rate Changes**

Client: Progressive Insurance

Team: Ashley Stopka, Ian Sharp, Hannah Roberts

Advisors: Jennifer Bowen (Mathematics) and John Ramsay (Mathematics)

The project consisted of analyzing filings that an insurance company is required to submit to each state’s Department of Insurance (DOI) whenever the company changes its rates or rules. The first part of the project involved reading through filings and making observations based on what is included, what is changed, methodology and objections from the DOI. The second part involved focusing on the average number of claims and the size of the payouts for these claims in Pennsylvania. We collected data from the files to determine how Progressive ranks among their competitors in terms of the frequency and severity of claims within different coverage types. The largest focus in the second part of the project was to look at data about Personal Injury Protection (PIP) claims in Kentucky. Progressive has seen evidence of increasing fraudulent PIP claims in Kentucky. We looked to determine whether or not other companies are seeing similar trends in PIP fraud.

**Pansophy Software Updates**

Client: The College of Wooster Dean of Students Office

Team: Trisha Fultz, Spencer Hall, Qisheng Li

Advisor: Denise Byrnes (Computer Science)

The Pansophy student contact management software was created by a previous AMRE team for the Dean of Students Office. Pansophy is used to keep a record of potential problems and important information concerning students at The College of Wooster. Some examples include a death in the family, low grades in a particular class, or a parent’s concerns about financial aid. Documenting these prospective issues helps prevent students from falling through the cracks. This summer, we were tasked with upgrading the software to fix bugs and add new features, such as a way to archive graduated students. Along with the new features, we updated the user help documentation to aid users in recognizing and understanding the new features.
**College of Wooster Energy Usage Tracking**

**Client:** Physical Plant, College of Wooster  
**Team:** Micah Caunter and Michael Janning  
**Advisors:** Denise Byrnes (Computer Science) and Matt Mariola (Environmental Studies)

This project creates a website that provides access to information about the College’s various forms of energy consumption: electricity, water, and gas. The website allows an administrative user to analyze the College’s energy efficiency in these three areas on a building-by-building basis. The analysis can be used to improve the energy distribution on campus, conserve resources and save money. There are two components to the website: a public and a private section. The public area provides an interactive map of campus that can be used to pull recent energy usage history for campus buildings. There is also functionality to compare two buildings at the same time. The private section allows for administrative users to pull data from the website database in either report form or tabular form. The website is also maintained through the private section by uploading the most recent usage data from energy providers.

**Absolute Characterization of Crosslink Density**

**Client:** The Goodyear Tire and Rubber Company  
**Team:** Alexandra Kuzmishin and Adam Trontz  
**Advisor:** Sarah Schmidtke (Chemistry)

The experimental chemistry team worked this summer to develop a method to directly measure the crosslink density of rubber samples. The strategy was to adapt a common biochemical technique to measure disulfide bonds, the chemical bonds that link polymer units in the rubber, through a reaction with Ellman’s reagent. This reagent produces a chromophore upon reaction with disulfide bonds, which can be visualized using UV-VIS spectroscopy to quantify the number of disulfide bonds that reacted. A key difficulty in this adaptation is the organic nature of rubber, relative to the aqueous matrix necessary for the Ellman’s reaction. Some of the milestones accomplished in this project were: determination of co-solvent buffer system allowing for the Ellman’s reagent reaction and solubilizing the rubber, obtaining a linear calibration curve for the cysteine standard in the co-solvent system, development of a purification and reduction method for the rubber sample, qualitative proof of principle that the technique works for solid rubber samples, and preliminary quantitative data yielding concentration of disulfides within the anticipated order of magnitude for tire rubber.