Contents:

- Welcome from the Math Program Chair – 3
- Faculty Spotlights – 5
- Carroll Starts a Data Science Major – 7
- Spotlights on Recent Graduates – 9
- Alumni Spotlights – 11
- Student Internships – 15
- Highlights from Recent Senior Theses – 17
Welcome from Math Program Chair

The 2017-2018 school year was filled with many exciting events in the mathematics department. In recent years, the mathematics faculty have seen a large shift. Dr.'s Eric Sullivan and Ted Wendt joined the math faculty in 2013, Dr. Jodi Fasteen joined the faculty in 2015, Dr. Amanda Francis joined the faculty in 2016, and Dr. Kelly Cline is in his 14th year! Of note during the 2017-2018 school year, Dr. Cline was on a year-long sabbatical in Ireland. His official title for the year was “Visiting Scholar” at the University of Galway. More importantly, he moved his family to Ireland and spent the year touring the island, visiting castles, and enjoying the culture of Ireland. While Dr. Cline was abroad, the math department hired Dr. Ben Dill - a Carroll grad from 2011 - to fill in as a visiting professor. Dr. Dill did an amazing job!

In the fall of 2017 we hosted the fourth annual Montana Mathematical Modeling Contest (MMMC). Dr. Wendt has organized the contest for several years and we have more than doubled in size since the first iteration a few years ago. In October of 2017 we hosted teams from Montana State, University of Idaho, Washington State, Rocky Mountain College, and Providence College. The students had the choice between building an evacuation plan for Glacier National Park and building an alternative to the Electoral College. The 2018 event will be in late October and we are looking forward to engaging students in genuine modeling problems, team building, and a good healthy sense of competition. The MCM was fantastic this past year. We had 8 teams participate with 2 teams scoring a “Meritorious” award and placing them in the top 10% worldwide. We are very proud of our modeling students and are looking forward to the 2019 MCM.

The math debates continued even while Dr. Cline was away for the 17-18 school year. For the past several years, Dr.'s Sullivan and Cline have engaged in a once-per-semester math debate. This year Dr. Francis participated in the spring event: Greatest Impossible Problem in Mathematics. Dr. Francis won by a narrow margin with a discussion of Arrow's Impossibility Theorem -- a theorem that asserts the impossibility of a fair voting scheme. Seems a bit fishy to win by popular vote when your stance was that there is no fair way to vote. The 2018 debates started in late September at which time Dr. Cline will take on Dr. Sullivan - arguing their opinions as to who the greatest mathematician is. Going into the 2018-2019 school year we are excited to announce the new Data Science major. The new major is a combination of the existing math and computer science majors with a sprinkle of new data science classes. Dr. Sullivan piloted the Machine Learning class in the spring semester with a dozen students. This fall we are piloting the Advanced Statistics class and we proudly have 6 new Data Science majors. The school administration, advising, marketing, and admissions groups are helping us to advertise for the new program so that we can build the program and encourage more students to fall in love with math, statistics, computer science, and data -- a love that will last a lifetime.

At the end of the 2017-2018 school year, Dr. Francis announced that she was leaving to take a position at the American Mathematical Society. Good luck Amanda! We were fortunate to find Dr. Patrick
Torres to come as a visiting professor for the 2018-2019 school year. Dr. Torres comes to us from Washington State University where he was doing research on stability analysis in matrix theory. We are proud to call Dr. Torres a Saint for this school year.

-- Dr. Eric Sullivan
Program Director of Mathematics and Data Science at Carroll College.
Faculty Spotlights

Kelly Cline:

Recent projects: Dr. Cline spent the 2017-2018 academic year on sabbatical, as a visiting scholar in the school of mathematics, statistics, and applied mathematics at the National University of Ireland, Galway. He has worked with collaborators in Ireland authoring a series of papers studying the use of clicker questions in mathematics and statistics. He has worked on our “Project InterStats: Redesigning Statistics Education with Research Methods and Active Learning” based on a three year grant from the W. M. Keck Foundation, to develop materials to improve our statistics courses. He is director of the annual University Physics Competition, which attracted 265 entries this year from teams all over the world.

Ted Wendt:

How long at Carroll: Since 2013.
Recent projects: Dr. Wendt continues to organize and run the Montana Mathematical Modeling Challenge (MMMC). He is also involved in the COMAP MCM/ICM contest as well as the ACM computer science contest. Most recently he has become the chair of the Math, Engineering, and Computer Science department. He is also branching out from his mathematical roots and teaching more computer science these days including courses on computer graphics and parallel processing.

Eric Sullivan:

How long at Carroll: Since 2013.
Recent projects: Over the past few years, Eric has been working on adapting and writing open source course materials for several of the math classes. Of particular interest, he helped to pilot and modify the free and open course, Active Calculus text for the introductory Calculus sequence. Beyond working with open source material, Eric has published several differential equations modeling scenarios on the online platform SIMIODE. The SIMIODE platform is a way for differential equations educators to publish peer reviewed modeling activities related to differential equations and mathematical modeling.
Jodi Fasteen:

How long at Carroll: Since Fall 2015
Recent projects:

Dr. Fasteen has been working on Project InterStats, creating and piloting the open source Active Statistics materials. She has been involved in national teacher education conferences (NCTM & AMTE). She has also participated in regional conferences, including the annual meetings of the Symposium on Montana Mathematics Teaching (SuMMiT) which brings together Montana math teachers and teacher educators. She is working to blend the mathematics content and teaching methods for future K-8 teachers at Carroll and she regularly brings education students from Carroll to volunteer in a local 4th/5th grade math class. Jodi also ran a Lego challenge program in a local elementary school.
Carroll Starts a Data Science Major

In May 2018, the Carroll College Board of Trustees approved the creation of a Data Science major. Data Science is one of the fastest growing present-day careers both nationally and internationally. It combines computer science, mathematics, statistics, and business knowledge with the goal of analyzing and understanding data in its various forms.

“We are at the forefront of what other colleges and universities around Montana are doing to train students in the skills required to be a Data Scientist,” said Eric Sullivan, Associate Professor of Mathematics and Data Science. “Carroll’s liberal arts focus gives our students a wider exposure than just computer science and statistics; they are prepared to not only handle the technical problems but also to understand the ethical, economic, humanitarian, and business aspects of big data analysis. Coming out of our program, our students will understand data, be able to write programs to make sense of it, and will be able to apply it to the specific demands of whichever industry they’re working in,” said Sullivan.

The new Data Science major and minor at Carroll gives students a blend of skills including computer programming, database management, applied mathematics and statistics, business operations research, machine learning, advanced statistical methods, and advanced computing. In addition, students will be engaged in real data science projects locally through Carroll’s Math in the Mountains program and through the students’ Senior Data Science Capstone projects. Carroll Data Science courses employ real data sets in a variety of different fields such as medical diagnostics, image recognition, economic predictions, transportation analysis, ecological classification, and many others.

“At Carroll we are focused on preparing our students for successful careers. With this new degree, we recognized an overwhelming demand for these skill sets in the workforce. The faculty in our mathematics, computer science and engineering departments worked collaboratively to design a degree program that responds to both the needs of the workforce and provides our students with a breadth of skills applicable to a variety of fields,” said Dr. John Cech, Carroll College’s incoming president.

The program is naturally multidisciplinary and gives students a wide body of knowledge to draw from in order to solve problems and communicate solutions. “Data science is not just restricted to the technical fields such as math, statistics, and
computer science. There are very few industries these days that have not been impacted by big data analysis and data science. Companies are gathering massive amounts of data on their customers and their products and they need people with the proper skill sets to analyze it. This is precisely what we’re preparing our students for,” said Sullivan.

Carroll has piloted several data science courses which have already resulted in Carroll College students acquiring internships and research experiences doing data science. One student spent the summer of 2018 doing systems planning and analysis in Washington D.C. This internship resulted in a job offer. Another student conducted a research project at Montana State University where they were looking for errors made by neural networks - a challenging machine learning and computer science problem. This student was encouraged to apply for the computer science graduate program at MSU with a promise of funding. A third student worked as a machine learning and data science intern for a diabetes research group in Seattle. “These opportunities have arisen out of our new program at Carroll and we look forward to placing more students in opportunities such as these moving forward,” said Sullivan.

To learn more about the Data Science degree at Carroll College, visit www.carroll.edu/datascience.
Spotlights on Recent Grads

Erica Wiens
Major and Concentration: Math with a minor in Computer Science

Senior Project: Exploring different uses of network flows for the purpose of optimization
Plans after graduation: Master's of Science in Business analytics from William and Mary in Virginia
Advice for Carroll math students: When you're stuck, get help. Don't let your pride stand in the way of succeeding. Learn how to program!

Lizzy Younce
Major and Concentration: BA Mathematics, AA Foreign Language for International Development

Senior Project: I examined household survey responses collected in the vaccination zone of the Serengeti Health Initiative and the surrounding region through statistical methods from epidemiology, such as odds ratios and risk ratios, and multiple methods of geometric data analysis including principal component analysis, multiple correspondence analysis, as well as modified methods of both principal component and multiple factor analyses. The primary goals were to: 1) determine if there is a significant difference of survey answers between households inside and outside the vaccination zone 2) understand the role of individual survey questions in the vaccination zone time series 3) understand the role of individual years of surveys in the vaccination zone time series.
Plans after graduation: Short term---Get a job where I can use math to make a positive difference in the world, reach fluency in Spanish and French, backpack the Americas, and go to grad school for economics or statistics. Long term--get into veterinary school
Advice for Carroll math students: 1) It's hard to do math proofs if you only get 3 hours of sleep a night. Take care of yourself first, and everything and everyone else second. 2) Learn a language that's not your native tongue, then take a math class in that language. It's good for your brain. 3) I wish I had done the MCM competitions starting freshman year vs junior year, but didn't think I was smart enough. If you want to do it, you are smart enough--be like Nike and "just do it"

Jesica Bauer
Major and Concentration: BA Mathematics and Computer Science with an emphasis in Data Science.

Senior Project: Interpolation is a process for generation functions that pass through specified points in space. I discussed and developed several one-dimensional interpolation techniques which allowed me to "connect-the-dots" in various fashions. I applied these techniques to several things, but most notably a set of points in order to generate the top silhouette of a hand-drawn cat in an attempt to best mimic the shape digitally.
Plans after graduation: I am pursuing my PhD in Applied Mathematics at Rensselaer Polytechnic Institute.
Advice for Carroll math students: There will be things that challenge you, but remember that Carroll has so many resources in order to help you. Go to tutoring hours at the ARC, crash office hours, and make friends. Also, get involved with the MMMC and the MCM--and the ACM if you're into coding--eat too much pizza, attend the math debates, and in no time, these people will become like family.
Alumni Spotlights

Alex Chopyak (Math for Secondary Education -- 2016):
Current Position: Math Teacher at and Kentlake High School in Kent, WA
Bio: I am a native Coloradan that found himself in love with Montana. Carroll was one of the best decisions I ever made. After graduation from Carroll I made the decision to move out to the Pacific Northwest, and I have enjoyed every moment out here.
Recent Math Related Projects: I participated in the MCM for during my junior and senior year of college. It was an awesome experience. I have worked in on the creation of a curriculum guide for the Kent School District Geometry classes this last past year. We have used the Math Standards and created a guide as to go through units that follow and meet the standards instead of rather than going through the book chapter by chapter.
Advice for Carroll Math Students: Just don’t be afraid of your professors. They are awesome people and are more than willing to work with you. I also suggest doing the MCM because it is an awesome experience to use math for an actual project.

Tyler Zimmer (Math and Chemistry Double Major -- 2016):
Current Position: Scientific Games - Contracting with the California Lottery as the Account Manager in Sacramento, CA
Bio: I have made a home in the Lottery Industry since my time at Carroll, working as the Product Analyst for the Montana Lottery before taking my current role with Scientific Games. I still enjoy a lot of what I did for fun in college including hiking, running, picking a guitar from time to time, being involved with my church, and meeting new people!
Recent Math Related Projects: Since my time at Carroll I have made programming an essential part of both positions I have had. SQL, R or Python have been used on a daily basis and I have become a specialist in generating automated reports and visuals in R. I recently made a by-county sales projection visual for future Lottery sales that inputs various features from a ticket and uses generalized linear models (GLM's) to predict what sales will be in any given county depending on the features of the ticket, color, price point, # of play spots, etc. I geeked out on it, but learning how to make responsive and interactive visuals is something that makes for easy conversations with people who are intimidated by numbers. Also, I've found that people who are intimidated by numbers make up about 90% of the American workforce....
Advice for Carroll Math Students: Learn as much programming as you can -, the knowledge of SQL, R and Python have become an invaluable resource. When I first entered the workforce I knew exactly how I wanted to present data, thanks to classes like Numerical and Optimization, but I oftentimes often times had no way of collecting it or munging(?) munging it into anything useful. Becoming proficient in data structure manipulation took me to the next level, and my boss calls on me for reports for ALL of his accounts because I can generally get presentable data faster to him faster than any of his other account managers. … Also, study 1,000 times as long as you think you need to for any Real Analysis exam.
Elizabeth Carlson  
(Math with a Physics minor -- 2016):

Current Position:  
Graduate student at the University of Nebraska - Lincoln

Bio: I was born in Washington and raised in Helena, where I attended Carroll College to earn my BA in math with a minor in physics. I started my journey to a career in math when I took MA 131 at Carroll and was captivated by the applications of mathematics to difficult, relevant problems in our world. Later on the elegant proofs and incredibly deep logic became an aspect of mathematics I loved, but still the primary reason I enjoy math is how it describes the world around us. I am starting my third year as a graduate student in mathematics at the University of Nebraska - Lincoln, and my research focus is towards fluid dynamics and is/will be both theoretical and computational.

Recent Math Related Projects: In undergrad I participated in the MSGC BOREALIS internship (check it out!) where I helped predict where the high-altitude weather balloons we launched were going to land. This influenced the topic for my undergraduate thesis, which was a computational study of the Reynolds Averaged Navier-Stokes Equations (one type of equation which describe fluid flow) and how their evolution is affected by topography. In graduate school, I have started working on how to make make differential equations (sans initial conditions but instead with some initial data) incorporate observed data using feedback control.

Advice for Carroll Math Students: 1) I cannot count the number of times I have heard people say, "You have coding experience? Wow I wish I did, that will take you so far." Carroll gives a lot of experience with coding within the math program, which is just one aspect that makes the program incredibly good. Put this experience on your resume! 2) After graduating from Carroll, I have noticed not everyone realizes the incredible value of mathematical modeling competitions. Do as many as you can, especially the MCM; they show you what it is like to do research, stretch your mind, and test your creativity; you learn so much. This experience on your resume is not only attractive on graduate school applications but also on job applications; it shows you can be creative and work under (some) pressure. 3) Get to know your math professors well. They are some of the most amazing people you will ever meet, and they have fantastic advice! 4) Speaking of advice, regularly seek out and accept advice from many people who have walked the path you want to walk. "Without counsel purposes are disappointed: but in the multitude of counsellors they are established." Proverbs 15:22

Go change the world, Saints!
Jordan Trinka (Math and Computer Science -- 2017):

Current Position: Graduate student at Marquette University and also an intern at Direct Supply in Milwaukee, WI Wisconsin.

Bio: I am currently a computational sciences Ph.D. student at Marquette University who just finished his first year. I am also a teaching assistant at Marquette and I work as well as working as a data science intern at Direct Supply.

Recent Math Related Projects: I have used statistical techniques to analyze atrazine levels in lakes across the United States. I am currently working on a project for Direct Supply that involves choosing a subset of combinations from an n choose k number of combinations where each number across the subset appears the same number of times. This project has turned into my first industry ready, scalable algorithm.

Advice for Carroll Math Students: Graduate school is tough. In the end, however, it is totally worth it and will open up your mind to mathematical concepts that you could only dream of. Make sure you are able to see things from a major top-down view. For instance, rather than just doing calculations involving Lagrange multipliers, make sure you understand the big idea behind them and how those ideas are manifested in mathematics. Be able to explain mathematical ideas to non-mathematically inclined audiences and why these ideas are important. Work hard and don’t give up! Good luck!

Jeffrey Larson (Math -- 2005):

Current Position: Argonne National Laboratory

Bio and Recent Projects: I am an computational mathematician at Argonne National Laboratory. I study and apply methods for numerical optimization. There are many optimization applications that I work on, including particle accelerator design, operation of concentrated solar power plants, and quantum computing.

Advice for Carroll Math Students: If you are interested in applied mathematics, consider doing a SULI at a national laboratory. It’s a cool opportunity that I didn’t know about as an undergrad. If you are like me and are equally interested in “pure” and “applied” mathematics, consider going the more applied route for many more career opportunities.
Dempsey Rogers  
(Math and Physics -- 2016):

Bio: After graduation I took a year to ski, climb and bike across Canada and the PNW while studying for the physics GRE. While waiting for the GRE and grad school application results I worked in California for Guided Discoveries as a technician and instructor in their observatory. I left California for my first semester of grad school at the University of Colorado, Colorado Springs. During this semester I was accepted, and funded, in my dream program at the University of Alaska studying plasma physics.

Recent Math Related Projects: During my first semester at UCCS I took the statistical mechanics of particles and general relativity. In relativity we used formal proofs to derive matrix operators that describe the curvature of space-time. It's safe to say that I used all of the math that I learned at Carroll.
Student Internships

Student Internships summer 2018
- Terry Cox -- Machine Learning internship with Novo Nordisk in Seattle, WA.
- Dan Olszewski -- Machine Learning and AI RIPS (Research for Industrial Projects) at UCLA
- Amy Telck -- Systems Planning and Economic Forecasting in Washington DC
- Andrews Johnson -- Software Engineering internship at MSU
- Kristen Bressler -- DOD SMART Internship
- Nathan Boone -- Berkeley Livermore National Labs and Dr. Peter Larson Economic Modeling
- Elizabeth Younce -- Consulting for Headwaters
- Trey Scofield -- Electrical Engineering internship with Morrison Maierle in Helena

Internship Highlights:

Terry Cox
Title: Intern
Location: Novo Nordisk Research Center Seattle Inc. (NNRCSI) in Seattle, WA

In my summer research for NNRCSI, I worked on three different projects to ultimately help diabetes patients stay on top of their disease. The first two projects were creating a Short-Term Hypoglycemia Predictor (STHP) and a Short-Term Hyperglycemia Predictor (STHEP). The models I used were Random Forest Regressors and Deep Learning Neural Network Regressors that took Continuous Glucose Monitor (CGM) values and predicted the Blood Glucose level of the patient in 15, 30, 45, 60, and 75 minute Prediction Horizons (PH) or minutes ahead. The point is to warn the patient of having too high of a blood sugar (not thinking clearly, headaches, loss of circulation) or too low of a blood sugar (seizures, passing out, death). The third project was a Response Horizon of Insulin Dose Predictor (RHIDP). Again, using Random Forest and Neural Network Regressors that take in CGM values, I predicted 60, 120, and 180 minute Response Horizons (RH) or minutes in the past of actual insulin dosage. This informs the patient of how well they are on top of taking the correct amount of insulin. I learned new programming and data science techniques as well as the very first steps of up and coming research and technology in the medical field.

Andrew Johnson
Title: Intern
Location: Montana State University

The goal of my summer REU was to test scientific software for machine learning algorithms. This is becoming more important as the scientific community as a whole starts to rely on machine learning more often without considering that the program they are using may be flawed. Software which implements ML algorithms can be difficult to test due to not having an effective test oracle (a mechanism by which to determine...
whether a test has passed or failed). One way these algorithms can be tested is through metamorphic tests, which define relationships between the input and output of a given algorithm and assert that the relationship holds with many different inputs. My summer work focused on how to effectively test neural networks and researching and applying metamorphic tests with respect to neural networks and other ML algorithms.
Highlights from Recent Senior Theses

Every Carroll College math major must complete a three-credit independent senior thesis or senior project. These projects allow students freedom to explore topics beyond their coursework.

Ben Jensen (’16):
Title: Searching for Lost Targets using Bayesian Search Patterns.
Advisor: Ted Wendt
The image below shows a three-agent search for a lost hiker in wilderness terrain.

Jordan Trinka (’17):
Title: Modeling Contaminant Flow in the Puget Sound
Advisor: Eric Sullivan
The image below shows solutions to the Navier-Stokes equations on a finite element triangularization in the Puget Sound area around Seattle.

Marcellus Randall (’18):
Title: Classifications of Electrical Resistance Distance in Simple Graphs
Advisor: Amanda Francis
The image below shows an exploration of Pendant-vertex graphs on 6 vertices that have Marcellus’ “ER-diff” property.

Dylan Allen (’17):
Title: Topological Data Analysis: Giving Data Shape.
Advisor: Amanda Francis
The images below illustrate the process of transforming topologically rich data into a graph structure that can then be analyzed using techniques from graph theory and topology.