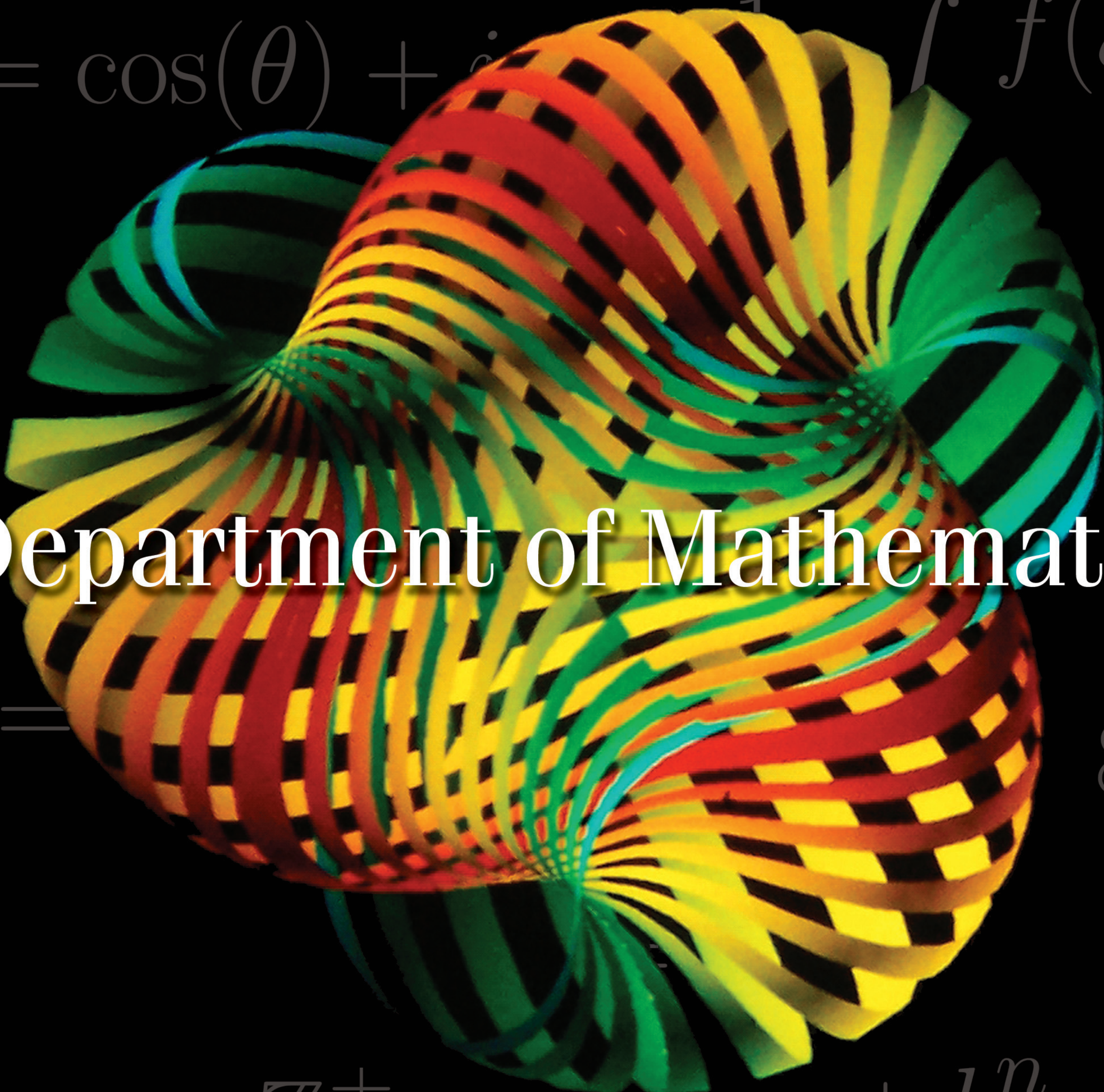
DUKE UNIVERSITY

Department of Mathematics



We're more

than numbers

Q&A

Why should I consider a major in mathematics at Duke?

What makes mathematics different from other majors?

As a field of study, mathematics is unique. Known as "The Queen of the Sciences," it is the purest form of quantitative analytical reasoning and thus has applications to almost every other science. In fact, many sciences rely so heavily on mathematics that their most important questions are, fundamentally, math problems.

What will a math major do for me after graduation?

Mathematics is a powerful and versatile major. Students with degrees in mathematics are highly sought after in a variety of industries, because employers know that success in mathematics requires strong problem solving abilities and outstanding analytical skills. Thus, math majors are very marketable.

Math majors are also strong candidates to go on to medical school, law school, high tech industries, finance industries, or graduate school in any of a variety of different fields, including engineering, economics, finance, and computer science.

Above: Students in the PRUV Fellows program in the summer of 2010.

What is it like being a math major?

As a mathematics major, you will have a wide variety of options in your course of study. After completing a set of core courses, you can sample from a variety of different courses representing the main areas of mathematics. You will have the opportunity to take directed reading courses, and to participate in undergraduate research, working with faculty members.

Through the whole process, you will have a faculty advisor that will help you make decisions that will optimize your undergraduate mathematics experience.

Will I have the opportunity to do research?

Yes, there are several ways students can become involved in research while still an undergraduate!

The **PRUV Fellowship Program** provides financial support for summer research with a faculty sponsor in the Duke Mathematics Department. Students receive a stipend and live on campus with other students in the program, and can afterwards continue that in a senior research project to earn graduation with distinction. Recent titles include *Language Evolution*, *Robotics*, *T-Cell Diversity*, and *Modeling Swarming Dynamics*.

There are also opportunities to do research with faculty members for course credit during the year – for example, in the seminar Math 196S on Mathematical Models, or Math 194 on topics that have recently included *Mathematical Models of Panting Frequency*, *Wavelets*, and *Random Matrices*.

Students are also encouraged to participate in the many REU (Research Experience for Undergraduates) programs that are held in the summers at a variety of schools around the country.

I'm taking 31L right now, I'm not the best student in the class, and many of my friends are already in 103; can I still do a math major?

Absolutely! There is plenty of time in a typical schedule to finish a math major after starting in 31L. Many students have started in the regular freshman courses and gone on to be successful math majors.

If you are interested in your options on majoring in math, ask your current instructor for details.

How many math majors are women?

About one third of math majors at Duke are women. The department encourages women to consider majoring in mathematics. In honor of the female mathematician Emmy Noether (and in reference to an algebraic object she defined and studied), the department has an organization of female mathematicians called the "Noetherian Ring." This group is dedicated to providing additional encouragement for women pursuing studies in mathematics.

What if I choose another major?

Will mathematics courses help me in my chosen major?

If you are majoring in finance, economics, political science, psychology, or any other science, then you will find that the coursework in your major relies heavily on math. In order to have the best opportunity to do well in those courses and absorb that material, it can be very beneficial to identify and take the appropriate math course.

All of the courses offered by the Mathematics Department have applications to other fields — here are some examples:

Math 196S and Math 229, Mathematical Modeling: These courses show how to develop and analyze mathematical models for real-world scientific problems such as mechanical systems and biochemical reactions. Students in biology, economics, chemistry, physics, or engineering should consider this course.

Math 49S, Applications of Mathematics to Physiology and Medicine: The course creates simple mathematical models that help explain complex biological systems; it would be a perfect course for any student majoring in any biological science.

Math 211, Applied PDE's and Complex Variables: This course gives thorough training in classic advanced mathematical methods that are used in most areas of engineering and applied science. It would be very useful for any student in engineering, physics, or economics.

Math 215, Financial Mathematics: With only one prerequisite above entry level courses (Math 135, Probability), this course introduces students to the mathematical questions and tools involved in finance, helping to prepare students for a career in that always lucrative industry.

Math 160S, Mathematical Numerical Analysis: This course carefully studies the fundamental principles that are used in developing numerical methods and applies them to practical computations of challenging mathematical problems. Perfect for students in computer science, economics, engineering, or physics.

If you are uncertain of your mathematical needs, talk to your advisor in your major department, or come to the Mathematics Department and ask us!

What about a double major?

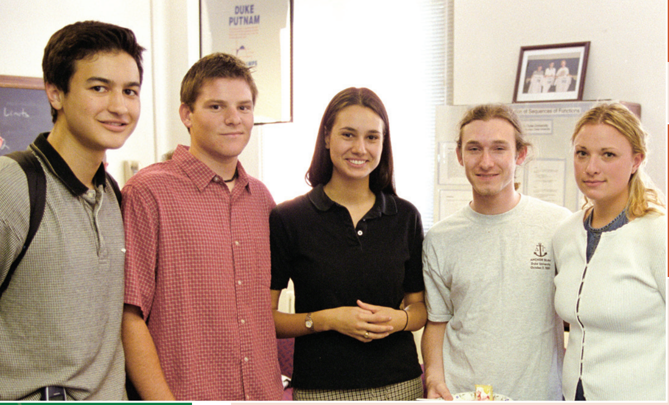
Using mathematics as a supplement to your primary major can make your future applications much stronger!

Potential employers and graduate school admissions committees know that the study of mathematics requires and develops strong problem-solving skills, comprehension of abstract concepts, and creative thinking ability; and these are all highly desired qualities in applicants to almost any field or industry.

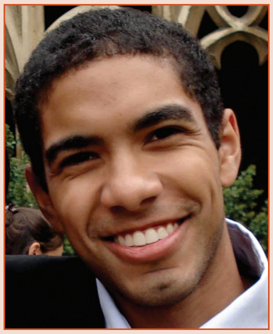
In addition, many of them know that the applicant who can be successful working with them will need specific mathematical skills; the applicant with a major in mathematics will thus be at the top of their list.

If you are interested in having an informal conversation about being a math major, contact Clark Bray at

cbray@math.duke.edu



Who are Duke math majors?



"Mathematics is a beautiful subject, and Duke is a fantastic place for it. What really sticks in my mind about the faculty at Duke is how delighted they were to work with students, and how eager professors were to take time out of their schedules to answer questions. Additionally, the best academic experience I had while at Duke consisted of my senior thesis project. I worked on a problem that was very interesting to me, and the enthusiastic mentorship I received greatly enhanced my undergraduate experience."

– Aaron Pollack, Ph.D. candidate, Princeton University; PRUV Fellow

"Majoring in math has taught me to think logically and learn conceptually. For instance, constructing proofs helped me develop abstract thinking skills, which can in turn foster a very valuable internal problem-solving method that can be used for life. By exposing me to entirely new problems under pressure, it helped me develop the confidence and problem-solving abilities that are necessary for success in the fast-paced world of finance. The professors, aside from being world-class, are very accessible and always willing to help out; they offer valuable guidance on career paths both inside and outside of mathematics."

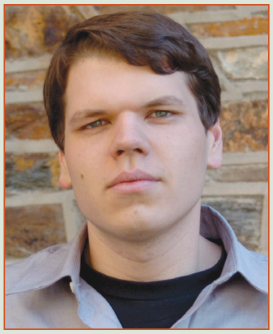
– Matt Moore, Fixed Income Exotics Trading, JPMorgan

"For the first few weeks of Math 32, my first class at Duke, I felt intimidated and unsure by the difficulty and the rigor of the subject matter. I had considered quitting math altogether, but because I had a passion for it, I decided to try out a few more courses. Fifteen math classes later, I am very grateful for my decision to stick it out; it has been one of the most rewarding experiences of my life. Math at Duke, with the aid of the faculty, has taught me to approach and break down, step by step, any problem with solid logic and clever approaches. Since it has been such a rewarding experience, I have planned to continue more advanced mathematics in graduate school."

– Jeremy Semko, Ph.D. candidate, University of California, San Diego

"The benefits of pursuing a mathematics degree at Duke University are endless. As a math major, I developed a logical and analytical mindset that has assisted me within the academic, professional and personal realms of life. I learned to identify the implicit assumptions within a problem or situation, break it down into a series of steps and critically think about viable solutions available through an analytic lens. Due to these acquired skill sets, job acquisition was made that much easier, as I was easily able to portray key skills highly sought after by employers. Given that the Duke Math program is still a part of a liberal arts academic experience, you gain exposure to interdisciplinary opportunities and inevitably develop into a well-rounded individual."

– Taiesha Abrams, Consultant, Booz Allen Hamilton



"I had a wonderfully rich experience as a math major. Beyond pure math, my coursework was applicable to biology, logic, physics, economics, and statistics. More importantly, math taught me how to think, greatly improving my ability to express myself logically. Thanks to accessible, supportive, and skilled faculty, the opportunities afforded a Duke math major are unparalleled."

– Elliott Wolf, J.D. candidate, Stanford Law School; President, Duke Student Government; PRUV Fellow

"I went to Duke wanting to study both math and theater, but worried about the difficulty of pursuing two such different majors. Fortunately, I connected early on with wonderful mentors in the Math department who were supportive of both my interests. I have been able to blend my math and theater majors, even developing a senior distinction project that involves performing a play about math. I also had the opportunity to serve as a TA and work in the math help room, which was perfect for someone like me who wants to teach math. While I don't consider myself a 'math genius,' I felt at home in the math department and they have helped me achieve my unique education goals."

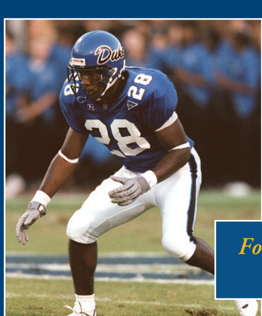
– Heather Wiese, Math major, Theater Studies major

"By pursuing a math major I was able to study quantitative topics relevant to diverse disciplines of science and the social sciences while keeping my post-Duke options open for as long as possible. Most majors in science, engineering, economics, etc. require knowledge of some combination of multivariable calculus, differential equations, probability and statistics, and general problem-solving intuition. Even as late as fall of senior year I was simultaneously interviewing for consulting positions and applying to Neuroscience Ph.D. programs.

A math major is an outstanding degree to get under your belt if you like to pursue content from a quantitative analytical perspective, regardless of your particular content areas of interest."

– Catherine Hartman, Neuroscience Ph.D. candidate, Harvard University

Duke math majors have gone on to do a broad variety of great things after graduation, including professional sports (Trajan Langdon plays professional basketball in Europe; D'Juan O'Donald plays professional arena football; Thora Helgadottir plays professional soccer in Norway.)



Former math major D'Juan O'Donald, of the Duke Football team.

"My time as a math major at Duke was extremely enjoyable. The faculty were very understanding and helpful, which was important to me since playing on the Duke soccer team and the Icelandic national team kept me very busy. I liked that the classes were often quite small, which made it easier to get to know my classmates and get more attention from my professors."

– Thora Helgadottir ('04), professional soccer player

Duke Math Faculty

"My goal as a teacher is to make mathematics fun and interesting for the students. I've found that students enjoy understanding and being able to express themselves creatively more than memorization, so my classes reflect this. Students also really seem to enjoy being able to apply what they've learned in class to new and interesting questions from their other classes as well as from everyday life. Mathematics was developed with applications in mind, so I find it essential to discuss the applications which, over the centuries, motivated the greatest thinkers to come up with their most beautiful mathematical ideas."

Professor Hubert Bray received his Ph.D. from Stanford in 1997 and was an associate professor at MIT and Columbia before joining the faculty at Duke. He does research in differential geometry, which he then uses to study general relativity, black holes, and other large scale structures in the universe. As an undergraduate at Rice he used statistics and mathematical modeling to help his intramural ultimate frisbee team win the championship game 18-1. These days he uses mathematical modeling and computer simulations to study dark matter and spiral galaxies. He also studies game theory and preferential ballot vote counting methods that reduce the role of political parties and make it easier for centrist candidates to win.

"My teaching philosophy is that a professor is a facilitator of the learning process – a coach of a highly talented team. In my math courses, I foster an appreciation for math's far-reaching methods and applications, and cultivate an intuition for the beauty with which it fits together and flows."

Professor Arlie Petters received his Ph.D. in Mathematics from MIT and was on the faculty at MIT and Princeton before moving to Duke. He specializes in Mathematical Physics, specifically how gravity's action on light probes the nature of dark matter and black holes. Dr. Petters also has a strong interest in financial mathematics, which he frequently teaches. He enjoys movies and walking, as well as the foods and music from different cultures.

For more information about faculty members and their research, go to **math.duke.edu.**
To look at the Handbook for Mathematics Majors and Minors, go to **http://math.duke.edu/undergraduate/info.html.**

"Traditional mathematics courses are frequently perceived by students as hurdles to jump over prior to graduation, particularly among non-math majors. I believe that students will find math courses enjoyable if they are taught using examples that relate to students' backgrounds."

Professor Anita Layton received her Ph.D. in computer science from the University of Toronto in 2001. She is interested in modeling biological systems and solving combustion model equations. She enjoys her work because she can answer (or try to answer) real-life scientific questions using mathematics. When she is not doing math, she enjoys reading recreationally, watching movies, and spending time with her two children.

"Math teaches you to think critically, to tackle questions which at first seem insurmountable. You chip away at confusion, stretching your mind, until all of a sudden the answer is as plain as day. Those moments of revelation are what it is all about."

Professor Jonathan Mattingly is a Charlotte, N.C. native who graduated the Carolina School of Science and Math. He received his BS in Applied Mathematics from Yale University and his Ph.D. in Applied and Computational Mathematics in 1998 from Princeton University. He spent two years living and studying in France and four years teaching at Stanford and living in San Francisco before returning to North Carolina to teach at Duke in 2002. He is an avid soccer player, though not very good (he says, modestly), and enjoys listening to live music.

Some Duke Mathematics Majors participate in national and international competitions, and succeed impressively

In recent years Duke Mathematics majors have been awarded numerous prestigious scholarships. This includes three Rhodes Scholarships (Adam Chandler, Sam Malone, Alex Hartemink), one Marshall Scholarship (Ethan Eade), six Churchill Scholarships (Brandon Levin, Christopher Beasley, Robert Schneck, Elizabeth Ayer, Malisa Troutman, Stephen Craig), and two Gates Scholarships (Melanie Wood, James Zou). Mathematics majors have also been prominent in receiving Duke Faculty Scholarships, including twelve awards in the last ten years. In that time they have also been awarded twelve Goldwater Scholarships.

The William Lowell Putnam Mathematics Competition is the most prestigious competition in the nation between undergraduate students in mathematics. Nearly 4000 students from over 500 colleges and universities throughout the US and Canada participate each year. Duke is a perennial powerhouse – since 1990, Duke has fielded three first place teams, two second place teams, and six third place teams.

One of the biggest contributors to that record was Duke Mathematics major Melanie Wood, who won one of five top individual prizes in 2002. Her other awards include two Elizabeth Lowell Putnam Prizes (the top woman contestant), the Morgan Prize (awarded to one student each year by the AMS for outstanding undergraduate research), a Gates Cambridge Scholarship, and the Schafer Prize (awarded by the AWM; other recent Duke honorees are Sarah Dean, Jennifer Slimowitz, and Jeanne Nielson).

Duke has also been a powerhouse in the Mathematical Contest in Modeling, in which over 1500 teams from around the world participate in a 96 hour competition. In the past ten years, fourteen Duke teams have achieved the designation "Outstanding" (top 1%), and fifteen have achieved the designation "Meritorious" (top 15%).

What is mathematics like beyond calculus?

Mathematics is much more diverse than most people realize!

ANALYSIS is the subject that grew out of Newton's discovery of the calculus. It includes the study of ordinary differential equations, partial differential equations, and probability theory. All three subjects are critical to the applications of analysis to physics, engineering, finance, statistics, biology,… almost anything that has a quantitative component.

ABSTRACT ALGEBRA is a pure field but it also has a wide variety of applications, from understanding the Rubik's cube to classifying crystal structures and designing algorithms. Here's another powerful example: How do you communicate securely over an insecure network like the internet? This problem has been around in simpler form for centuries and you use its solution (found in the late 1970's) every time you use your browser to send information you want to keep secret, like credit card or banking information. The solution, part of what is now called Public-key Cryptography, is described completely using mathematical ideas which are presented in Math 121 and 128S. You can even easily make your own unbreakable code!

TOPOLOGY studies global characteristics of shapes and surfaces. For example, the shape of a doughnut is qualitatively different from that of a basketball, fork, or piece of paper – specifically, the doughnut has a 'hole' in it, while the others do not. While we have a visual intuition for this difference, topology allows us to quantify this difference algebraically and use those algebraic tools to further explore these and related ideas. Topology has strong connections to abstract algebra, analysis, and geometry. Topology also has applications to physics, genetics, and computer science. Topology has been used to understand the knotting and unknotting of DNA.

APPLIED MATHEMATICS – In traditional applied mathematics, calculus and ordinary and partial differential equations were the quantitative tools of the physical sciences and engineering, and that is still true. However, since the mid-20th century, diverse methods from many other branches of mathematics have played important roles in an astounding variety of situations. Linear programming and probability theory are used to design traffic flow and airlines schedules as well as to inform business pricing decisions. Ordinary and partial differential equations are ubiquitous in Economics. Graph theory and probability theory are used in Sociology. Geometric concepts are crucial to understanding the shapes of large biological molecules and to rational drug design. Graph theory is also central to phylogenetics; and combinatorics, statistics, and probability theory play major roles in Genomics and Proteomics. In fact, the mathematical content of every undergraduate course, whether "pure" or "applied," is used in important applications.

GEOMETRY began over 2500 years ago as a collection of techniques for dealing with and relating the lengths, angles, areas, and volumes of physical objects, both on Earth and in the sky. In the hands of the Greeks, it also became a tool for developing logical arguments, abstract reasoning, and investigating the nature of space and time. Geometric thinking became understood to mean finding the most efficient way to model a given phenomenon, after abstracting it from its particular instances. After the development of the calculus and the theory of differential equations, geometry was expanded to cover situations in which the classical lines, planes, and spheres were replaced by shortest paths on a surface (or higher dimensional objects), minimal surfaces (like soap films), and constant mean curvature surfaces (like soap bubbles). In fact, all sorts of problems in which the solution was a configuration that minimized some quantity (such as mass, energy, volume, etc.) were seen to be special cases of a new "differential" geometry, and this launched a revolution in the study of partial differential equations that is continuing today. Einstein's theory of relativity and modern quantum theory (including string theory and its generalizations) are all part of differential geometry's wide scope. Its applications include not only theoretical physics, but computer modeling of shapes, graphical representations, heat flow, optimization and control theory, and understanding properties of partial differential equations and their transformation rules.

Front Cover: This is a view of a geometric surface discovered by Duke Mathematician Robert Bryant, one that minimizes an overall "bending energy" among all surfaces deformable to the classic "Boy's Surface". The image was generated by G. Yates Fletcher