The content of this booklet is for informational purposes only and is not intended as an official statement of policy for the Mathematical Sciences Department or Clemson University. The graduate program may change at any time and individual requirements and courses of study may vary.
An In Depth Look into the 
Clemson University 
Mathematical Sciences Graduate Program

Overview
The Department of Mathematical Sciences at Clemson University was a pioneer in integrating key areas of the mathematical sciences (algebra and discrete mathematics, applied analysis, computational mathematics, operations research, and probability and statistics) into a balanced program, emphasizing both teaching and research. In terms of our degree programs and the composition of our faculty, we are not a traditional mathematics department. The Department is unique among mathematics departments at other universities. Compared to peer mathematics programs, the Department maintains well-funded and highly active research programs in all areas of the mathematical sciences. Our faculty is engaged in collaborative research with other faculty from a variety of departments and centers and in a range of disciplines. Our involvement with The Center for Advanced Films and Fibers is but one significant example.

The nature of our B.A., B.S., M.S., and Ph.D. programs make our students highly employable. They emerge upon graduation as skilled problem solvers that also have the ability to effectively communicate technical material, both verbally and in writing. In recent years job offers received by our graduates have been comparable to those received by engineering students.

The Department has made efforts to develop new and to strengthen existing programs to meet changing demands and opportunities. One example is the area of financial mathematics, which has received considerable national press. Our Department is well structured to develop a nationally recognized program in this area. In the area of Mathematical Education, we have hired a new faculty member and revised curricula to strengthen our program.

Mission
In support of Clemson University’s commitment to world-class teaching, research and public service, and its mission of offering a wide array of high quality degree programs, the mission of the Department of Mathematical Sciences is to create and discover new knowledge in the mathematical sciences, and to apply and disseminate new and existing knowledge for the educational and economic benefit of the state and nation.

Vision
The Department of Mathematical Sciences will progress in step with Clemson University toward the goal of being ranked among the Top 20 programs at public research universities. The Department will be recognized by Clemson University as a multidisciplinary department offering degree programs of the highest quality, and for its collaborative research with individuals, departments and centers across the campus. The graduate program will be recognized nationally for its efforts to prepare mathematical scientists for academic and nonacademic employment, and for the high quality of the disciplinary and interdisciplinary research by its faculty and students.
Study in all areas include courses to provide both **breadth** and **depth**.
ACADEMIC INTEGRITY, GRADUATE PHILOSOPHY

An academic environment of integrity is one in which students, faculty and staff interact with each other from a position of mutual trustworthiness. Clemson University has committed itself to preparing a community of scholars dedicated to integrity in teaching, research, scholarship, mentorship and the acquisition and display of professional values of trust, honesty, fairness, responsibility and respect. It is an expectation that Clemson graduate students avail themselves of the many opportunities and resources both on and off campus to learn how to engage in professional practice with integrity. The Graduate School and the community of scholars engaged in graduate-level education will vigorously and expeditiously respond to charges of violations of academic integrity.

In order to promote an academic environment of integrity, all students, faculty and staff must commit to fostering honesty in academic work. Each individual has an important role in ensuring that Clemson’s policy on academic integrity is respected and used most effectively as a mechanism for teaching versus a mechanism for punishment. The Graduate School encourages all faculty and students to take a proactive role in eradicating ignorance of violations of academic integrity. Faculty must be clear on syllabi and in verbal instructions to students on the academic expectations for completing assignments. Graduate programs must engage students in discussions about disciplinary-specific issues and professional practice relative to academic integrity, and may include expectations, procedures and consequences aligned with professional licensing or certification requirements beyond those listed here. Faculty might inform students of national cases of academic dishonesty by other faculty and graduate students so as to heighten students’ awareness of the necessary seriousness of making a commitment to honesty in their work and implications of not doing so. Students must be proactive in asking for clarification on procedures for completing assigned work. As plagiarism appears to be the most prevalent type of violation of academic integrity observed and reported at Clemson University among graduate students, the Graduate School, in conjunction with the Rutland Center for Ethics and the Office for Teaching Effectiveness, will convene and encourage departments to convene seminars and workshops that all newly incoming graduate students attend as a requirement for receipt of a degree from Clemson.

INTERNATIONAL STUDENT POLICY

As stated in the Assistantship Offer Letter, international student support is contingent upon passing the SPEAK (TSE) test with a score of at least 50 so that you may fulfill your teaching assistantship duties. This test must be retaken each time it is offered until this score is achieved, and special courses are available at Clemson to assist you in acquiring English fluency. If a passing score of 50 is not achieved after 2 semesters of study, your assistantship may not be continued.
Master of Science Program

Program Purpose
In 1975 the Department put together a successful curricular reform to create an applied master’s program in mathematical sciences. A grant from the NSF Program Alternatives in Higher Education supported efforts to create this novel program, where the emphasis was to prepare graduates for careers in business, industry, and government. A distinguished Board of Advisors provided valuable guidance during the planning phase of the applied master’s program and included both academic members (from Brown, Princeton, Cornell, Rice) as well as members from industry (Milliken Corporation) and government (ICASE, Office of Naval Research, Oak Ridge National Labs). It was agreed that a level of training between the baccalaureate and the Ph.D., something more ambitious than the traditional master’s degree, would be attractive to students and fill a significant national need. The applied master’s program was formally created in December 1975.

Specifically, the applied M.S. program was based on the following premises (which not only turned out to be correct but which also anticipated several recent national trends):

• The major source of employment for mathematical scientists in the future will be nonacademic agencies.
• Most such employers will require more than a B.S. degree but less than a Ph.D. degree in the mathematical sciences.
• Employers will prefer personnel who possess not only a concentration in a particular area of the mathematical sciences, but also diversified training in most of the other areas.
• Graduates should possess more than superficial education in applying mathematical techniques to solve problems in areas other than the mathematical sciences. Inherent in this training is the ability to communicate, both orally and in writing, with persons from such areas.
• It is desirable to obtain such broad-based education in the mathematical sciences prior to specializing for the Ph.D. degree.

Our applied master’s program has subsequently been a model for other programs nationally, anticipating the breadth of training and computational skills needed for employment in business, industry, and government. The teaching component of the program, carried out as part of their assistantship duties, also affords our graduates valuable experience (and a competitive advantage) when applying for academic positions.

Goals
• to offer a stimulating and intellectually challenging Master of Science degree that integrates various areas of the mathematical sciences into a balanced curriculum
• to train graduates of the highest caliber to meet the needs of industry and government, thus contributing to the economic future of the state and nation
• to prepare students for additional graduate work in the mathematical sciences

Objectives
The major objectives of the master’s degree program are to develop students
• with a breadth of training in the mathematical sciences
• with a concentration that reflects depth of knowledge in selected area(s)
• who can effectively communicate
• who have flexible career options in both academic and nonacademic spheres
**Graduate Student Profile**

There are typically over 50 students in the Masters program with 20 to 30 graduating each year. The M.S. program attracts a substantial number of females into the program, counter to the experience at most mathematics/statistics programs. In fact the most recent data reveals approximately 52% males and 48% females are enrolled in the master’s program. Also counter to national trends, U.S. citizens comprise a large percentage (66%) of the M.S. candidates in the program.

These demographics dovetail well with the goals of our graduate program (in which such graduates have increased opportunities for both nonacademic and academic careers). Also, the abundance of U.S. citizens is necessitated by the fact that graduate students teach a large number of service courses for the university. By their second year, the teaching assistants have primary responsibility for teaching, holding office hours, and assigning grades in their individual courses.

**Admission Requirements**

In general, it is expected that students possess a bachelor’s degree in mathematics, statistics, or computer science. In some cases, students from other departments who have an interest and background in mathematics can be admitted into the master’s program or into a post baccalaureate program (from which they can transfer into the master’s program after taking the requisite background courses). All students entering the program are expected to have undergraduate prerequisite courses (linear algebra, differential equations, statistics, and a computer language) as well as undergraduate foundation courses (modern algebra, advanced calculus, probability, and discrete computing). Generally, an entering student is expected to have completed three of the four foundation courses prior to entry into the program in order to complete the master’s program in two years plus two summer sessions.

Deficiencies will ordinarily be removed by taking the corresponding mathematical sciences course (MTHS 6120, 6530, 6000, and 6600/8630, respectively).

Typical Requirements for admission include a bachelor’s degree with at least a 3.4 grade point average. A minimum GRE score of 750 (159 on current scale) Quantitative, 550 (156 on current scale) Verbal, and 4-5 Analytical Writing is also expected. (GRE quantitative scores of entering Masters students in recent years have averaged around 162 and undergraduate GPA’s have averaged approximately 3.7.)

For international students, a TOEFL score of at least 600(100 Internet Based) is required. On occasions, when other factors are considered (such as extremely strong letters of recommendation or extenuating circumstances in the undergraduate record), students may be admitted into the program; their progress in the first semester is then closely monitored by the Graduate Coordinator.

**Financial Support of M.S. Graduate Students**

The department supports virtually all graduate students on some type of assistantship, except for a few international students who may have support provided by their home country. Total assistantships are projected to be approximately $1,800,000 for the 2013-2014 school year. Full-time graduate research or teaching assistants qualify for reduced tuition and fees from the University. Graduate Assistants pay a flat fee per semester (currently close to $1100 per semester,
$450 per summer session), which is substantially lower than the regular cost of tuition and fees. Students are also responsible for a Health Insurance subsidy of approximately $700.

Entering M.S. students are supported almost exclusively with Graduate Teaching Assistantships. Advanced students may be supported as graduate research assistants. Teaching Assistantships are paid according to the following schedule:

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
<th>FALL</th>
<th>SPRING</th>
<th>SUMMER I</th>
<th>SUMMER II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MS</strong></td>
<td>$17,000</td>
<td>$7000</td>
<td>$7000</td>
<td>$1500</td>
<td>$1500</td>
</tr>
<tr>
<td><strong>PhD</strong></td>
<td>$17,000</td>
<td>$7000</td>
<td>$7000</td>
<td>$1500</td>
<td>$1500</td>
</tr>
<tr>
<td>PhD passed</td>
<td>$17,500</td>
<td>$7200</td>
<td>$7200</td>
<td>$1550</td>
<td>$1550</td>
</tr>
<tr>
<td>Preliminary Exams</td>
<td>$18,000</td>
<td>$7400</td>
<td>$7400</td>
<td>$1600</td>
<td>$1600</td>
</tr>
<tr>
<td>PhD passed</td>
<td>$18,000</td>
<td>$7400</td>
<td>$7400</td>
<td>$1600</td>
<td>$1600</td>
</tr>
<tr>
<td>Comprehensive Exams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Master’s students receive graduate teaching assistantships for two consecutive academic years and one summer session, which is the typical time required to complete the M.S. degree.

Teaching Assistants spend no more than twenty hours per week engaged in teaching activities. In their first semester, M.S. students assist in laboratory sessions, hold recitation sections for large lecture classes (college algebra and precalculus), administer quizzes and serve as resources in the Help Center. In their second semester, students assist instructors of (smaller section) classes, preparing them for teaching those classes in the second year.

Throughout, the students are supervised and mentored by faculty members who serve as course coordinators. In the second year, students are the teachers of record for approximately 8-9 credit hours of teaching per academic year. The department makes a conscious effort to limit the enrollment of the courses taught by second year graduate students to less than 20 students.

Research Assistantships carry a stipend of $17,000–$22,000 per year, with the amount varying according to the funding specified by the grant or contract. These assistantships require approximately twenty working hours per week (one-half time). No teaching responsibilities are involved, and the recipients are engaged in research with their faculty advisors. Research Assistantships often pay a somewhat higher rate than teaching assistantships and are awarded based on the availability and qualifications of the recipients.

In recent years, multiyear grants from The Office of Naval Research, The National Science Foundation, and private industry have supported several graduate students.

In addition, the University has available a number of fellowships that are awarded (by nomination only) on a competitive basis by the Graduate School. These fellowships currently pay $5,000 per academic year in addition to the assistantship provided by the department. Fellowships require no explicit duties. Applicants to our department have been quite successful in winning these awards in recent years. Typically, four of the department’s nominees have been offered such fellowships, with two of the nominees accepting the awards and joining the class of incoming master’s
students. SC Graduate Incentive Fellowships are also available to minority graduate students. These renewable awards provide $5,000 per year for master’s students.

Curriculum
Entering students undergo a four-day orientation and training program, which introduces them to the department and the master’s program. They also attend workshops provided by both the College of Engineering and Science and the Department on the duties and responsibilities of being a Graduate Teaching Assistant. Panel discussions are organized to discuss teaching methodologies as well as potential problems arising in the classroom. As part of this orientation program, the students are assigned to a temporary advisor, based on their initial interest area(s) in the mathematical sciences. Advisors meet with students and help the students plan courses for the upcoming year, taking into account any deficiencies in their undergraduate record that will need to be removed by appropriate coursework. It is expected that the students will fulfill the breadth requirement within the first calendar year. Any deviations from this deadline will have to be pre-approved by the Graduate Coordinator.

Nonthesis Option
The master’s degree is based on developing breadth as well as depth in the mathematical sciences; it requires two years of coursework and culminates with a master’s project, undertaken under the direction of a faculty member. For breadth, each student selects courses to satisfy certain distribution requirements across the spectrum of mathematical sciences. For depth, each student, in consultation with a faculty advisor, chooses six courses, which comprise a meaningful concentration in some specialty within the mathematical sciences. A minimum of 37 credit hours of courses is needed to complete the master’s program (twelve three-credit courses plus the one-credit master’s project course). Typical M.S. programs in the thesis option contain 40 hours of coursework.

Specifically, the breadth requirement consists of six 3-hour graduate courses: one selected from each of algebra/discrete mathematics, analysis, computing, operations research, and statistics plus one additional course in operations research or statistics. In addition, six 3-hour courses are selected to define an identifiable concentration area. Every student’s program is required to include at least one course, possibly chosen from outside the Department of Mathematical Sciences, that emphasizes mathematical modeling. As a means of integrating the student’s program of diverse study, a master’s project must be completed by the end of the second year. Each student chooses an advisor and master’s committee during the second semester. There is considerable flexibility in the topic and scope of the master’s project work; in some cases it can involve consulting for an external client and may generate financial support for the student. The student prepares a written report and also makes an oral presentation of the master’s project to his or her advisory committee.
Components of the M.S. (nonthesis) degree

<table>
<thead>
<tr>
<th>Prerequisites</th>
<th>Foundations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Algebra</td>
<td>Modern Algebra</td>
</tr>
<tr>
<td>Differential Equations</td>
<td>Advanced Calculus</td>
</tr>
<tr>
<td>Computer Language</td>
<td>Probability</td>
</tr>
<tr>
<td>Statistics</td>
<td>Discrete Computing Course</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Breadth Area</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>MTHS 8530: Matrix Analysis</td>
</tr>
<tr>
<td>Analysis</td>
<td>MTHS 8210: Linear Analysis</td>
</tr>
<tr>
<td>Scientific Computing</td>
<td>MTHS 8600: Intro. to Scientific Computation</td>
</tr>
<tr>
<td>Operations Research</td>
<td>MTHS 8100: Linear Programming</td>
</tr>
<tr>
<td>Statistics</td>
<td>MTHS 8050: Data Analysis</td>
</tr>
<tr>
<td>Statistics/OR</td>
<td>MTHS 8040: Intro. to Statistical Inference</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concentration Area</th>
<th>Master’s Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Six Courses</td>
<td>MTHS 8920</td>
</tr>
</tbody>
</table>

Concentration Areas
Students, in consultation with their advisor and their master’s committee, have flexibility in structuring the six 3-hour courses that define the concentration area. Typical areas of concentration are algebra/discrete mathematics, applied analysis, computing, operations research, and probability/statistics. Possible concentration courses in these areas are shown in below. It is also possible for a student to combine several of these disciplines to define a hybrid concentration area (such as financial mathematics). Graduate courses outside the Department of Mathematical Sciences can be used to fulfill the concentration requirement, if they contribute to a meaningful program for the student. In addition to the courses listed in the next table, Selected Topics courses (MTHS 98x0) are regularly offered within the various concentration areas.

Possible concentration courses by area

<table>
<thead>
<tr>
<th>Algebra/Discrete Mathematics</th>
<th>Applied Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTHS 8500: Computational Algebraic Geometry</td>
<td>MTHS 8210: Linear Analysis</td>
</tr>
<tr>
<td>MTHS 8510: Abstract Algebra I</td>
<td>MTHS 8220: Measure and Integration</td>
</tr>
<tr>
<td>MTHS 8520: Abstract Algebra II</td>
<td>MTHS 8230: Complex Analysis</td>
</tr>
<tr>
<td>MTHS 8530: Matrix Analysis</td>
<td>MTHS 8250: Introduction to Dynamical Systems Theory</td>
</tr>
</tbody>
</table>
### Computational Mathematics
- MTHS 8600: Introduction to Scientific Computing
- MTHS 8610: Advanced Numerical Analysis I
- MTHS 8630: Digital Models I
- MTHS 8650: Data Structures
- MTHS 8660: Finite Element Method

### Operations Research
- MTHS 8030: Stochastic Processes
- MTHS 8100: Mathematical Programming
- MTHS 8110: Nonlinear Programming
- MTHS 8120: Discrete Optimization
- MTHS 8130: Advanced Linear Programming
- MTHS 8140: Network Flow Programming
- MTHS 8160: Network Algorithms
- MTHS 8170: Stochastic Models I
- MTHS 8180: Stochastic Models II
- MTHS 8190: Multicriteria Optimization
- MTHS 8200: Complementarity Models
- MTHS 8740: Integration through Optimization

### Probability/Statistics
- MTHS 8000: Probability
- MTHS 8010: General Linear Hypothesis I
- MTHS 8020: General Linear Hypothesis II
- MTHS 8040: Statistical Inference
- MTHS 8050: Data Analysis
- MTHS 8060: Nonparametric Statistics
- MTHS 8070: Applied Multivariate Analysis
- MTHS 8080: Reliability and Life Testing

### Thesis Option
It is also possible for students to pursue the thesis option under the master’s program. In this case, the student again satisfies the breadth requirements (six 3-hour courses) listed above. A minimum of 36 credit hours of approved course work is required, which includes 6 hours of thesis research (MTHS 8910). The thesis is written according to Graduate School and Department guidelines.
under the direction of a research advisor, and the student presents the thesis research to his or her master’s thesis committee in an oral defense.

**Graduate Student Supervision**
The Department’s Graduate Coordinator assigns all new graduate students to a temporary academic advisor, based on the student’s transcript and stated interest areas. This academic advisor assists in planning for the first year’s courses (fall, spring, and summer), and also serves as a mentor to the student relative to curriculum matters and career choices. In addition, the student’s teaching activities are also monitored by a faculty member, typically the official course coordinator. In this way, feedback concerning effective teaching strategies is provided as well as advice about handling potential classroom problems. Each spring semester, new graduate students are required to attend a seminar in which faculty members from the department present their research interests and possible topics for master’s projects. M.S. students select their advisor and their master’s committee by the end of the second semester in the program, at which time the GS2 (plan of study) is filed with the Graduate school. The student’s M.S. committee is comprised of three faculty members (including their advisor), with at least two of the three members selected from the Department of Mathematical Sciences. The faculty advisor also serves as mentor for the student’s teaching activities during the second year. Classroom visits are scheduled and an on-line teaching evaluation form is submitted by the advisor after each visit.

During the past five years, over 30 faculty members have served as advisors to master’s degree students, helping to plan their curriculum and directing their master’s project. In addition, faculty serve on the advisory committees that approve each student’s curriculum plan and administer the final oral examination on the student’s project. A faculty member also serves as the advisor to the SIAM (Society for Industrial and Applied Mathematics) student chapter, helping the three student officers gain leadership experience.
International Cooperative Programs
The Department of Mathematical Sciences has two international cooperative programs with universities in Germany and one in Russia.

University of Kaiserslautern
Together with the Department of Mathematics in Kaiserslautern, Germany, the department offers a graduate exchange program in mathematical sciences. This program was established in 1996 and enables exchange students to receive the M.S. degree from their home university and the host university. This is an innovative exchange program enabling Clemson students to obtain two graduate degrees and a cross-cultural, educational experience from Germany.

Eligibility
For current qualifying guidelines please refer to the agreement on the Department of Mathematical Sciences web site.

Schedule
This is at least a two-and-a-half-year program. Individual schedules will be determined depending on the credentials of each student.

Financial Aid
Students from Clemson University participating in the exchange program will be offered graduate assistantships at the University of Kaiserslautern equivalent to those that are offered to master’s level graduate students in the University of Kaiserslautern, Department of Mathematics.

Final Degrees
The intent of the program is for a student to earn two graduate degrees: one from the home university and one from the host university. Participating students must meet all applicable academic requirements of each university in order to earn that university’s degree.

Location
The University of Kaiserslautern is located in the state of Rheinland-Pfalz, 70 miles from Frankfurt, a city with the biggest airport in Europe. It is a leading technical university in Germany with a student body of over 9,000 students. The Department of Mathematics at this university has been the first mathematics department in Germany to receive a German federal government grant for the program Mathematics International. Participants of the program are German and foreign students in approximately equal numbers.

Language
All lectures are held in English, which makes Kaiserslautern a unique place in Germany, and most likely in Europe, with this kind of program.

Curriculum in Germany
A single master's project will suffice for both degrees.
Students can choose to specialize in one of the following five areas:
- Algebraic Geometry and Computer Algebra
- Financial Mathematics
- Applicable Analysis and Probability
- Industrial Mathematics: Modeling and Scientific Computing
Optimization and Statistics

For further information contact: Dr. Margaret M. Wiecek, O-208 Martin Hall, tel: 864 656 5245, wmalgor@clemson.edu

University of Bremen
The Department of Mathematical Sciences at Clemson University and the Center of Industrial Mathematics at the University of Bremen agree to a cooperative program for Graduate Students. The primary purpose of the program is to give students an international experience in graduate school. Additional purposes are to promote joint research and educational experiences between the universities, to enhance faculty and other exchanges between the universities, and to strengthen international cooperation. The program is directed at the preparation of highly qualified and internationally aware graduate students.

Description
Clemson University graduate students who have completed their first year of study will participate in a summer program at Bremen for a period of two and a half months. At Bremen, participating Clemson students will take one mathematics course for four weeks, work on a research project for another four weeks as a part of their pre-determined research project, and spend another two weeks for writing up the project. The Center of Industrial Mathematics will offer the summer course in English as well as supervise research projects in English. A maximum of four Clemson students may participate in this program every year.

Eligibility
In order to participate in the cooperative program, students must have completed two semesters of graduate studies at Clemson University. Additional academic standards will be required by the University of Bremen.

Admissions
Admissions decisions for the summer program at the University of Bremen for Clemson students in Mathematical Sciences will be based on academic records at Clemson and on recommendations by the faculty members at Clemson. At most, four Clemson students can participate in the summer program each year. Clemson students participating in the summer program will be exempted from any language requirement for admission to summer programs at the University of Bremen. In particular, Clemson students en route to their PhD or students interested in a Master’s Thesis option are most encouraged to apply for this program.

Final Degrees
Clemson University students will receive a certificate of participation in the summer program from the University of Bremen. The intent of the summer program is to supplement the Clemson graduate program with international experience for Clemson students as well as foster research collaboration between Clemson and the University of Bremen.

Financial Assistance
Students from Clemson participating in the program will be offered a summer graduate research assistantship from the Department of Mathematical Sciences at Clemson. The Center of Industrial Mathematics will supplement the summer support for graduate students by covering local expenses in Germany – to include student accommodation and some expense money for the summer.
Airfare and other expenses related to travel in Europe are the responsibility of the participating Clemson student.

For further information contact: Dr. Taufiquar Khan, O-201 Martin Hall, tel: 864 656 3257, khan@clemson.edu.

**Russian Academy of Sciences**
The Department of Mathematical Sciences at Clemson University and the Institute of Machine Sciences at Russian Academy of Sciences in Moscow, Russia (IMASH) agree to implement a Graduate Student Exchange Agreement. The purpose of this agreement is to enhance the educational experience and the cross-cultural understanding of students and faculty from both institutions. The program is directed at the preparation of highly qualified and internationally aware graduate students.

**Description**
Clemson University graduate students who have completed two semesters of study are eligible to participate in the program at IMASH for either a full semester or for a shorter, summer program. The purpose of each student exchange will be to enable students to take classes and/or engage in research activities at, but not to pursue a degree from, IMASH. Academic work passed at IMASH will normally be accepted for credit towards the MS or PhD degree at Clemson.

**Eligibility**
In order to participate in the student exchange, students must have completed two semesters of graduate studies at Clemson University. Additional academic standards will be required by IMASH.

**Admissions**
Students will be screened for eligibility for admission to the student exchange with respect to the standard rules, regulations, and availability of positions at IMASH (www.imash.ru). Prospective Semester Track students should follow the admissions procedures or IMASH as described on their website (www.imash.ru). Semester Track admissions decisions will be based on academic records and faculty recommendations. Students must also meet requirements of language proficiency whose first language is not Russian. At most two Clemson students may participate in the Semester Track. Admissions decisions for the Summer Program at IMASH will be based solely on academic records and recommendations by the faculty members at Clemson. At most four Clemson students can participate in the summer program and will be exempted from any language requirement for admission at the IMASH, however enrollment in a Russian language class while at IMASH is encouraged.

**Financial Assistance**
Students from Clemson participating in the Semester Track will be offered graduate assistantships at the IMASH equivalent to those that are offered to graduate students at IMASH. Clemson students participating in the Summer Program at IMASH will be offered regular summer graduate assistantships by the Department of Mathematical Sciences. Airfare and other expenses related to travel in Europe are the responsibility of the participating Clemson student.

For further information, contact Dr. Irina Viktorova, O-219 Martin Hall, iviktor@clemson.edu, tel. 656-6906.
Doctor of Philosophy Program

Program Purpose
As before mentioned, the Department began a complete restructuring of its graduate programs in 1975, aided by the NSF grant Alternatives in Higher Education. In addition to constructing an applied master’s program, geared to preparing graduates for nonacademic careers, the NSF grant also called for the development of a Ph.D. program that would build upon the breadth-and-depth philosophy of the M.S. degree. The resulting Ph.D. program was approved by the faculty in the spring of 1979.

In particular, the Doctor of Philosophy program in mathematical sciences emphasizes a solid foundation in five areas (algebra/discrete mathematics, analysis, computational mathematics, operations research, and probability/statistics), with in-depth dissertation research carried out in a specific area. The Ph.D. program structures these five areas of the mathematical sciences into three disciplines: applied and computational analysis (continuous modeling), discrete mathematics (discrete modeling), and statistics and probability (stochastic modeling). Doctoral research within each discipline may range from topics having a strong emphasis on modeling to those that are purely theoretical. All graduate students are required to have a significant exposure to modeling throughout the curriculum. The Department believes that a generous exposure to modeling is valuable for all students in preparation for academic as well as industrial careers.

Goals
- to offer a Doctor of Philosophy degree with a foundation in broad areas of the mathematical sciences, with a research focus in one of these areas
- to prepare doctorate level mathematical scientists for a successful career in industry, government, or academia.

Objectives
The major objectives of the Doctor of Philosophy degree program are to develop students
- who are broadly trained in the mathematical sciences
- who have an in-depth understanding of a specialized area
- who can effectively communicate
- who have flexible career options in both academic and nonacademic spheres

Doctoral Graduate Student Profile
There are typically over 70 students enrolled each year in the Doctor of Philosophy program, with approximately 7 to 8 students earning their doctorates each year. The Ph.D. program attracts a significant number of females into the program, counter to the trend at most mathematics/statistics programs. On average, some 32.9% of students in the doctoral program are female. U.S. citizens comprise 44.5% of doctoral candidates in the program, again running counter to national trends. Both of these statistics are expected to rise due to the composition of the MS program.

These demographics dovetail well with the goals of our graduate program (in which such graduates have increased opportunities for both nonacademic and academic careers). Also, the abundance of U.S. citizens, considering both MS and PhD students, is necessitated by the fact that graduate students teach a large number of service courses for the university. Most doctoral candidates are utilized by the department as teaching assistants, who have primary responsibility
for lecturing, holding office hours, and assigning grades in their individual courses. Other doctoral students are supported by research grants and contracts obtained by faculty in the department.

**Admission Requirements**

In general, it is expected that students possess a master’s degree in mathematics, statistics, or a very closely related area. Moreover, sufficient breadth of training in the mathematical sciences is expected. For example, students who already possess a master’s degree from the Department of Mathematical Sciences already satisfy this breadth requirement. In cases of students who have M.S. degrees from other universities, it should be possible to remedy any deficiencies in background courses within one year of doctoral study at Clemson.

Requirements for admission include a master’s degree with at least a 3.4 grade point average on graduate work. A minimum GRE score of 159 (750 on old scale) Quantitative, 156 (550 on old scale) Verbal, and 4-5 Analytical Writing is also expected. For international students, a TOEFL score of at least 600 (100 Internet Based) is required. On occasions, when other factors are considered (such as extremely strong letters of recommendation or extenuating circumstances in the prior graduate work), students may be admitted into the program; their progress in the first semester is then closely monitored by the Graduate Coordinator.

**Financial Support of Ph.D. Graduate Students**

The department supports virtually all graduate students on some type of assistantship, except for a few international students who may have support provided by their home country. Total assistantships are projected to be approximately $1,800,000 for the 2013-2014 school year. Full-time graduate research or teaching assistants qualify for reduced tuition and fees from the University. Graduate Assistants pay a flat fee per semester (currently close to $1100), which is substantially lower than the regular cost of tuition and fees. Students are also responsible for a Health Insurance subsidy of approximately $700.

Ph.D. students are supported primarily by Graduate Teaching Assistantships. Teaching Assistantships are paid according to the following schedule:

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
<th>FALL</th>
<th>SPRING</th>
<th>SUMMER I</th>
<th>SUMMER II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MS</strong></td>
<td>$17,000</td>
<td>$7000</td>
<td>$7000</td>
<td>$1500</td>
<td>$1500</td>
</tr>
<tr>
<td><strong>PhD</strong></td>
<td>$17,000</td>
<td>$7000</td>
<td>$7000</td>
<td>$1500</td>
<td>$1500</td>
</tr>
<tr>
<td><strong>PhD passed</strong></td>
<td>$17,500</td>
<td>$7200</td>
<td>$7200</td>
<td>$1550</td>
<td>$1550</td>
</tr>
<tr>
<td>Preliminary Ex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PhD passed</strong></td>
<td>$18,000</td>
<td>$7400</td>
<td>$7400</td>
<td>$1600</td>
<td>$1600</td>
</tr>
<tr>
<td>Comprehensive Ex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All Ph.D. students will receive graduate teaching assistantships for the duration of their matriculation, so long as they are making sufficient and satisfactory progress toward the Ph.D. degree and fulfill their assistantship duties.
Teaching Assistants spend no more than twenty hours per week engaged in teaching activities (approximately 8–9 credit hours of teaching per academic year). Their duties typically involve the teaching of undergraduate classes, under the supervision of a faculty course coordinator.

Some students are supported as graduate research assistants, when they possess relevant qualifications. Currently 5 students are supported by research grants or contracts. Research Assistantships carry a stipend of $17,000–$24,000 per year, with the amount varying according to the funding specified by the grant or contract. These assistantships require approximately twenty working hours per week (one-half time). No teaching responsibilities are involved, and the recipients are engaged in research with their faculty advisors. Research Assistantships often pay a somewhat higher rate than teaching assistantships and are awarded based on the availability and qualifications of the recipients. In recent years, multiyear grants from The Office of Naval Research, The National Science Foundation, and private industry have supported several graduate students, as well as grants or contracts to individual faculty members.

In addition, the University has available several fellowships that are awarded (by nomination only) to Ph.D. students on a competitive basis by the Graduate School. These fellowships currently pay $5,000 to $10,000 per academic year in addition to the assistantship provided by the department. Fellowships require no explicit duties. The College of Engineering and Science also has the Dean’s Scholars Program, which provides supplementary awards to exceptional Ph.D. students for three years. SC Graduate Incentive Fellowships are also available to minority graduate students; these renewable awards provide $10,000 per year for doctoral students.

**Curriculum**

Clemson University has pioneered the concept of integrating the areas of the mathematical sciences (algebra/combinatorics, analysis, computational mathematics, operations research and statistics/probability) into a balanced educational program. The Ph.D. degree structures the five areas of the mathematical sciences into three disciplines: applied and computational analysis (continuous modeling), discrete mathematics (discrete modeling) and statistics and probability (stochastic modeling). Ph.D. students may pursue their interests in any area of the mathematical sciences by choosing one of these disciplines. Doctoral research within each discipline may range from topics having a strong emphasis on modeling to those that are purely theoretical. All graduate students have a significant exposure to modeling throughout the curriculum. The department believes that a generous exposure to modeling is valuable for all students as preparation for academic as well as industrial careers.

Students are admitted to candidacy for the Ph.D. degree upon successful completion of the preliminary examination and the comprehensive examination. The preliminary examination consists of three tests chosen from any of the areas of algebra, analysis, computing, operations research, statistics or stochastic processes. The comprehensive examination assesses the student's readiness to perform independent research and competency in advanced graduate material. After completion of the thesis, a final oral examination is administered by the advisory committee.
Curriculum Guidelines
(1) The composition of the candidate's Ph.D. advisory committee should reflect the breadth and interdisciplinary nature of the department's doctoral program.
(2) The plan of study should include at least two 3-hour graduate courses in each of the five areas: algebra and combinatorics, analysis, computational mathematics, operations research and statistics and probability.
(3) The plan of study should include twenty or more hours of 8000 or 9000 level graduate courses constructed to give depth to the student's concentration area and to supporting secondary area. Here area refers to those listed in (2).
(4) Normally, students should begin to participate in seminars and pursue independent research no later than the third year of graduate studies.

If these guidelines are not met, the Director of Graduate Studies will discuss the student's plan of study with the student's advisor and with the Graduate Affairs Committee.

Graduate-level concentration courses by area

<table>
<thead>
<tr>
<th>Algebra</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTHS 8500: Computational Algebraic Geometry</td>
<td>MTHS 8210: Linear Analysis</td>
</tr>
<tr>
<td>MTHS 8510: Abstract Algebra I</td>
<td>MTHS 8220: Measure and Integration</td>
</tr>
<tr>
<td>MTHS 8520: Abstract Algebra II</td>
<td>MTHS 8230: Complex Analysis</td>
</tr>
<tr>
<td>MTHS 8530: Matrix Analysis</td>
<td>MTHS 8250: Dynamical Systems</td>
</tr>
<tr>
<td>MTHS 8540: Theory of Graphs</td>
<td>MTHS 8260: Partial Differential Equations</td>
</tr>
<tr>
<td>MTHS 8550: Combinatorial Analysis</td>
<td>MTHS 8270: Neural Networks</td>
</tr>
<tr>
<td>MTHS 8560: Applicable Algebra</td>
<td>MTHS 8310: Fourier Series</td>
</tr>
<tr>
<td>MTHS 8570: Cryptography</td>
<td>MTHS 8370: Calculus of Variations and Optimal Control</td>
</tr>
<tr>
<td>MTHS 8580: Number Theory</td>
<td>MTHS 8410: Applied Mathematics I</td>
</tr>
<tr>
<td>MTHS 9510: Algebraic Number Theory</td>
<td>MTHS 9270: Functional Analysis</td>
</tr>
<tr>
<td>MTHS 9520: Analytic Number Theory</td>
<td></td>
</tr>
<tr>
<td>MTHS 9540: Advanced Graph Theory</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Computational Mathematics</th>
<th>Operations Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTHS 8600: Intro. to Scientific Computation</td>
<td>MTHS 8030: Stochastic Processes</td>
</tr>
<tr>
<td>MTHS 8610: Advanced Numerical Analysis I</td>
<td>MTHS 8100: Mathematical Programming</td>
</tr>
<tr>
<td>MTHS 8630: Digital Models I</td>
<td>MTHS 8110: Nonlinear Programming</td>
</tr>
<tr>
<td>MTHS 8650: Data Structures</td>
<td>MTHS 8120: Discrete Optimization</td>
</tr>
<tr>
<td>MTHS 8660: Finite Element Method</td>
<td>MTHS 8130: Advanced Linear Programming</td>
</tr>
<tr>
<td></td>
<td>MTHS 8140: Network Flow Programming</td>
</tr>
<tr>
<td></td>
<td>MTHS 8160: Network Algorithms</td>
</tr>
<tr>
<td></td>
<td>MTHS 8170: Stochastic Models I</td>
</tr>
<tr>
<td></td>
<td>MTHS 8180: Stochastic Models II</td>
</tr>
<tr>
<td></td>
<td>MTHS 8190: Multicriteria Optimization</td>
</tr>
<tr>
<td>Probability/Statistics</td>
<td>MTHS 8200: Complementarity Models</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td></td>
<td>MTHS 8740: Integration through</td>
</tr>
<tr>
<td></td>
<td>Optimization</td>
</tr>
</tbody>
</table>

**Mathematical Sciences Ph.D. Examinations**

The Ph.D. qualifying examination consists of two parts: (1) the preliminary examination, and (2) the comprehensive examination.

1. **Preliminary Examination**: This examination covers material essential to research in the mathematical sciences and it is administered by the Graduate Affairs Committee. Students are encouraged to take preliminary exams as soon as the required course work is completed. Examinations will be given in mid July and early January of each year. Students entering the PhD program with a Masters (Bachelors) Degree in mathematical sciences or equivalent must pass all three exams within two (three) calendar years of full-time enrollment in the PhD program. A student who has not passed three exams within the specified time limits or has failed more than three attempted exams will be dropped from the Ph.D. program. Each student is required to pass three of the following six exams:

   - Algebra
   - Analysis
   - Computational Mathematics
   - Mathematical Programming
   - Statistics
   - Stochastic Processes

An outline of topics to be covered in each is available upon request. Relevant coursework is as follows:

**Background courses for the preliminary examination**

<table>
<thead>
<tr>
<th>Algebra</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTHS 8510: Abstract Algebra I</td>
<td>MTHS 8210: Linear Analysis</td>
</tr>
<tr>
<td>MTHS 8530: Matrix Analysis</td>
<td>MTHS 8220: Measure and Integration</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Computational Mathematics</th>
<th>Mathematical Programming</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTHS 8600: Intro. to Scientific Computation</td>
<td>MTHS 8100: Linear Programming</td>
</tr>
<tr>
<td>MTHS 8650: Data Structures</td>
<td>MTHS 8130: Advanced Linear Programming</td>
</tr>
<tr>
<td></td>
<td>MTHS 8140: Network Flow Programming</td>
</tr>
</tbody>
</table>
A student is granted the opportunity to retake any failed exam when it is next offered. A student may choose exams from any subjects except those for which exams have already been passed.

2. Comprehensive Examination: This examination is required by the Graduate School. It may be oral and/or written and will be constructed by the student’s Ph.D. advisory committee. It serves three purposes:
   - to assess the student’s readiness to perform independent research
   - to assess the student’s competency in advanced graduate material relevant to the student’s research area
   - to provide a forum for members of the committee to learn about and provide input into the student’s proposed research program

A thesis proposal is not a required part of the comprehensive examination, although such a proposal is frequently included as part of the examination. The primary objective of the examination is to assess the student’s readiness for doctoral research. The student’s entire committee should determine the nature of the examination. This must be passed within 2 semesters of completing the preliminary exams.

The Graduate School requires that a student have an advisory committee and file a plan of study (GS2) prior to his/her comprehensive examination. The advisory committee is required to notify the Graduate School of a pass or fail within three weeks of the examination. In the event of failure, the advisory committee may recommend a second attempt. Failure of a second examination precludes the student from receiving a Ph.D. degree from Clemson University in Mathematical Sciences. Once the comprehensive examination is passed, the Graduate School will formally admit the student to candidacy for the Ph.D. degree. The comprehensive exam must be passed within two semesters of completing preliminary exams.

Degree Progress
Full time Ph.D. students are expected to complete all degree requirements within five years of graduate study at Clemson (three years if MS in mathematical sciences obtained prior to enrollment). In order to meet this expectation, some preliminary exams and the comprehensive exam may have to be taken concurrently rather than sequentially.

A student not making satisfactory progress toward a degree as outlined by these guidelines is in jeopardy of losing departmental support or being dropped from the doctoral program. A student must petition the Graduate Affairs Committee in order to relax these guidelines.

Graduate Student Supervision
The Department’s Graduate Coordinator assigns all new Ph.D. students to a temporary academic advisor, based on the student’s stated interest areas. After successfully passing the preliminary examinations, the student selects a research advisor who agrees to direct the student’s doctoral dissertation work. A faculty member (often the research advisor) is also assigned to monitor the student’s teaching activities and provide feedback on pedagogical matters. An advisory committee (of four members, including the research advisor) is then constructed to reflect the breadth and
interdisciplinary nature of the department’s doctoral program. At least three of the four members of the advisory committee must be full-time members of the Department of Mathematical Sciences.

During the past five years, 13 faculty members have served as research advisors to doctoral degree students, helping to plan their curriculum and directing their dissertation. In addition, faculty members serve on the advisory committees that approve each student’s curriculum plan and administer the comprehensive examination as well as the final oral examination for the doctorate. A typical advising load is one to two Ph.D. students per senior faculty. Several faculty members serve as mentors for the teaching activities carried out by the doctoral candidates as part of their assistantship duties. Also, a faculty member serves as the advisor to the SIAM (Society for Industrial and Applied Mathematics) student chapter, helping the four student officers gain leadership experience.

**Communication Skills**
In addition to breadth of academic training, virtually every study dealing with graduate student preparation for today’s job market stresses the importance of communication skills in preparation for college teaching as well as nonacademic jobs. The Doctor of Philosophy program attempts to facilitate the acquisition of such skills in various ways. The most obvious opportunity is in the role of classroom instructors, experience that is gained as teaching assistants. This training provides an opportunity for students to gain poise and self-confidence in front of an audience, whether it is a group of students in the classroom or a future group of clients or business associates in a board room. To prepare students for this role, all new Graduate Teaching Assistants are required to attend a four-day orientation session prior to commencement of classes. As part of this orientation program, they attend workshops provided by both the College of Engineering and Science and the Department on the duties and responsibilities of being a Graduate Teaching Assistant. Topics include: teaching methodologies (including the use of audiovisual aids and computing facilities in the smart classrooms) as well as potential problems arising in the classroom (such as cheating, plagiarism, and sexual harassment).

In addition to the above training given to all Graduate Teaching Assistants, special opportunities have been provided for all advanced Ph.D. students (i.e., students who have passed the preliminary examination). With support from the Fund for the Improvement of Post Secondary Education (FIPSE), Clemson was one of eight universities selected to cooperate with the AMS-MAA-SIAM Committee on Preparation for College Teaching in developing specific practices aimed at advanced graduate students. (The other participants were the University of Cincinnati, Dartmouth College, the University of Delaware, Harvard University, Oregon State University, the University of Tennessee, and Washington University.) These activities, directed by a faculty member who had been recognized for excellence in research and teaching with a University Alumni Professorship, a SC Teacher of the Year award, and a national MAA teaching award, focus on the following goals:

- helping students become more effective teachers
- helping students become more aware of the components and expectations of the profession
- broadening students’ mathematical sciences perspectives

These goals were met through the careful design of a professional seminar (MTHS 900) carrying three semester hours of graduate credit. In addition to reading and discussing relevant literature on effective teaching in the mathematical sciences, students visit the classrooms of well-respected teachers in the department and report their results to the class. Later in the semester, students
themselves present both a 50 minute classroom lecture and a 15 minute research lecture, which are videotaped and then critiqued. Outside speakers visit the class to discuss a range of issues relevant to those entering collegiate teaching positions: e.g., tenure and grant expectations, treatment of minorities and women, technology in the classroom, ethical issues, and professional service.

**Recent Industrial Employers**

- The Acacia Group
- Axiom Corporation
- Bank One
- Bank USA
- Blue Cross/Blue Shield
- BMW
- Capital One
- Centers for Disease Control
- Department of Defense
- J. D. Edwards
- Ericsson Inc.
- Fair, Isaac and Company
- Federal Reserve Bank
- First Union Securities
- First USA Bank
- Genworth Financial
- Global Energy Decisions
- Greenville Hospital System
- GTE
- IBM Corporation
- Institute for Defense Analyses
- Lockheed Martin
- Lucent Technologies
- Melita International
- Michelin Corporation
- Micron Technology Inc.
- Milliken & Company
- Naval Air Systems Command
- National Security Agency
- NVision Solutions, Inc.
- Rodale Press
- Sabre Systems
- SAIC
- SAS Institute
- Scientific Research Corporation
- Software Technology Inc.
- Solipsys Corporation
- Sonoco
- Sparta Inc.
- Talus Solutions, Inc.
- Technology Strategy Inc.
- Trilogy Computing
- Unisys
- WorldCom
A Closer Look into the Areas of Study

Degree programs are organized by discipline into five areas in the mathematical sciences: algebra and discrete mathematics, applied analysis, computational mathematics, operations research, and probability and statistics. Each of these areas is described briefly with a list of associated courses, and faculty. Although the areas are described separately, there is considerable overlap and interaction between the areas.

<table>
<thead>
<tr>
<th><strong>PURE AND APPLIED ANALYSIS</strong></th>
<th><strong>OPERATIONS RESEARCH</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brannan</td>
<td>Adams</td>
</tr>
<tr>
<td>Chen</td>
<td>Fralix</td>
</tr>
<tr>
<td>Khan, Coordinator</td>
<td>Gupte</td>
</tr>
<tr>
<td>S. Liu</td>
<td>Kiessler</td>
</tr>
<tr>
<td>Mitkovski</td>
<td>X. Liu</td>
</tr>
<tr>
<td>Peterson</td>
<td>Nasrabadi</td>
</tr>
<tr>
<td>Schmoll</td>
<td>Saltzman</td>
</tr>
<tr>
<td>Yoon</td>
<td>Shier</td>
</tr>
<tr>
<td>Non-Voting Faculty:</td>
<td>Wieccek</td>
</tr>
<tr>
<td>Cox, Ervin</td>
<td>Non-Voting Faculty:</td>
</tr>
<tr>
<td></td>
<td>Kulasekera, Novick</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Statistics and Probability</strong></th>
<th><strong>Algebra &amp; Discrete Mathematics</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Brown</td>
<td>Burr, Michael</td>
</tr>
<tr>
<td>C. Gallagher</td>
<td>J. Brown, Coordinator</td>
</tr>
<tr>
<td>Lund</td>
<td>Calkin</td>
</tr>
<tr>
<td>McMahan</td>
<td>Coykendall</td>
</tr>
<tr>
<td>Park, Coordinator</td>
<td>Dimitrova</td>
</tr>
<tr>
<td>X. Sun</td>
<td>Gao</td>
</tr>
<tr>
<td>Taylor</td>
<td>Goddard (joint w/SoC)</td>
</tr>
<tr>
<td>Williams</td>
<td>James</td>
</tr>
<tr>
<td>Non-Voting Faculty:</td>
<td>Macauley</td>
</tr>
<tr>
<td>Kiessler</td>
<td>Manganiello</td>
</tr>
<tr>
<td></td>
<td>Matthews</td>
</tr>
<tr>
<td></td>
<td>Novick</td>
</tr>
<tr>
<td></td>
<td>Poznanovikj</td>
</tr>
<tr>
<td></td>
<td>Xue</td>
</tr>
<tr>
<td>Non-Voting Faculty:</td>
<td>Non-Voting Faculty:</td>
</tr>
<tr>
<td></td>
<td>Kiessler</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Computational Mathematics</strong></th>
<th><strong>Undergraduate Education</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cawood</td>
<td>Bannister (Joint w/SoE)</td>
</tr>
<tr>
<td>Cox</td>
<td>Parrott</td>
</tr>
<tr>
<td>Ervin</td>
<td>Biggers</td>
</tr>
<tr>
<td>Heister</td>
<td>Prevost</td>
</tr>
<tr>
<td>Jenkins</td>
<td>Burr, Meredith</td>
</tr>
<tr>
<td>Lee, Coordinator</td>
<td>Reba</td>
</tr>
<tr>
<td>Moss</td>
<td>Cottingham</td>
</tr>
<tr>
<td>Rebholz</td>
<td>Rios-Adams</td>
</tr>
<tr>
<td>Warner</td>
<td>Davidson</td>
</tr>
<tr>
<td>Non-Voting Faculty:</td>
<td>Schick</td>
</tr>
<tr>
<td>Peterson, Saltzman</td>
<td>Dogby (joint w/SoE)</td>
</tr>
<tr>
<td></td>
<td>Simms</td>
</tr>
<tr>
<td>Non-Voting Faculty:</td>
<td>E. Gallagher</td>
</tr>
<tr>
<td></td>
<td>Stoddard</td>
</tr>
<tr>
<td></td>
<td>Guest</td>
</tr>
<tr>
<td></td>
<td>Teitloff</td>
</tr>
<tr>
<td></td>
<td>J. Hanna</td>
</tr>
<tr>
<td></td>
<td>Tyminski (joint w/SoE)</td>
</tr>
<tr>
<td></td>
<td>L. Hanna</td>
</tr>
<tr>
<td></td>
<td>Van Dyken, Coordinator</td>
</tr>
<tr>
<td></td>
<td>C. Johnson</td>
</tr>
<tr>
<td></td>
<td>Viktorova</td>
</tr>
<tr>
<td></td>
<td>T. Johnson</td>
</tr>
<tr>
<td></td>
<td>Walker</td>
</tr>
<tr>
<td></td>
<td>Keaton</td>
</tr>
<tr>
<td></td>
<td>Zhao</td>
</tr>
<tr>
<td></td>
<td>Lassiter</td>
</tr>
<tr>
<td></td>
<td>McKnew</td>
</tr>
<tr>
<td></td>
<td>Newton</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Applied Statistics</strong></th>
<th>Non-Voting Faculty:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breazel</td>
<td></td>
</tr>
<tr>
<td>Bridges</td>
<td></td>
</tr>
<tr>
<td>Luo</td>
<td></td>
</tr>
<tr>
<td>Dubsky</td>
<td></td>
</tr>
<tr>
<td>Martinez-Dawson</td>
<td></td>
</tr>
<tr>
<td>Gerard</td>
<td></td>
</tr>
<tr>
<td>Rieck</td>
<td></td>
</tr>
<tr>
<td>Hill, Coordinator</td>
<td></td>
</tr>
<tr>
<td>Sharp</td>
<td></td>
</tr>
<tr>
<td>Non-Voting Faculty:</td>
<td></td>
</tr>
<tr>
<td>Peterson</td>
<td></td>
</tr>
<tr>
<td>Non-Voting Faculty:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Other Teaching Faculty Members</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Professor Emeritus</strong></td>
</tr>
<tr>
<td>Brawley</td>
</tr>
<tr>
<td>Dearing</td>
</tr>
<tr>
<td>Fennell</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

23
SOME FACULTY INTEREST AREAS

ALGEBRA/DISCRETE MATH
- Graph Theory
- Combinatorics
- Geometry
- Coding Theory
- Cryptography
- Discrete Mathematics
- Finite Fields
- Number Theory

APPLIED ANALYSIS
- Nonlinear Differential Equations
- Biomathematical Modeling
- Financial Mathematics
- Partial Differential Equations
- Control Theory
- Dynamical Systems
- Neural Networks
- Functional Analysis

COMPUTATIONAL MATHEMATICS
- Fluid Dynamics
- Integral Equations
- Discrete Computing
- Environmental Modeling
- Simulation
- Parallel Processing

OPERATIONS RESEARCH
- Mathematical Programming
- Optimization
- Network Algorithms
- Stochastic Processes
- Graph Theory
- Computational OR

STATISTICS
- Decision Theory
- Reliability
- Data Analysis
- Statistical Computing
- Quality Control
- Sampling Theory
- Biostatistics
- Artificial Intelligence
- Experimental Design
Algebra and Discrete Mathematics

The area of algebra and discrete mathematics encompasses both theoretical and applied aspects of mathematics that are foundational for matrix analysis, modern algebra, number theory, combinatorics, and graph theory. This area of study has a significant impact on applications arising in statistics (linear models, experimental designs), probability (random models), operations research (mathematical programming, network analysis), communication engineering (coding theory, cryptography), and computer science (analysis of algorithms, nonnumerical computing). Students interested in the underlying theory of algebraic and discrete structures will also gain insights into how these concepts are fundamental to a wide array of practical problems.

Faculty

J. Brown » modular forms, Bloch-Kato conjecture, Iwasawa theory, Galois representations, special values of L-functions
M. Burr » algebraic geometry, computational geometry, and numerical algebraic geometry
N. J. Calkin » combinatorics, number theory, probabilistic methods
J. Coykendall » commutative algebra, number theory
Dimitrova » computational algebra, finite dynamic systems, systems biology, discrete modeling of biochemical networks
S. Gao » finite fields, cryptography, coding theory, computer algebra, combinatorial designs, algorithmic number theory
W. Goddard » graph theory, combinatorics and discrete math, graph and distributed algorithms
K. James » number theory, modular forms, elliptic curves
M. Macauley » discrete dynamical systems over graphs and complex systems
F. Manganiello » coding theory, cryptography, computational algebra
G. Matthews » algebraic coding theory
B. Novick » graph theory and combinatorial optimization
S. Poznanovikj » enumerative and algebraic combinatorics, discrete mathematical biology
H. Xue » number theory

Curriculum

The algebra and discrete mathematics concentration is structured around the following courses: abstract algebra, matrix analysis, applicable algebra, combinatorial analysis, and graph theory. All of these courses emphasize the algebraic, combinatorial, and graph-theoretic structures used to model problems arising in engineering, the life sciences, economics, statistics, operations research, and computer science. Abstract algebra surveys groups, rings, fields, and lattices. Matrix analysis treats a variety of topics in matrix theory which support a modern applied curriculum. Combinatorial analysis emphasizes applied topics from enumeration, graph theory, optimization, and block designs. Graph theory is the study of paths and networks, connectivity, trees, coverings, and coloring problems. The applicable algebra course and associated selected topics courses (cryptography, coding theory, finite fields, computational algebra) cover material that is of great interest in computer design and in ensuring the accuracy and security of digital information. Additional courses are available that integrate concepts from algebra and discrete mathematics with the areas of analysis, computational mathematics, operations research, and probability/statistics.

Courses

MTHS 8500: Computational Algebraic Geometry, 3 cr. (3 and 0) Covers algebraic geometry and commutative algebra via Grobner bases. Includes ideals and varieties (affine and projective), Grobner bases, elimination theory, dimensions, and solving polynomial systems via eigenvalues
and eigenvectors. Selected applications may include coding theory, computer vision, geometric theorem proving, integer programming, or statistics. Prerequisite: MTHS 3110 and 4120.

MTHS 8510: Abstract Algebra I, 3 cr. (3 and 0) S Basic algebraic structures: groups, rings and fields; permutation groups, Sylow theorems, finite abelian groups, polynomial domains, factorization theory and elementary field theory.

MTHS 8520: Abstract Algebra II, 3 cr. (3 and 0) F A continuation of MTHS 8510 including selected topics from ring theory and field theory.

MTHS 8530: Matrix Analysis, 3 cr. (3 and 0) F, S Topics in matrix analysis that support an applied curriculum: similarity and eigenvalues; Hermitian and normal matrices; canonical forms; norms; eigenvalue localizations; singular value decompositions; definite matrices. Prerequisite: MTHS 3110, 4530 or 4630.

MTHS 8540: Theory of Graphs, 3 cr. (3 and 0) S Connectedness; path problems; trees; matching theorems; directed graphs; fundamental numbers of the theory of graphs; groups and graphs. Prerequisite: permission of instructor.

MTHS 8550: Combinatorial Analysis, 3 cr. (3 and 0) F Combinations; permutations; permutations with restricted position; Polya's theorem; principle of inclusion and exclusion; partitions; recurrence relations; generating functions; Mobius inversion; enumeration techniques; Ramsey numbers; finite projective and affine geometries; Latin rectangles; orthogonal arrays; block designs; error detecting and error correcting codes. Prerequisite: MTHS 3110.

MTHS 8560: Applicable Algebra, 3 cr. (3 and 0) S Applied algebraic ideas in lattice theory and Boolean Algebra; finite-state sequential machines; group theory as applied to network complexity and combinatorial enumeration; algebraic coding theory. Topics vary with background and interests of students. Prerequisites: MTHS 8510 and 8530 or permission of instructor.

MTHS 8570: Cryptography, 3 cr. (3 and 0) Classical and modern cryptography and their uses in modern communication systems are covered. Topics include entropy, Shannon’s perfect secrecy theorem, Advanced Encryption Standard (AES), integer factorization, RSA cryptosystem, discrete logarithm problem, Diffie-Hellman key exchange, digital signatures, elliptic curve cryptosystems, hash functions, and identification schemes. Prerequisite: MTHS 3110, 4000 or 6000, 4120 or 8510.

MTHS 8580: Number Theory, 3 cr. (3 and 0) Covers topics and techniques from modern number theory including unique factorization, elementary estimates on the distribution of prime numbers, congruences, Chinese remainder theorem, primitive roots, n-th powers modulo and integer, quadratic residues, quadratic reciprocity, quadratic characters, Gauss sums, and finite fields. Prerequisite: MTHS 8530 or consent of instructor.

MTHS 9510: Algebraic Number Theory, 3 cr. (3 and 0) Covers arithmetic of number fields and number rings. Covers prime decomposition, ideal class groups, unit groups of number fields and distribution of prime ideals in number fields. Provides an overview of completions absolute values and valuation theory. Prerequisite: MTHS 8510
MTHS 9520: Analytic Number Theory, 3 cr. (3 and 0) The theory of Fourier analysis and complex analysis are essential to modern number theory. Course focuses on applications of this theory to number theory, such as the proof of the prime number theorem and the connection of complex L-series to the distribution of primes and to arithmetic geometry. Prerequisite: MTHS 8210 or consent of instructor.

MTHS 9540: Advanced Graph Theory, 3 cr. (3 and 0) F Continuation of MTHS 8540; topics not covered in 8540 including the four-color theorem, domination numbers, Ramsey theory, graph isomorphism, embeddings, algebraic graph theory and tournaments; research papers are also examined. Prerequisite: MTHS 8540 or permission of instructor.

MTHS 9850: Selected Topics in Algebra and Combinatorics, 1-3 cr. (1-3 and 0) Advanced topics in algebra and combinatorics from current problems of interest. May be repeated for credit, but only if different topics are covered. Sample Offerings:

Coding Theory: This course covers the basics of coding theory. Topics include cyclic codes, BCH codes, Reed-Solomon codes, and finite geometry.

Finite Fields: This course covers basic finite field theory and applications.

Algebraic Curves: This course covers some basic results about algebraic curves that are useful in constructing error-correcting codes and in implementing public-key cryptosystems. Basic concepts in algebraic geometry and commutative algebra to be covered include varieties, polynomial and rational maps, divisors, (prime) ideals, function fields, valuations, local rings, Riemann-Roch Theorem, etc.

Introduction to Computational Algebra I: The course focuses heavily on the theory and applications of Grobner bases. Coding theory is emphasized as an area of application, including decoding of Reed-Solomon codes and Hermitian codes.

Introduction to Computational Algebra II: Fast Fourier transforms, fast multiplication of polynomials (integers), fast decoding of RS codes, sparse linear systems (from coding theory, cryptography and computer algebra), Krylov subspace methods (Lanczos and bi-orthogonal methods), Wiedemann's method a la Berlekamp-Massey, block algorithms (Coppersmith's and Montgomery's) and their analysis.

Sample Curricula
- Sample Program for M.S. Concentration in Algebra
  FALL: 8050, 8100, 8500
  SPRING: 8600, 8210, 8510
  SUMMER: 8030
  FALL: 8220, 8520, 8550
  SPRING: 8540, 8560, 9850, 8920

- Sample Program for M.S. Concentration in Discrete Mathematics
  FALL: 8000, 8100, 8530
  SPRING: 8050, 8210, 8540
  SUMMER: 8600
  FALL: 8140, 8550, 8650

27
Recent M.S. Graduates (master's project title)
- Margaux Evans (Adaptive Dynamics of HA-MRSA via Ro Maximization)
- Jason Hedetniemi (Champion Primes for Elliptic Curves over Fields of Prime Order)
- Thomas Grady (Dynamics of Bi-threshold Graph Dynamical Systems)
- Christopher Wilson (Bifurcations in Epidemic Models)
- Kaitlin Woskoff (Correspondence Between the Steady States of Continuous and Discrete Models)
- Ryan Harper (Estimating Influenza Outbreaks)

Recent Ph.D. Graduates (dissertation title)
- Justin Peachey (Bases and Applications of Riemann-Roch Spaces)
- Jeffrey Beyerl (Factoring Heck Eigenforms and Applications to L-Values)
- Janine Janoski (A Collection of Problems in Combinatorics)
- Catherine Trentacoste (Modular Forms, Elliptic Curves and Drinfeld Modules)
Pure and Applied Analysis

The study of analysis provides a basic understanding of qualitative and quantitative problem-solving techniques, the ability to analyze new areas of interest, and the ability to interact with colleagues from other disciplines in a problem-solving situation. Modern applications of analysis include biomedical modeling, image analysis, robotic control, ecology, environmental modeling, and financial engineering.

Faculty

J. Brannan » mathematical modeling, stochastic analysis, financial mathematics
Q. Chen » ocean and climate modeling, mesoscale eddy parametrizations, numerical methods for PDEs, fluid dynamics, wave equations, turbulence
T. Khan » inverse problems, parameter estimation, optical tomography, biomedical imaging, control problems
S. Liu » inverse problems and control theory for PDEs, mathematical physics, dynamical systems, mathematical biology
M. Mitkovski » function theory, operator theory, harmonic analysis
J. Peterson » distributed computing, biological modeling, neurobiology, neuroscience
M. Schmoll » geometric analysis, geometric control theory, dynamical systems, ergodic theory, Teichmüller theory
J. Yoon » inverse problems, medical imaging, seismic imaging, partial differential equations, elastic wave propagation in complex (anisotropic, viscoelastic) media

Curriculum

A plan of study for students concentrating in analysis will include courses in theoretical analysis, applied analysis, numerical analysis, and physical system modeling.

Courses

MTHS 8210: Linear Analysis, 3 cr. (3 and 0) S, SS Normed spaces; Hilbert spaces, Banach spaces, linear functionals, linear operators, orthogonal systems. Prerequisites: MTHS 4540/6540 or 4530 and 8530

MTHS 8220: Measure and Integration Rings and algebras of sets, inner and outer measures; measurability and additivity, examples on the line and in space, Lebesgue integration, types of convergence, Lebesgue spaces; integration and differentiation, product measure, Fubini theorem. Prerequisite: MTHS 4540/6540

MTHS 8230: Complex Analysis, 3 cr. (3 and 0) Topological concepts; complex integration; local and global properties of analytic functions; power series; representation theorems; calculus of residues. Designed for nonengineering majors. Prerequisite: MTHS 4640/6640

MTHS 8250: Introduction to Dynamical Systems Theory, 3 cr. (3 and 0) F Techniques of analysis of dynamical systems; sensitivity analysis, linear systems, stability and control; theory of differential and difference equations. Prerequisites: MTHS 4540/6540 and 3110 or 4530 and 8530

MTHS 8260: Partial Differential Equations, 3 cr. (3 and 0) F First-order equations: elliptic, hyperbolic and parabolic; second-order equations: existence and uniqueness results, maximum
principles, finite difference and Hilbert Space methods. Prerequisite: MTHS 8210 or permission of instructor

MTHS 8270: Dynamical System Neural Networks, 3 cr. (3 and 0) Modeling problems in the context of dynamical systems theory; useful methods from Lyapunov stability, local linearization, qualitative analysis using graph theory and numerical approximations; several dynamical systems neural networks including binary code recognizers and binary matrix choosers. Prerequisites: MTHS 2060 and 3110

MTHS 8310: Fourier Series, 3 cr. (3 and 0) SS Fourier series with applications to solution of boundary value problems in partial differential equations of physics and engineering; introduction to Bessel functions and Legendre polynomials. Prerequisite: MTHS 4640/6640

MTHS 8370: Calculus of Variations and Optimal Control, 3 cr. (3 and 0) SS Fundamental theory of the calculus of variations; variable end points; the parametric problem; the isoperimetric problem; constraint inequalities; introduction to the theory of optimal control; connections with the calculus of variations; geometric concepts. Prerequisite: MTHS 4530/6530 or 4630/6630

MTHS 8410: Applied Mathematics I, 3 cr. (3 and 0) F Derivation of equations from conservation laws, dimensional analysis, scaling and simplification; methods such as steepest descent, stationary phase, perturbation series, boundary layer theory, WKB theory, multiple-scale analysis and ray theory applied to problems in diffusion processes, wave propagation, fluid dynamics and mechanics. Prerequisites: MTHS 2080 and 4530/6530 or 4630/6630

MTHS 9270: Functional Analysis, 3 cr. (3 and 0) N Linear operators on specific spaces, spectral theory, semigroups of operators and the Hille-Yosida theorem, applications of linear spaces and operators, convexity. Prerequisite: MTHS 8210

MTHS 9740: Mathematical Models in Investment Science, 3 cr. (3 and 0) The course deals with a collection of concepts, constructs, and mathematical models that have been created to help deal with (in a rational manner) a portion of the myriad of problems that arise in the financial arena. There are two major themes in the course: How to decide the best course of action in an investment situation, e.g. how to devise the best portfolio, how to devise the optimal investment strategy for managing an investment, how to select a group of investment projects. How to determine the correct arbitrage-free, fair, or equilibrium value of an asset, e.g. the value of a firm, the value of a bond, the value of a derivative such as a put or call option. Prerequisites: Individuals should have a technical background roughly equivalent to a bachelor's degree in engineering, mathematics, science, or economics; or have some familiarity with basic calculus, linear algebra, and probability theory. Most of the mathematics is at the level of undergraduate calculus.

MTHS 9820: Selected Topics in Analysis, 1-3 cr. (1-3 and 0) Advanced analysis topics from current problems of interest. May be repeated for credit if different topics are covered.

**Sample Offerings:**

**Stochastic Calculus for Finance:** This special topics course is intended as an introduction to some basic ideas for modeling and simulation in finance. The course begins with a discussion of simple random walks and the analysis of certain gambling games. These topics are used to motivate the theory of martingales and continuous time stochastic processes. The course will then take up the Ito integral and enough of the theory of the diffusion equation to be able to
solve the Black-Scholes PDE and prove the uniqueness of the solution. The foundations for
the martingale theory of arbitrage pricing are then prefaced by a well-motivated development
of the martingale representation theorems and Girsanov theory. Prerequisites: Some analysis
beyond calculus, an introduction to linear algebra, and basic methods from probability and
statistics.

**Computational Finance:** This special topics course is intended provide hands on familiarity
with simulation of financial models. This will be a "soft" computing course, i.e., we will not
prove convergence of the approximations used in the simulations. The course will make use of
Maple and MatLab programs from the literature: e.g.,

- D. J. Higham, An algorithmic introduction to numerical simulation of stochastic
- D. J. Higham and P. E. Kloeden, Maple and MatLab for stochastic differential equations in
finance, research report.
- D. J. Higham, Nine ways to implement the binomial method of option valuation in MatLab,
research report.
- S. Cygnowski, L. Grüne, and P. E. Kloeden, Maple for stochastic differential equations,
research report.

Prerequisites: Basic concepts from probability and stochastic processes. Familiarity with
martingales, MatLab, and Maple would be helpful but not necessary.

**Sample Curricula**

- **Sample Program for M.S. Concentration in Analysis**
  - FALL: 8100, 8530, 8250/8260
  - SPRING: 8050, 8210, 8600
  - SUMMER: 8030
  - FALL: 8410, 8610, 8250/8260
  - SPRING: 8090, 8110, 8310, 8920

- **Recent M.S. Graduates in Analysis (master's project title)**
  - Charity Lopez (A Nonlinear Stochastic Dynamic Model of the Onset of an Economic
Recession)
  - Faisal Samir (A Nonlinear Stochastic Dynamic Model of the Onset of an Economic
Recession)
  - Milena Goncalves (A Nonlinear Stochastic Dynamic Model of the Onset of an Economic
Recession)

- **Recent Ph.D. Graduates (dissertation title)**
  - John Cooper (Sparsity Regularization in Diffuse Optical Tomography)
  - Catherine White (Sensitivity Analysis and Detectability of Magnetic Resonance
Elastography)
  - Christopher Gillam (Sensitivity Analysis in Magnetic Resonance Elastography and a Local
Wavelength Reconstruction Based on Wave Direction)
APPLIED STATISTICS

Applied statisticians collaborate with scientists in academia, industry, and government on the design, implementation, and analysis of research studies. This collaboration combines traditional statistical methodology and development, and well as aspects of mathematical sciences such as model development and computation.

Faculty
E. Breazel » statistical genetics, statistics education
W. Bridges » statistical design, applications of mixed models, categorical data analysis
R. Dubsky » statistical education, data analysis
P. Gerard » nonparametric density estimation, environmental statistics,
H. Hill » applied regression analysis, sampling, statistical graphics, environmetrics
J. Luo » asymptotics in large p, statistical applications in economics and biology
R. Martinez-Dawson » statistics education-assessing statistical literacy, survey design and analysis
J. Rieck » reliability, estimation
J. Sharp » statistical computing, experimental design and analysis, biostatistics

Curriculum

The courses in applied statistics focus on design and analysis of experiments, statistical analysis, and statistical computing. They allow students to rigorously apply proper statistical methodology to solve real world problems in agriculture, education, engineering, forestry, life sciences, and beyond. Students interested in applied statistics can combine course offerings in Applied Statistics, Probability and Mathematical Statistics, and other areas of Mathematical Sciences to develop a deep and broad based understanding of statistics.

Courses
EXST 8010: Statistical Methods I, 4 cr. (3 and 3) Role and application of statistics in research; estimation, test of significance, analysis of variance, multiple comparison techniques, basic designs, mean square expectations, variance components analysis, simple and multiple linear regression and correlation, and nonparametric procedures. Prerequisites: Consent of instructor.

EXST 8020: Statistical Methods II, 3 cr. (3 and 0) Extended coverage of several methods introduced in EXST 8010: multiple regression model building and diagnostics, experiment design and analysis, and nonparametric methods; mixed models and repeated measures analyses; categorical data analysis; multivariate methods and sampling designs; appropriate use of statistical software. Prerequisite: EXST 8010.

EXST 8030: Regression and Least Squares Analysis, 3 cr. (3 and 0) Regression analysis; simple and multiple linear, curvilinear, and multiple curvilinear; curve fitting; least squares and computer techniques for fitting of constants and analysis of planned experiments. Offered spring semester only. Prerequisite: EXST 8010.

EXST 8040: Sampling, 3 cr. (3 and 0) Principles of scientific sampling; finite population sampling; simple random, stratified, multistage and systemic sampling; optimum allocation;
methods of obtaining, processing and reporting survey information; sampling as related to the environment, natural resources, and social and economic problems. Prerequisite: EXST 8010.

**EXST 8050: Design and Analysis of Experiments, 3 cr. (3 and 0)** Basic designs and analysis; data transformations; single degree of freedom, orthogonality and responses in ANOVA; covariance; response surfaces; incomplete blocks; introduction to least squares analysis of experiments; use of standard computer programs for selected analyses. Prerequisite: EXST 8010.

**EXST 8110: Special Problems in Experimental Statistics, 1-3 cr. (0 and 2-6)** Statistical aspects of an individualized research problem; determining an appropriate experimental design; performing proper analyses and generating effective reports.

**EXST 8120: Selected Topics, 1-3 cr. (1-3 and 0)** Topics in applied statistics not covered in other courses. May be repeated, but only if different topics are covered.

**EXST 8150: Environmental and Ecological Statistics, 3 cr. (3 and 0)** Overview of statistical techniques in Environment Sciences and Ecology. Probability distributions and sampling; population estimation using capture/recapture, line transect and line intercept methods; spatial point pattern analysis; modelling environmental and ecological data; environmental monitoring. Prerequisites: EXST 8010 and 8030 or consent of instructor.

**EXST 8160: Spatial Statistics, 3 cr. (3 and 0)** Introduction to spatial data analysis emphasizing concepts and interpretation, spatial point processes, clustering, spatial autocorrelation, semivariograms, kriging, spatial regression and analysis of variance. Prerequisite: EXST 8010 and 8030 or consent of instructor.

**EXST 8170: Multivariate Statistics in Agriculture, Forestry, and Natural Resources, 3 cr. (3 and 0)** Application of multivariate techniques for linear models (MANOVA, Hotellings T2), covariance structure (principal components, factor analysis), classification (discriminant and cluster analyses), and structural equation modeling drawing examples from life sciences, natural resources, tourism, and related programs. Prerequisite: EXST 8010 and 8030 or consent of instructor.

**EXST 8190: Biostatistics, 3 cr. (3 and 0)** Statistical analyses applicable to disease/mortality occurrence. Introduction to epidemiology study designs and appropriate statistical analyses. Statistical methodology applicable to life-tables and survival curves and clinical trials. Prerequisite: EXST 8010.
Computational Mathematics

Advanced work in all areas of science and technology relies critically on computation. Computational mathematics involves the design and analysis of mathematical models for various problems and the construction of algorithms which efficiently and accurately compute solutions. A concentration area in Computational Mathematics includes courses in digital modeling, continuous and discrete simulation, and numerical analysis. The goal of the program is to offer depth in the area of concentration and breadth in the other mathematical sciences, with special emphasis on courses that will provide tools for innovative approaches to computer applications in industry. The first course in digital models is an introductory, but fundamental, course concerned with the construction of models for various problem types and the study of the structure of problem solving. The course in scientific computing, also a basic course, includes the study of some of the most frequently used mathematical algorithms in scientific problems. Students can specialize in computational problems which primarily lend themselves to discrete or to continuous mathematical models. Advanced courses in discrete and continuous simulation are available.

Faculty

M. E. Cawood » numerical linear algebra, optimization, numerical methods for differential equations
C. L. Cox » finite element methods, viscoelastic flow modeling, parallel processing, numerical linear algebra, groundwater modeling
V. J. Ervin » numerical analysis, computational mathematics, partial differential equations
T. Heister » numerical analysis, numerical solutions to PDEs, flow problems, algorithms for massively parallel finite element simulations, efficient linear algebra
E. W. Jenkins » Newton-Krylov-Schwarz methods, mixed finite element methods for acoustic waves, air-water models
H. K. Lee » numerical methods for PDEs, parallel algorithms, computational optimal control, finite element methods
W. F. Moss » mathematical modeling, computational mathematics, inquiry based K-12 science education, technology based curriculum development, effective teaching with technology
L. Rebholz » numerical analysis of partial differential equations, computational fluid mechanics, turbulence, control theory
D. D. Warner » numerical analysis, computational science, parallel computing, distributed scientific simulations

Curriculum

Data Structures, Graph Algorithms, Computational Problems in Discrete Structures, Numerical Linear Algebra, Numerical Approximation Theory, Numerical Solution of Ordinary and Partial Differential Equations, Digital Models, Introduction to Scientific Computing. Some of the courses in computer science at the graduate level offered by the Department of Computer Science which may be chosen as electives are: Theory of Computation, Introduction to Artificial Intelligence, Design and Analysis of Algorithms, and Software Development Methodology. Students often take a graduate course in engineering or science which supports their graduate research.

Courses

MTHS 8600: An Introduction to Scientific Computing, 3 cr. (3 and 0) S, SS Floating point models, conditioning and numerical stability, numerical linear algebra, integration, systems of ordinary differential equations and zero finding; emphasis is on the use of existing scientific software. Prerequisites: MTHS 2080, 3110 and CP SC 1100.
MTHS 8610: Advanced Numerical Analysis I, 3 cr. (3 and 0) Consideration of topics in numerical linear algebra: eigenvalue problems, the singular value decomposition, iterative algorithms for solving linear systems, sensitivity of linear systems, and optimization algorithms. Prerequisites: MTHS 3110 and 4600, or MTHS 8600.

MTHS 8630: Digital Models I, 3 cr. (3 and 0) F Experimental mathematics; pseudo-stochastic processes; analytical and algebraic formulations of time-independent simulation; continuous-time simulation and discrete-time simulation; digital optimization; Fibonacci search; ravine search; gradient methods; current research in digital analysis. Prerequisites: MTHS 3110, 4530/6530 and digital computer experience.

MTHS 8650: Data Structures, 3 cr. (3 and 0) F Representation and transformation of information; formal description of processes and data structures; tree and list structures; pushdown stacks; string and formula manipulation; hashing techniques; interrelation between data structure and program structure; storage allocation methods. Prerequisites: Computational maturity and permission of instructor.

MTHS 8660: Finite Element Method, 3 cr. (3 and 0) Discusses the basic theory of the finite element method (FEM) for the numerical approximation of partial differential equations. Topics include Sobolev spaces, interpolation theory, finite element spaces, error estimation, and implementation of FEM in one and higher dimensions. Prerequisite: MTHS 8600 or consent of instructor.

MTHS 9830: Selected Topics in Computational Mathematics, 1-3 cr. (1-3 and 0) Advanced topics in computational mathematics and numerical analysis from current problems of interest. May be repeated for credit if different topics are covered.

Sample Offerings:
Scientific Simulations in Java: Because of its Object Orientation, its Platform Independence, and its tight specifications on arithmetic operations, Java is an appealing language for the development of Scientific Simulations. Since Java-based simulations can be distributed in the context of web-based documentation, such Java-based simulations can greatly enhance the dissemination of scientific knowledge and can substantially improve scientific training particularly in the area of understanding complex models. This course focuses on developing Scientific Simulations written in Java and distributed through the World Wide Web. The course is project oriented and involves the development of interactive web-based simulations of scientific topics chosen by the students.

Fiber and Film Systems: Modeling and Simulation: This course, cross-listed as ChE 845, ME 893, and MTHS 983, is team-taught by Math Sciences and Chemical Engineering faculty. The course presents a systems perspective of fiber and film processes using existing and new models developed by the Center for Advanced Engineering Fibers and Films. Constitutive equations are developed and applied to specific geometries and flow problems encountered in the production of fibers and films. Specific objectives are to develop the governing equations for polymeric fluids, derive various constitutive equations including those based on molecular models, explore analytical and numerical solution of the governing equations for special cases, develop an understanding for the strengths and weaknesses of the models to be discussed, and apply constitutive equations to fiber and film processing geometries.
Sample Curricula
- Sample Program for M.S. Concentration in Computational Mathematics
FALL: 8050, 8100, 8650
SPRING: 8600, 8210, 8530
SUMMER: 8030
FALL: 8220, 8250, 8610
SPRING: 9270, 9830, modeling course in another department, 8920

Recent M.S. Graduates (master's project title)
- Erica D’Agnillo (Importance of Discrete Mass Conservation in Incompressible Flow Simulations)
- Michael Dowling, JR (Enhance Physics Schemes for the 2D NS-\(\alpha\) Model of Incompressible Flow)
- Andrew Ash-Fuchs (Characterization of Shaped-Fiber Chromatography Separation Columns)
- Benjamin Greco (Quantum System Decomposition for the Semi-Classical Quantum Fourier Transform)
- Kara Kohler (A Mathematical and Physical Study of Multiscale Deconvolution Models of Turbulence)
- Paul Kuberry (Genetic Algorithm and Nelder-Mead Hybrid)
- Christopher Paribello (Determining Influence in the Egyptian Revolution on Twitter)
- Jeremy White (Model of Fluid Flow through Shaped-Fiber Separations Columns)
- Shuhan Xu (Numerical Study for Viscoelastic Fluid-Structure Interaction Problem)

Recent Ph.D. Graduates (dissertation title)
- Jason Howell (“Numerical Approximation of Shear-Thinning and Johnson-Segalman Viscoelastic Fluid Flows”)
- Louis Ntasin ("A Posteriori Error Estimation and Adaptive Computation of Viscoelastic Fluid Flows")
- Dave Szurley (“Optimal Control for Polymer Process Modeling”)
- Nicholas Wilson (Physics-Based Algorithms and Divergence Free Finite Elements for Coupled Flow Problems)
Operations Research

Operations Research (OR) is distinguished by its use of quantitative methods (mathematics, statistics, and computing) to aid in rational decision making. Operations Research has been successfully applied to a wide range of problems arising in business and government, such as locating industrial plants, allocating emergency facilities, planning capital investments, designing communication systems, and scheduling production in factories. A common element of these decision problems is the need to allocate scarce resources (such as money, time, or space) while attempting to meet conflicting objectives (such as minimizing cost or maximizing production).

Faculty

W. P. Adams » mathematical programming, optimization
B. Fralix » levy processes, markov processes, point processes, palm measures, time-dependent behavior of queues, pathwise approximations of queueing processes
A. Gupte » theoretical and algorithmic aspects of optimization, optimization under uncertainty, decomposition methods for nonlinear problems
P. C. Kiessler » stochastic processes, queueing theory
X. Liu » diffusion approximations for stochastic networks, stochastic stability and control for stochastic networks, stochastic analysis and modeling
E. Nasrabad » robust and stochastic optimization, networks, optimal control algorithmic game theory, online algorithms, optimization in infinite-dimensional spaces
M. J. Saltzman » computational operations research, mathematical programming
D. R. Shier » network optimization, discrete mathematics
M. Wiecek » optimization, multicriteria decision making

Curriculum

Operations Research often approaches a particular problem from several modeling perspectives and uses various analytical techniques. Because of the diversity and broad scope of decision problems, the successful OR practitioner requires training in a number of mathematical concepts and techniques. Areas in the mathematical sciences that relate directly to OR are optimization (linear, nonlinear, integer, network programming, calculus of variations, control theory); applied probability (stochastic processes, queueing, reliability); and applied statistics (simulation, econometrics, time series). Computational mathematics also plays an important role in the effective application of OR because of the need to structure and analyze vast amounts of data and to solve large-scale problems efficiently. Other areas of the mathematical sciences related to OR are combinatorics, graph theory, financial mathematics, and dynamical systems.

Courses

MTHS 8030: Stochastic Processes, 3 cr. (3 and 0) S, SS Theory and analysis of time series; recurrent events; Markov chains; random walks; renewal theory; application to communication theory; operations research. Prerequisite: MTHS 4000/6000 or 8000

MTHS 8100: Mathematical Programming, 3 cr. (3 and 0) F, S Formulation and solution of linear programming models; mathematical development of the simplex method; revised simplex method; duality; sensitivity analysis; parametric programming, implementation, software packages. Prerequisite: MTHS 3110
MTHS 8110: Nonlinear Programming, 3 cr. (3 and 0) S Theoretical development of nonlinear optimization with applications; classical optimization; convex and concave functions; separable programming; quadratic programming; gradient methods. Prerequisites: MTHS 4400 and 4540

MTHS 8120: Discrete Optimization, 3 cr. (3 and 0) F Principal methods used in integer programming and discrete optimization; branch and bound, implicit enumeration, cutting planes, group knapsack, Lagrangian relaxation, surrogate constraints, heuristics (performance analysis), separation/branching strategies and polynomial time algorithms for specific problems on special structures. Prerequisite: MTHS 8100 or equivalent

MTHS 8130: Advanced Linear Programming, 3 cr. (3 and 0) S Development of linear programming theory using inequality systems, convex cones, polyhedra and duality; solution algorithms and computational considerations for large scale and special structured problems using techniques of upper bounded variables, decomposition, partitioning and column generation; game theory; nonlinear representations and other methods such as ellipsoid and Karmarkar. Prerequisite: MTHS 4400/6400, 8100 or equivalent

MTHS 8140: Network Flow Programming, 3 cr. (3 and 0) F Max-flow/min-cut theorem; combinatorial applications; minimum cost flow problems (transportation, shortest path, transshipment); solution algorithms (including the out-of-kilter method); implementation and computational considerations. Prerequisite: MTHS 4400/6400, 8100 or equivalent

MTHS 8160: Network Algorithms and Data Structures, 3 cr. (3 and 0) F Design, analysis and implementation of algorithms and data structures associated with the solution of problems formulated as networks and graphs; applications to graph theory, combinatorial optimization and network programming. Corequisite: MTHS 6400, 8100, 8540, 8630 or permission of instructor

MTHS 8170: Stochastic Models in Operations Research I, 3 cr. (3 and 0) F Stochastic control; structure of sequential decision processes; stochastic inventory models; recursive computation of optimal policies; discrete parameter finite Markov decision processes; various optimality criteria; computation by policy improvement and other methods; existence of optimal stationary policies; stopping-rule problems; examples from financial management, maintenance and reliability, search, queuing and shortest path. Prerequisite: MTHS 8030

MTHS 8180: Stochastic Models in Operations Research II, 3 cr. (3 and 0) S Introduction to queuing theory: Markovian queues, repairman problems, queues with an embedded Markov structure, the queue GI/G/1, queues with a large number of servers, decision making in queues; introduction to reliability theory; failure distributions; stochastic models for complex systems; maintenance and replacement policies; reliability properties of multicomponent structures. Prerequisite: MTHS 8170

MTHS 8190: Multicriteria Optimization, 3 cr. (3 and 0) S Theory and methodology of optimization problems with vector-valued objective functions; preference orders and domination structures; generating efficient solutions; solving multicriteria decision-making problems, noninteractive and interactive methods with applications. Prerequisite: MTHS 8100 or equivalent

MTHS 8200: Complementarity Models, 3 cr. (3 and 0) S Theory, algorithms and applications of linear and nonlinear complementarity; classes of matrices and functions and corresponding
algorithms; applications to economics, mechanics and networks; generalizations to fixed-point problems and nonlinear systems of equations. Prerequisite: MTHS 8100

**MTHS 8740: Integration through Optimization, 3 cr. (3 and 0)** Theory, methodology and applications of decomposition, integration and coordination for large-scale or complex optimization problems encountered in engineering design. Topics include conventional and non-conventional engineering optimization algorithms, analysis models and methods, multidisciplinary optimization, analytic target cascading, multiscenario optimization, and multicriteria optimization. Case studies are included. Prerequisite: MTHS 8100, 8600, or ME 8710, or equivalent.

**Sample Curricula**

- **Sample Program for M.S. Concentration in Optimization**
  FALL: 8000, 8100, 8530  
  SPRING: 8050, 8210, 8600  
  SUMMER: 8030  
  FALL: 8120/8190, 8140, 8170  
  SPRING: 8110, 8130, 8920, 9880

- **Sample Program for M.S. Concentration in Stochastics**
  FALL: 8000, 8100, 8530  
  SPRING: 8030, 8210, 8600  
  SUMMER: 8030  
  FALL: 8170, 9010, 9880  
  SPRING: 8110, 8090, 8180, 8920

**Recent M.S. Graduates (master's project title)**
- Jodi Haponski (Methods in Approximating Renewal Functions)
- Christa Johnson (An Introduction to Multidisciplinary Design Optimization Methods)
- Karyn Muir (Sparse Implementation of Google’s PageRank Algorithm)
- Lucas Waddell (Linear Programming Insights into Solvable Special Cases of the Quadratic Assignment Problem)

**Recent Ph.D. Graduates (dissertation title)**
- Katherine Hastings (Algebraic Approaches to Stochastic Optimization)
- Bradley Paynter (An Optimization Approach to a Geometric Packing Problem)
- Frank Muldoon (Polyhedral Approximations of Quadratic Semi-Assignment Problems, Disjunctive Programs, and Base-2 Expansions of Integer Variables)
Statistics and Probability

Graduate study in statistics and probability has taken on a new look and increased importance in the last two decades due to dramatically increased computational power and the aggressive and highly successful application of statistical methods by our competitors in the world market-place. In particular, the Japanese have extensively employed design of experiments, data analysis, and statistical process control to improve the quality of their processes and the quality of their manufactured products. Recently a number of major U.S. corporations began emulating the Japanese approach by getting management to support the introduction of "statistical thinking" throughout the company, and requiring that the people running their processes have sufficient formal training in statistics to properly implement and monitor statistical process control programs.

Faculty

A. Brown » Bayesian statistics, functional MRI data analysis, large-scale simultaneous inference, Markov chain Monte Carlo methods
C. Gallagher » limit theorems, time series, modeling heavy-tailed data
Y. Li » Bayesian statistics and nonparametrics, variable selection, data mining, adaptive MCMC simulation, social network analysis, statistical data analysis
R. Lund » time series, applied probability, statistics in climatology
C. McMahan » categorical data analysis, group testing, survival data analysis, nonparametric methods, measurement error models, shape analysis, Bayesian parametric/nonparametric estimation, statistical computing, epidemiology/public health, and biomedical applications
C. Park » statistical computing, simulation, robust inference
X. Sun » statistical decision theory, Bayesian Statistics, multivariate analysis, and bioinformatics
R.L. Taylor » laws of large numbers, density estimation, bootstrap estimation, statistical education
C. Williams » biostatistics, computational statistics, categorical data

Curriculum

Whether one is interested in applying statistical methods to problems in government or industry, or would like to engage in teaching and research at a university, a program can be tailored to meet these objectives within the constructs of the graduate program at Clemson. In addition to comprehensive training in statistical theory and methodology, students are exposed to areas such as combinatorics, mathematical programming, and scientific computing. While these areas are not part of a traditional statistics program, knowledge of them is becoming essential to the application and development of statistical methods. Thus, the Mathematical Sciences Department at Clemson is an ideal place to pursue the study of statistics. Students who choose to pursue the PhD degree may do research within the Department of Mathematical Sciences or they may enroll in the Management Science PhD program which is jointly administered by Mathematical Sciences and the Department of Management. That program stresses the use of analytic models and quantitative methods for decision making.

Courses

MTHS 8000: Probability, 3 cr. (3 and 0) F Basic probability theory with emphasis on results and techniques useful in operations research and statistics; axiomatic probability, advanced combinatorial probability, conditional expectation, functions of random variables, moment generating functions, distribution theory and limit theorems. Prerequisite: MTHS 2060

MTHS 8010: General Linear Hypothesis I, 3 cr. (3 and 0) F Least-square estimates; Gauss-
Markov theorem; confidence ellipsoids and confidence intervals for estimable functions; tests of hypotheses; one-, two- and higher-way layouts; analysis of variance for other models. Prerequisites: MTHS 4030/6030 and 3110

MTHS 8020: General Linear Hypothesis II, 3 cr. (3 and 0) S Continuation of MTHS 8010. Prerequisite: MTHS 8010

MTHS 8040: Statistical Inference, 3 cr. (3 and 0) Sampling distributions; maximum likelihood estimation and likelihood ratio tests; asymptotic confidence intervals for Binomial, Poisson and Exponential parameters; two sample methods; nonparametric tests; ANOVA; regression and model building. Prerequisite: MTHS 4000/6000 or equivalent or permission of instructor.

MTHS 8050: Data Analysis, 3 cr. (3 and 0) F, S Methodology in analysis of statistical data emphasizing applications to real problems using computer-oriented techniques: computer plots, transformations, criteria for selecting variables, error analysis, multiple and stepwise regression, analysis of residuals, model building in time series and ANOVA problems, jackknife and random subsampling, multidimensional scaling, clustering. Prerequisites: MTHS 3001 and 4000/6000, or MTHS 4010/6010 and 8000.

MTHS 8060: Nonparametric Statistics, 3 cr. (3 and 0) F Order statistics; tolerance limits; rank-order statistics; Kolmogorov-Smirnov one-sample statistics; Chi-square goodness-of-fit test; two-sample problem; linear rank statistics; asymptotic relative efficiency. Prerequisite: MTHS 6000 or 8000.

MTHS 8070: Applied Multivariate Analysis, 3 cr. (3 and 0) F Applied multivariate analysis: computer plots of multivariate observations; multidimensional scaling; multivariate tests of means, covariances and equality of distributions; univariate and multivariate regressions and their comparisons; MANOVA; principle components analysis; factor analysis; analytic rotations; canonical correlations. Prerequisites: MTHS 4030/6030 and 8050 or permission of instructor.

MTHS 8080: Reliability and Life Testing, 3 cr. (3 and 0) S Probability models and statistical methods relevant to parametric and nonparametric analysis of reliability and life testing data. Prerequisites: MTHS 4000/6000 and 4010/6010 or equivalent.

MTHS 8090: Time Series Analysis, Forecasting and Control, 3 cr. (3 and 0) F Modeling and forecasting random processes; autocorrelation functions and spectral densities; model identification, estimation and diagnostic checking; transfer function models; feedforward and feedback control schemes. Prerequisites: MTHS 6000 and 6050, or MTHS 8000 and 6050 or equivalent.

MTHS 8810: Mathematical Statistics, 3 cr. (3 and 0) S Fundamental concepts of sufficiency, hypothesis testing and estimation; robust estimation; resampling (jackknife, bootstrap, etc.) methods; asymptotic theory; two-stage and sequential sampling problems; ranking and selection procedures. Prerequisite: MTHS 4030/6030 or equivalent.

MTHS 8840: Statistics for Experimenters, 3 cr. (3 and 0) Statistical methods for students who are conducting experiments; introduction to descriptive statistics, estimation, and hypothesis testing as they relate to design of experiments; higher-order layouts, factorial and fractional factorial designs, and response surface models. Offered fall semester only. Prerequisite: MTHS
2060 or equivalent.

**MTHS 8850: Advanced Data Analysis, 3 cr. (3 and 0) F** Continuation of MTHS 805, covering alternatives to ordinary least squares, influence and diagnostic considerations, robustness, special statistical computation methods. Prerequisites: MTHS 6030, 8000 and 8050.

**MTHS 9010: Probability Theory I, 3 cr. (3 and 0)** Axiomatic theory of probability; distribution functions; expectation; Cartesian product of infinitely many probability spaces, and the Kolmogorov consistency theorem; models of convergence; weak and strong laws of large numbers. Prerequisite: MTHS 4000 and 8220, or MTHS 8000 and 8220, or consent of the instructor.

**MTHS 9020: Probability Theory II, 3 cr. (3 and 0)** Continuation of MTHS 9010; characteristic functions, infinitely divisible distributions, central limit theorems, laws of large numbers, conditioning, and limit properties of sums of dependent random variables, conditioning, martingales. Prerequisite: MTHS 9010.

**Sample Curricula**

- **Sample M.S. Program for Well-Prepared Students**
  FALL: 8000, 8040, 8530  
  SPRING: 8050, 8600, 8810  
  SUMMER: 8210  
  FALL: 8010, 8070/8090, 8100  
  SPRING: 8020, 8030, 8060/8080/9810, 8920

- **Sample M.S. Program for Students Lacking Advanced Calculus***
  FALL: 8000, 8040, 6530  
  SPRING: 8530, 8050, 8810  
  SUMMER: 8600  
  FALL: 8010, 8070/8090, 8100  
  SPRING: 8020, 8060/8080/9810, 8210, 8920

*If lacking any other prerequisite course, substitute this for 6530 in the Fall.

**Recent M.S. Graduates (master's project title)**

- Joshua Crunkleton (Analysis of POLYMOD Contract Rates)
- Michael Finney (Local Polynomial Regression with Applications to Sea Surface Temperatures)
- Chelsey Law (Threshold Regression and First Hitting Time Models)
- Angela Marvin (Residual Analysis in Generalized Linear Mixed Models)
- Trevor Partridge (Local Polynomial Regression with Applications to Sea Surface Temperatures)
- Taylor Sink (Regression Analysis Incorporating Random Effects and Cost Functions)
- Teng Zhang (Intrinsic Point Estimation in Exponential Model)
- Jingshu Zhao (Sure Independence Screening and Standard Ratio Method for Ultrahigh Dimensional Feature Space)

**Recent Ph.D. Graduates (dissertation title)**

- Nan Su (New Results in Multivariate Time Series with Applications)
• Tharanga Wickramarachchi (Asymptotics for the Arc Length of a Multivariate Time Series and its Applications as a Measure of Risk)
Seminars
The Mathematical Sciences Department has a plethora of seminars every year providing cutting-edge presentations from highly respected mathematicians and an opportunity for students to develop their presentation skills. Last year the department hosted 200 seminars, colloquiums or presentations on campus. The 28th Annual Clemson Mini-Conference on Combinatorial Optimization hosted 10 speakers bringing in over 250 speakers over its history. Besides 13 colloquiums from off-campus speakers and 11 First Year seminars last year, several focus areas have weekly seminars. Listings of seminars can be found on the departmental web page.

The Student Seminar
The weekly Student Seminar is designed and organized by graduate students giving over 20 presentations a year. Pizza and soft drinks are provided by the department following the seminar. All students are welcome.
Some of the purposes of the seminar:
• To provide a forum for students to talk in an informal and unpressured way about their work to other graduate students. Ph.D. students and 2nd year MS students may wish to talk about their own research - at a level geared toward second year students as an audience. However, the seminar is not strictly a forum for original research. Speakers may also wish to give a general background talk on topics of interest to them or on potential research topics.
• To provide exposure to research level mathematics.
• To share ideas.
• To gain speaking experience.
• To get to know each other better.

Other Information
We invite prospective students to visit the Clemson campus and meet with professors and graduate students. The Mathematical Sciences department would be happy to help with arrangements. If you wish to visit, please contact the Graduate Program Coordinator.

• Graduate Program Coordinator: Dr. C. L. Cox, O-101 Martin Hall, (864) 656-5203, clcox@clemson.edu

• Student Services Coordinator: Ms. Kris Hunnicutt, O-100 Martin Hall, (864) 656-5201, hunnicu@clemson.edu

• Departmental information: Main Office (864) 656-3434 www.math.clemson.edu

• online application www.grad.clemson.edu

If you wish to receive more information about Clemson University and student life, including on and off campus housing, please email: hunnicu@clemson.edu.