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DEPARTMENT OF MATHEMATICS
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GRADUATE STUDENT HANDBOOK

ALLAN MILLS (CHAIR)

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SEPTEMBER 2009

CAMPUS AND PROGRAM OF STUDY
INFORMATION FOR GRADUATE STUDENTS IN MATHEMATICS

Dear Prospective or Current Graduate Student:

We have prepared this Graduate Student Handbook with you in mind. We have included a description of the application process, reviewed conditions for admission, described responsibilities of our graduate assistants and students and our expectations of you as a graduate student. While we hope that this handbook will answer many of your questions as you progress through our Graduate Program, we would like for you to always feel free to stop by the Mathematics Department Office or contact us by phone or e-mail. We look forward to your mathematics graduate studies at Tennessee Technological University.

Sincerely,

Graduate Faculty

Please consult the current "Graduate School Catalog" for the most current and complete information about various Graduate School policies and procedures. The web address for the graduate catalog is http://www.tntech.edu/gcat/.

Location

Cookeville, Tennessee, the home of Tennessee Technological University (TTU), is located 80 miles east of Nashville and 100 miles west of Knoxville on Interstate 40. Major airline services are available through Nashville and Knoxville. A limousine service (costing about $50 one way) provides rides to both the Nashville and Knoxville airports. Another major international airport is about 214 miles away in Atlanta, Georgia. Greyhound Bus service connects Cookeville with many major cities. The city of Cookeville, which has a population of more than 25,000, is located on the eastern Highland Rim of Tennessee at an elevation of 1,140 feet and is in the Central Time Zone. In the vicinity of Cookeville, there are three large lakes, several state parks, a multitude of rivers and waterfalls, underground caves, mountain streams with white-water rafting, etc. It is a paradise for boaters, scuba divers, canoeists, fishermen, and hikers.

The Department of Mathematics is housed in Bruner Hall (see number 51 on the campus Internet map available at http://www.tntech.edu/gen/map). The Mathematics Office is in Bruner 235. Our two departmental secretaries, Patsy Peavyhouse (931) 372-3441 and Vickie Mayberry (931) 372-3442, are able to help you with many questions you may have.

Graduate Student Advisor

Dr. Michael Allen is the Graduate Student Advisor. His office is in Bruner 312 and he can be reached at (931) 372-3594, or at his e-mail mallen@tntech.edu. Dr. Allen serves as the initial Academic Advisor for graduate students. During the first year of study, each student should select his/her Advisory Committee which then directs his/her studies.
The Graduate Student Advisor also:

1. Informs students about policies of the Mathematics Department and the Graduate School, and makes sure that these policies are followed and various deadlines are met, etc.
2. Conducts the Teaching Seminar and the Graduate Seminar.
3. Is responsible for scheduling presentations of students and faculty at the Graduate Seminar.
4. Is the first person to contact with questions outside of academic advising, e.g. about conducting classes and other matters related to your teaching duties, about social and all other needs?

Admission to the Graduate School

Applications for admission to the Graduate School must be made to the Dean of Graduate Studies **at least four weeks** prior to the anticipated date of registration. International students should submit applications **at least six months** in advance to allow ample processing time. However, we encourage you to inquire about admission at any time. All applicants must submit satisfactory official scores on the General Test of the Graduate Record Examination (**GRE**)[1]. Official transcripts, three letters of recommendation, and a Personal Essay written by the applicant must support each application. We view the Essay as an important informational tool for us since it tells us about your mathematical interests and career goals.

Additional admission criteria for international students: Applications should be filed at least six months prior to the anticipated date of enrollment[2]. Students from non-English-speaking countries must submit a satisfactory score of at least 525 on the **Test of English as a Foreign Language (TOEFL***)*. Upon their arrival on the TTU campus, all international students admitted to the Graduate School must take an additional English language examination, which is arranged and conducted by the Department of Foreign Languages about a week before the beginning of the semester. If the examination reveals that the student does not possess an adequate command of English, the student will be required to enroll in one or two remedial English course(s) ESL 1010/ESL 1020, beginning with his/her first semester of study.

In order to be considered for admission, international applicants must provide satisfactory proof of having sufficient funds to cover all of their expenses (including travel) during the first year at

[1] The Department requires a minimum GRE score total for the quantitative and verbal parts of 1000, and a minimum Analytical Writing score of 2.5.
[2] Please check with the Graduate Student Advisor in the Mathematics Department to determine what constitutes adequate preparation. Normally it is expected that applicants will have a B.S. degree in mathematics from an accredited institution. Students whose B.S. degree is not in mathematics or who do not have a B.S. degree may be conditionally admitted. International students will have their credentials reviewed by the Department and the Dean of the Graduate School.

TTU. This amounts to $28,800[3] for the 2009-2010 year. If admission is approved, Form I-20 will be issued as follows: not later than June 1 for the fall term; November 1 for the spring term; and April 1 for the summer term. Upon arrival, international students will have to purchase health insurance from the university. The cost is $810, which covers 12 months and can be paid in full, or by the semester.

For more information go to
http://www.tntech.edu/international/health_insurance.html.

Financial Aid: Graduate Assistantships, Tuition and Fee Waivers

During the 2009-2010 academic year, the Department of Mathematics has nine graduate assistantships. Each assistantship covers all tuition and fees, and pays a stipend of $7,500 for the academic year.[4]

Graduate students who are granted an assistantship are required to participate in the graduate and teaching seminars, and, for 20 hours a week, are expected to either help faculty grade written assignments, staff our mathematics tutoring lab, or teach up to two courses (6 credit hours) per semester. Students normally teach during their second year at TTU after they accumulate at least 18 graduate hours in mathematics during the first two semesters. In order to remain on a graduate assistantship, all graduate assistants are required to maintain a minimum quality point average of 3.0 each semester, which is equivalent to a B average. Graduate assistantships normally do not cover more than four semesters of study.

Graduate students who do not have assistantships are not required to perform any duties; however, they are expected to attend the graduate and teaching seminars.

Application for an assistantship is made separately from the application for admission and should be received in the Mathematics Department no later than February 15 for the fall semester, and no later than October 15 for the spring semester.

For more information go to http://www.tntech.edu/financialaid.

Housing

Graduate students may live on campus or off campus. On-campus housing consists of dormitories and an apartment complex known as *Tech Village*. Dormitory rooms are furnished but the apartments are not. It is possible, for a small extra charge, to request a dormitory room without a roommate. The dormitory rent of $2,280 per semester (Fall 2009) includes all utilities. Most dormitories are equipped with access to the campus computer network. The apartment rent at Tech Village is $310 per month (fall 2009/spring 2010) includes services such as local telephone, water, and basic cable TV. However, at present, no network access is available at *Tech Village*. Internet access is available through one of the local internet service providers. To

[3] The value of the graduate stipend and the current dollar value of the tuition and fees waiver reduce this amount if they have been awarded. This leaves a sum of $5,174 that must come from the applicant's personal funds.
[4] The stipend is paid over a 10-month period. Currently there is no summer support available.

get more information about on-campus housing or to request an application form, please contact Maggie Hooks, Office of Residential Life/Tech Village, tel. (931) 372-3271 or (800) 268-0240, fax (931) 372-3268, mchooks@tntech.edu or see web page http://www.tntech.edu/reslife/techvillage/index.htm. Apply early to be sure to get a room. The waiting time for an apartment at the Tech Village is about six months from the time an application is made (a priority in assigning these apartments is given to student families and students who are single parents). On the other hand, the waiting time for a dormitory room is much shorter. For international students, living on campus is the most practical solution.

There are several off-campus apartment complexes located within a short five-ten minute walk to the TTU campus. These apartments usually require a 12-month lease, a down payment for the first month and a security deposit equal to one month of rent. Various size apartments are available and graduate students often share them to reduce costs. All units are usually rented two to three weeks before the semester begins.

If you need help with your housing arrangements, in addition to contacting our Housing Office through the web page http://www.tntech.edu/reslife/techvillage/index.htm, please contact the Mathematics Department Office.

Practical Matters

The following is a list of some practical things that graduate students should know about:

1. Each graduate student will need an I-9 card as well as a Social Security Number before starting their first semester. While U.S. students already have such a number, each international student will need to apply for that number at the Social Security Office located at 1145 Perimeter Park Drive in Cookeville. Please call that office at (931) 528-9765 to find out when the office is open. There is no charge to apply for the number.
2. Each graduate assistant will need to open a bank account at a local bank since assistantship stipends are paid via direct deposit.
3. There is one ATM (cash machine) on campus in the University Center on the ground floor.
4. A medical clinic open to students is located in the Nursing and Health Services Building.
5. The International Student Office (located in Derryberry Hall 103, phone 372-3634) is the first and main contact point between international students and the University. It provides orientation to all incoming international students. In particular, it provides rides to a local grocery store at no charge.
6. Each graduate student is issued a mailbox in the Mathematics Department Office. Thus, all mail can be sent to the student at the following address: Department of Mathematics, 110 University Drive, Box 5054, Tennessee Technological University, Cookeville, TN 38505.
7. Each graduate assistant is supplied with a desk in the Graduate Student Office located in Bruner 418. There is one phone in that office (931) 372-3033. Students are requested not to make long-distance or overseas calls from that office unless they use phone cards. There is, of course, no problem receiving calls at that number if it does not disturb other students.
8. For keys to the Graduate Student Office please see Vickie Mayberry in Bruner 235. To schedule hours of work in our tutoring lab, please see Vickie in the Math Office after registering for classes.

Requirements for the Master's Degree (M.S.) in Mathematics

The Department offers the Master of Science degree in mathematics with emphasis in applied mathematics, statistics, and pure mathematics. While the preferred academic background for applicants to the Graduate Program is a B.S. in mathematics the Department also encourages talented students holding B.S. degrees in areas related to mathematics to apply. A number of our recent graduates held undergraduate degrees in physics, engineering and secondary education. We have also had a number of international students from China, Kuwait, Poland, Turkey, and Ukraine. Students who do not hold a bachelors degree but who have completed four years of university studies within, for example, the European system are also encouraged to apply.[5]

If you have not taken an advanced calculus course or its equivalent or have not taken a two-semester undergraduate course in abstract algebra, you may be required to take these courses before you can take our 6000-level classes.

Requirements for the Thesis Option M.S. degree in Mathematics:

* 3 semester hours of 6000-level Algebra
* 3 semester hours of 6000-level Analysis
* Two one-year approved sequences (chosen from the list below) totaling 12 semester hours
* A written thesis and 6 semester hours of thesis credit
* A minimum of 30 graduate semester hours, including at least 21 hours at the 6000 level.

Requirements for the Non-Thesis Option M.S. degree in Mathematics:

* 3 semester hours of 6000-level Algebra
* 3 semester hours of 6000-level Analysis
* Three one-year approved sequences (chosen from the list below) totaling 18 semester hours
* A Comprehensive Examination in two of the three subject areas covered by the three required sequences. Selection of the two areas of the examination will be left to the graduate student and to the graduate student's advisor subject to the approval of the student's Graduate Advisory Committee.
* A minimum of 33 graduate semester hours, including at least 24 hours at the 6000-level, and 3 hours of MATH 6991 Research and Independent Study (1-3).

Each student must select an Advisory Committee and submit his/her Program of Study to the Committee for approval.[6] After the Advisory Committee approves the Program, it is then submitted to the Mathematics Department Chair and the Dean of the College for approval. Once the Chair approves the Program of Study, the graduate student applies for Admission to

[5] * Students who do not hold an undergraduate degree in mathematics or who have not completed an equivalent of four years of university studies in mathematics may be admitted conditionally. They will then be required to complete certain undergraduate courses in mathematics before achieving full standing. These presentation courses, typically include MATH 5110/5120 Advanced Calculus I and/or II, and/or MATH 3510/3520 Modern Algebra I and/or II, and/or MATH 3400 Introduction to Concepts of Mathematics (to see course descriptions go to http://www.math.tntech.edu/course_descript.html). Please contact Dr. Michael Allen, at mallen@tntech.edu if you have any questions related to your background and its suitability for admission to our Graduate program.

[6] Approval of a student's Program of Graduate Study, Application for Admission to Candidacy, and Appointment of Advisory Committee are all done using one application. A copy is included in the Appendix.

Candidacy. According to the Graduate School guidelines, "Graduate students in a program leading to the master's degree […] should make application for admission to the candidacy immediately following the completion of 9 semester hours of graduate credit. If application is not made by the time 15 hours are completed, the student may not be permitted to register for subsequent work until the application is approved".[7]

The Advisory Committee should be formed no later than the second semester but preferably before the end of the first semester of study. The Graduate Advisor advises the student until the Advisory Committee is formed. Per recommendation of the departmental Graduate Committee, the first and sometimes the second semester schedule may include some additional preparatory courses such as advanced calculus or undergraduate abstract algebra. International students may also be required to take ESL 1010 and/or ESL 1020. These additional courses are applied toward the 12-credit maximum semester load, but ESL courses do not count toward the minimum of 30-credit hours required for the master's degree.

For more information go to http://www.math.tntech.edu/graduate.html**.**

Graduate School Policy on Comprehensive Examinations for Non-Thesis Option Masters Degree

"The comprehensive examination for the non-thesis masters degree will be prepared and administered by the department offering the program. The student's performance on the examination must be reported to the Graduate School by the date for reporting grades of graduating seniors. A student will normally have a maximum of two attempts to pass the comprehensive examination. In extenuating circumstances, and on the recommendation of the students's Advisory Committee, the Chair of the Department, and the Dean of the College, the Associate Vice President for Research and Graduate Studies may grant the student one more attempt to pass the comprehensive examination. This policy was approved at the Graduate School Executive Committee Meeting on April 15, 2003."

Program Description

The flexibility of our graduate program allows students to concentrate in either pure or applied mathematics, or statistics.

Pure Mathematics: The Department regularly offers courses in complex, functional, and real analysis, abstract algebra, linear algebra, graph theory, combinatorics, and less frequently in topology, differential geometry, and number theory. These courses offer a solid background for further graduate study or for a teaching position in a community college.

Applied Mathematics: The Department frequently offers several courses in ordinary and partial differential equations and in numerical analysis. Other courses regularly taught include calculus of variations, operational mathematics, and integral equations. These classes provide a good

[7] For a complete list of requirements that must be met before approval of Admission to Candidacy, please consult The Graduate School Catalog 2008-2009, p. 40.

foundation for further graduate study and also support master and doctoral programs in engineering at Tennessee Tech.

Statistics: The Department currently offers courses that cover topics in applied regression analysis, analysis of variance, design of experiments, probability theory, mathematical statistics, and stochastic processes. These courses, especially probability and mathematical statistics, provide students with a very good foundation in statistical theory. In the applied statistics courses, students are trained to formulate scientific concepts and problems in mathematical terms, to solve the resulting problems, and to prepare and interpret summary statistical reports. Overall, students learn statistical theory and applications that prepare them for further graduate study and/or careers in business, industry and government.

For more information go to http://www.math.tntech.edu/graduate.html.

Graduate Courses

The following graduate courses are offered in the Mathematics Department. Students should consult our web page http://www.math.tntech.edu/course_descript.html to find out when a course is scheduled to be offered since most of the upper level courses are not offered each semester. If there are any topics that interest a graduate student but which are not represented as a regular course (for example, algebraic geometry, theory of quadratic forms, Clifford algebras, mathematical physics, and more), a special topics course, MATH 6910, may be requested by the student. Note that MATH 6910-6920 - Special Topics counts toward the degree provided it is taught as a six-hour sequence and that it has received prior approval of the student's Advisory Committee or, if the committee has not yet been appointed, by the Graduate Committee.

Note: Our 5000-level graduate courses are dual-listed as 4000-level undergraduate courses.

MATH 4050 (5050)	Number Theory. Lec. 3. Credit 3.
MATH 4110-2 (5110-2)	Advanced Calculus I-II. Lec. 3. Rec. 1. Credit 3.
MATH 4210-2 (5210-2)	Numerical Analysis I-II. Lec. 3. Credit 3.
MATH 4250-6 (5250-6)	Advanced Ordinary Differential Equations I-II. Lec. 3. Credit 3.
MATH 4310-2 (5310-2)	Introduction to Topology I-II. Lec. 3. Credit 3.
MATH 4350 (5350)	Introductory Combinatorics. Lec. 3. Credit 3.
MATH 4360 (5360)	Graph Theory. Lec. 3. Credit 3.
MATH 4410 (5410)	Differential Geometry. Lec. 3. Credit 3.
MATH 4470-8 (5470-8)	Probability and Statistics I-II. Lec. 3. Credit 3.
MATH 4510 (5510)	Advanced Mathematics for Engineers. Lec. 3. Credit 3.
MATH 4530-4 (5530-4)	Linear Algebra I-II. Lec. 3. Credit 3.
MATH 4610 (5610)	History of Mathematics I. Lec. 3. Credit 3.
MATH 4620 (5620)	History of Mathematics II. Lec. 3. Credit 3.
MATH 4710 (5710)	Vector Analysis. Lec. 3. Credit 3.
MATH 4750 (5750)	Category Theory of Sets. Lec. 3. Credit 3
MATH 4850 (5850)	Computational Algebraic Geometry I. Lec. 3. Credit 3
MATH 4860 (5860)	Computational Algebraic Geometry II. Lec.3. Credit 3
MATH 4910-2 (5910-2)	Directed Readings. Credit 3.

MATH 4950 (5950)	Topics in Mathematics. Lec. 3. Credit 3.
MATH 4970	Senior Seminar. Credit 1, 1 hour
MATH 4991, 4992, 4993	Mathematical Research. Credit 1, 1 hour; 2, 2 hours; 3, 3 hours
MATH 6010-6020	Functional Analysis I-II. Lec. 3. Credit 3.
MATH 6070-6080	Applied Linear Statistical Methods I-II. Lec. 3. Credit 3.
MATH 6110-6120	Abstract Algebra I-II. Lec. 3. Credit 3.
MATH 6150	Mathematical Modeling. Lec. 3. Credit 3.
MATH 6170-6180	Experimental Design I-II. Lec. 3. Credit 3.
MATH 6210-6220	Topology I-II. Lec. 3. Credit 3.
MATH 6270	Mathematical Statistics. Lec. 3. Credit 3.
MATH 6310-6320	Complex Analysis I-II. Lec. 3. Credit 3.
MATH 6370-6380	Probability Theory and Stochastic Processes I-II. Lec. 3. Credit 3.
MATH 6410-6420	Real Analysis I-II. Lec. 3. Credit 3.
MATH/CSC 6450	Advanced Theory of Computation. Lec. 3. Credit 3.
MATH/CSC 6460	Computational Methods for Graphics and Modeling. Lec. 3. Cr. 3.
MATH 6510	Finite Difference Solutions of PDE's. Lec. 3. Credit 3.
MATH 6520	Finite Element Solutions of PDE's. Lec. 3. Credit 3.
MATH 6530	Integral Equations and Applications. Lec. 3. Credit 3.
MATH 6540	Calculus of Variations and Applications. Lec. 3. Credit 3.
MATH 6610	Operational Mathematics. Lec. 3. Credit 3.
MATH 6810	Partial Differential Equations. Lec. 3. Credit 3.
MATH 6900	Mathematics Seminar. Lec. 1. Credit 0-1.
MATH 6910-6920	Special Topics in Mathematics. Credit 1-3.
MATH 6990	Research and Thesis. Credit 3,6.
MATH 6991	Research and Independent Study. Credit 1-3.

For more information go to http://www.math.tntech.edu/course_descript.html.

Approved Sequences

Each graduate student must select two sequences totaling 12 credits from among the ones listed below.

MATH 6010-6020 Functional Analysis I and II
MATH 6070-6080 Applied Linear Statistical Methods I and II
MATH 6110-6120 Abstract Algebra I and II
MATH 6170-6180 Experimental Design I-II
MATH 6210-6220 Topology I and II
MATH 6310-6320 Complex Analysis I and II
MATH 6370-6380 Probability Theory and Stochastic Processes I and II
MATH 6410-6420 Real Analysis I and II

- One of the following two sequences:
  MATH/CSC 6450 Advanced Theory of Computation and
  MATH/CSC 6460 Computational Methods for Graphics and Modeling
  MATH/CSC 6450 Advanced Theory of Computation and
  CSC 6700 Software Engineering

- Any two of the following courses (all four must be taken in order to complete two sequences):
  MATH 6510 Finite Difference Solutions of Partial Differential Equations
  MATH 6520 Finite Element Solutions of Partial Differential Equations
  MATH 6810 Partial Differential Equations
  MATH 6540 Calculus of Variations and Applications

MATH 6910-6920 Special Topics in Mathematics

Permissible Loads

Nine credit hours per semester constitute a minimum full load for a graduate student. During the Summer Semester, six hours is considered full-time for a graduate student. The maximum permissible load is 16 hours of credit during the Fall, Spring, and Summer semesters for students not on a graduate assistantship. These are inclusive totals of credits earned at all institutions. An overload of graduate credit is not permitted in these semesters. Students who are serving as graduate assistants are limited to course loads appropriate to the extent of their service. A full-time assistant may not exceed 12 hours of credit per semester. In extenuating circumstances, a full-time assistant may take up to 14 hours per semester if approval is granted by the major advisor, the departmental chairperson, and the Associate Vice President for Research and Graduate Studies.

An international student must be a full-time student at Tennessee Technological University August through May. Each semester except summer, an international student must earn a minimum of 9 credit hours if a Master's candidate and 6 credit hours if a Ph.D. candidate.

A U.S. graduate student must be enrolled in at least 9 graduate hours and work no more than 20 hours per week in order to have his or her wages excluded from FICA/Medicare taxes (7.65 percent of the student's wages). (FICA/Medicare does not apply to international students.)"

In the Mathematics Department, all full-time graduate students receiving an assistantship are expected to complete 18 graduate hours of mathematics by the end of their second semester (including any graduate transfer credits).[8]

Drop Policy

The Drop Policy for graduate students shall be consistent with the policy for undergraduate students. That is, graduate students are permitted to drop a course without a grade on the same day that undergraduate students drop a course without a grade. Graduate students are permitted to drop a course with a "W" grade on the same day that undergraduate students drop a course with a "W" grade.

Note: In Fall and Spring Semesters, the last day for undergraduates to drop with a "W" grade shall be the last day of advisement week. In Summer Semesters, the last day for undergraduates

[8] Approved by the Mathematics Department faculty on September 5, 2002.

to drop with a "W" grade shall be the class day that is two-thirds of the way through each of the terms (1st term, or full term). This policy shall also apply to graduate students.

Academic Resources

- Mathematics graduate students have access to our computer laboratory in Bruner 305. Computers in Bruner 305 are networked and offer a variety of software packages in statistics, mathematics, engineering, mathematical typesetting as well as standard Windows word-processing software and spreadsheets.
- Each graduate assistant is provided with a personal computer on his/her desk in the Graduate Student Office (BR418). These up to date workstations are networked and they are connected to a laser printer located in the same office.
- We maintain bulletin boards where we post current information about seminars, lectures, conferences, job opportunities, etc. We often bring speakers from Ph.D. programs who provide information about their programs to our students.
- All students have on-line access to MathSciNet that contains Mathematical Reviews published on the Web by the American Mathematical Society.
- All students have access to the TTU University Library On-line Catalog.
- Tutoring, weekly teaching seminars, and interaction with other faculty members help graduate students formulate teaching philosophies and improve their teaching skills during their first year of graduate studies.
- The Department makes every effort to support presentations made by graduate students at regional and national mathematics conferences and workshops.
- Weekly seminars give all graduate students the opportunity to learn about various active research topics and branches of mathematics not normally covered in regular courses.
- A Graduate School *"Guide to the Preparation of Theses and Dissertations"* can be found online at http://www.tntech.edu/graduatestudies/thesis/pdf/manual.pdf.
- LaTeX2e templates and style files for a master thesis are posted on the web URL: http://www.tntech.edu/gcat/asp/degree_master_thesis.asp. For help with the templates please contact Dr. Ablamowicz, 372-3622, rablamowicz@tntech.edu .

Additional Highlights of the Program

- Each graduate student has a desk and a cubicle in the Graduate Student Office in Bruner 418. A refrigerator, a microwave, and a coffee maker are in the office for the students' use.
- The Faculty Lounge is open to our graduate students. A microwave, a refrigerator, a sink, comfortable chairs, and some mathematical periodicals are available there.
- Students are encouraged and invited to interact with faculty on various research projects. This should help students in their pursuit of advanced degrees in mathematics and other fields.
- Students have easy access to mathematics typesetting software such as TeX, LaTeX and a laser printer in the graduate office. A PostScript network printer, a copier, a scanner, and a fax/telefax machine are located in the Mathematics Department Office and available to the graduate students.

- A variety of mathematical, statistical, and programming software such as Maple, Matlab, SPSS, StatGraph, Cyclone, C++, and more, are available on the computer network from the computer lab or from the graduate student office.
- In our program, students are able to have a significant amount of one-on-one interaction with faculty members. The Department also tries to involve all graduate students in extracurricular activities such as picnics, visits to interesting sites, cultural programs, etc.

Faculty Interests

Dr. Rafal Ablamowicz, Ph.D., Southern Illinois University at Carbondale, 1983, Clifford Algebras, Symbolic Computations

- Representations of the symmetric group in the package **SymGroupAlgebra** including representing S_n in a Clifford algebra $C1_{n,n}$
- Mathematical structure of classical and quantum Clifford algebras and their application in physics and engineering
- Continuous development and support of Maple packages such as **CLIFFORD/Bigebra, SymGroupAlgebra, SP**, etc.
- Non-commutative Groebner bases in Grassmann and Clifford algebras, see package **GfG**
- Application of Groebner bases to solving engineering problems, see a joint package with Dr. Jane Liu called **RJgrobner**
- Development of Maple packages for effective reaching of engineering courses
- Hopf algebra of symmetric functions with Prof. Bertfried Fauser, see package **SchurFkt**
- Applications of category theory to automata theory
- Application of quaternions in robotics: single and double RPP chains, singularity spaces, workspaces, screw theory
- Hecke algebras (q-Young tableaux, representations, q-spinors)
- Mulitlinear algebras (Quantum Clifford algebras, Rota-Stein Cliffordization)
- Application of quaternions and dual quaternions in robotics: single and double RPP chains, singularity spaces, workspaces, screw theory

Dr. Michael Allen, Ph.D., University of Georgia, 1997, Time Series, Bootstrapping, Re-sampling Methods and Time Series

When dealing with statistical models, there are usually conditions and criteria which must be met in order for the model to be valid. For instance, in simple linear regression, classical analysis requires that the error terms be normally distributed. If the errors terms are far from normal, then classical inference methods do not apply. My current research deals with relaxing such criteria for some more advanced statistical models, like spatial and logistic models, in order to find new robust methods of statistical inference for these models.

Dr. Amy Chambers, Ph.D., University of Colorado, 2006, Functional Analysis and Operator Theory.

My current research began in the area of multiresolution wavelet theory, but the connection between multiresolution wavelet theory and representations of the Cuntz algebras led into the realm of tensor products, conditional expectations, and graph C*-algebras. The Cuntz algebras have proved very useful in the classification of certain types of C*-algebras. These algebras show up as examples in many mathematical contexts, including the area of multiresolution wavelet theory. They are prototypes of those simple, purely infinite, separable, and nuclear C*-algebras that have recently been classified up to *-isomorphism. Since the classification of these algebras is understood, it then becomes of interest to see how Cuntz algebras, and more generally graph C*-algebras, can be embedded into other such algebras as subalgebras, and if so, whether or not conditional expectations exist onto these subalgebras.

Dr. Andrzej Gutek, Ph.D., Uniwersytet Slaski, 1981, Topology

My research interests are Topology, Functional Analysis, and History of Mathematics. The most recent project I am working on involves shift operators on Banach spaces of continuous (real or complex valued) functions on compact zero-dimensional metric spaces.

Dr. Andrew Hetzel, Ph.D., University of Tennessee Knoxville, 2003, Multiplicative ideal theory with an emphasis on the study of prime ideals, and probabilistic studies in linear algebra and number theory.

In my first area of research, I explore the connections prime ideals have with some of the most powerful and useful properties in algebra, such as integrality, flatness, and unique factorization of elements. Often, topological considerations and notions from the theory of partially ordered sets are central to such an exploration. In this area of research, I am currently interested in certain generalizations of the notion of “prime ideal”, contractions of chains of prime ideals, and the study of particular non-chains of prime ideals. In my second area of research, I examine the probabilities that certain properties hold either within special subsets of matrices or within special subsets of the rational numbers. I have recently led a productive undergraduate research project in this area, and am currently interested in answering several open questions (potentially well-suited for a graduate student) that remain from that project. A major thread that runs through both of my areas of research is the extension of results predicated on a finite set of data to results predicated on a corresponding infinite set of data.

Dr. Richard Le Borne, Ph.D., University of California, San Diego, 1993, Numerical analysis, scientific computation, signal processing

Signal processing can be characterized as the study of problems involving information that, after having been transmitted, is altered in some undesirable way before being received at its desired destination. The aim is to intelligently and efficiently separate from the collected data that part which is not desired. Applications that can be associated with signal processing are ever growing and include such diverse fields as biomedical engineering, radar, control and communications.

My research has concentrated on the numerical analysis of adaptive filtering algorithms in signal processing. In particular, I have worked to improve the theoretical understanding of algorithmic performance, i.e., analyzing the numerical behavior of adaptive filtering algorithms. Additionally, and to address the apparent confusion regarding numerical analysis techniques employed on algorithms and their meaning with respect to the value of an algorithm's computed result, I have worked to facilitate the correct interpretation given by numerical analysis that is employed on signal processing algorithms.

My current and ongoing research continues in this direction and devotes attention to the interconnectiveness relating an analysis involving exact arithmetic (perturbation analysis) to one assessing the effect from finite precision arithmetic. Results have been applied to specific solution methods such as the so-called lattice and transverse-based algorithms.

Dr. Sabine Le Borne, Ph. D., Christian-Albrechts-Universität Kiel, Germany, 1999, Numerical Analysis, Scientific Computation, Partial Differential Equations

My research interests lie in methods involved in the numerical solution of partial differential equations. Specifically, I'm interested in algorithms for the solution of the discrete systems of equations that arise in the discretization of partial differential equations. Most recently, I have been conducting research in the field of so-called (hierarchical) *H*-matrices which are data-sparse and allow an approximate matrix arithmetic of almost linear complexity. This novel approach is of significant importance since it permits the study of quite new applications. An example is the treatment of saddle point problems where typically non-sparse Schur complements appear.

Dr. Yung-Way Liu, Ph.D., University of Delaware, 1987, Partial Differential Equations

My research interests include Differential Equations and Integral Equations with applications. My graduate teaching interests are Partial Differential Equations, Integral Equations, Calculus of Variations, Numerical Analysis and Numerical Solutions to PDE. During the past ten years I have supervised many graduate students who have written theses on various applied areas. Thesis topics include Integral Equations, Singular Perturbations, Liapunov Stability, Bifurcations of Chaotic Systems, and Linear Programming.

Dr. Motoya Machida, Ph.D., The Johns Hopkins University, 1999, Probability and Statistics; Perfect sampling methods, Markov chain Monte Carlo, and Bayesian inference.

Markov chain Monte Carlo (MCMC) is extremely useful when it is intractable to sample directly from distribution of interests. In MCMC methodology, one designs a Markov chain whose stationary distribution is the target distribution, and runs the Markov chain for a long time. The analysis of rate of convergence can provide information necessary to decide the running time, but such analysis is very difficult or even found impossible in practice. The emergence of perfect sampling---coupling from the past (CFTP) algorithm is largely studied and used for its ease of implementation; my research is motivated by the development of the prefect rejection algorithm---a currently less-used alternative.

The practicality of perfect sampling is of great interest in Bayesian inference. For example, Hobert, Robert, and Titterington (1999) studied the CFTP algorithm for the MCMC evaluation of simple mixtures. I began my own investigation on the perfect rejection algorithm for the mixture model. In doing so, I hope to demonstrate that the perfect rejection algorithm has its own advantage in practice and can be a genuinely useful alternative to the CFTP algorithm.

Dr. Allan Mills, Ph.D., Louisiana State University, 1995, Matroid Theory, Graph Theory

My research interests lie in an area of discrete mathematics known as Matroid Theory. Most of my research has involved the determination of a matroid's structure from properties of certain large minors or submatroids. I have also worked on extending the notion of a perfect graph to that of a perfect binary matroid. I am currently interested in studying elongations of matroids and determining when the elongation of a matroid is graphic.

Dr. Jeffrey Norden, Ph.D., SUNY at Binghamton, 1988, General and Geometric Topology and Set Theory

My research interests are primarily in the areas of topology and set theory. Topology can be described as a sort of "messy geometry". Topologists are interested in geometric notions such as shape and connectedness, but we do not study the "exact" shape of objects. For example, a square and a circle are equivalent in topology, but are very different from an interval (an interval has endpoints, while the other examples do not).

Set theory is the study of collections of objects. While it seems like this would be a simple and perhaps boring research area, it becomes quite interesting as soon as one introduces various kinds of *infinite* collections. The resulting research has important connections with logic and the foundations that underlie all mathematics.

The topology that interests me the most has connections with set theory, in that topological properties can depend upon the set-theoretic assumptions one chooses to adopt. This often produces what are called "relative consistency results" which show that we are fundamentally *unable* to answer certain questions in any absolute sense. This is a relatively new mathematical phenomenon, and there are many ways to view it. My own philosophy is a somewhat Zen one, which we are investigating the ways in which our own thoughts and assumptions about the world can affect the (mathematical) world, in which we find ourselves living.

Dr. Brian O'Connor, Ph.D., University of Illinois, 1977, Numerical Analysis, Partial Differential Equations

My area of expertise is in the areas of numerical analysis and partial differential equations. Specifically, I am interested in the finite element method as a tool for solving partial differential equations, usually elliptic PDE's. I have taught a course, Finite Element Solutions of PDE's, Math 6520, several times. I also regularly teach, on the graduate level, Math 6510 - Finite Difference Solutions of PDE's, and Math 6610 - Operational Mathematics, which deals with Laplace and Fourier transforms. Undergraduate courses taught frequently include the calculus sequence, advanced math for engineers, and numerical analysis.

Master theses that I have supervised have been in the areas of Laplace transforms, Fourier series, integral and differential equations, PDE's in several variables, infinite series, and optimal paths.

Other areas of interest include pedagogy, mathematical puzzles, and mathematical aspects of baseball.

Dr. Richard Savage, Ph.D., University of Utah, 1981, Analysis, Differential Geometry, Topology

My main research interests deal with inequalities involving compact, convex sets in the plane. There are many problems of this type to consider but here is an example. Suppose that two congruent compact, convex sets in the plane intersect. Consider now the boundary of the intersection. Two parts of the boundary can be distinguished – namely, the part which was on the boundary of one of the original sets and the part which was on the boundary of the other set. The question to consider is whether there is an upper bound to the ratio of the lengths of these two parts. Answers are known in some special non-trivial cases, e.g., when the sets are rectangles or isosceles triangles and answers are conjectured in the case that one has a twice differentiable boundary with constraints on the curvature. The general case though remains open.

Dr. Alexander Shibakov, Ph.D., Auburn University, 1998, Topology, Functional, and Set Theory

Topology can be defined as a branch of mathematics that studies shape and continuity, while Functional Analysis concentrates on studying functions and families of functions and Set Theory provides the foundation for mathematics. I'm also interested in the theory of Partial Differential Equations, and (outside of mathematics) image synthesis and hardware simulation.

Dr. David Smith, Ph.D., University of Georgia, 2001, Small Area Estimation, Kernel Density Estimation, and Minimum Hellinger Distance Estimation.

Small area estimation seeks to provide reliable and accurate estimates when sample sizes are small. Linear models can be used to develop such estimates. My current research studies the performance of several methods of constructing confidence intervals for the means of a linear model through simulation.

I am interested in developing a bivariate extension to a univariate kernel density estimator when the bounds of the data are known. An example of this type of data comes from the bivariate exponential distribution.

A minimum Hellinger distance estimate (MHDE) is the value that minimizes the distance between a kernel density estimator and a model density. Such an estimator has very nice properties in terms of efficiency and robustness. I am interested in studying MHDE's in a multivariate context. One such application is for the bivariate exponential distribution previously mentioned. I am also interested in developing a robust approach to the One-way ANOVA using minimum Hellinger distance.

Appendix

1. Graduate School Master's Checklist
2. Application for Admission to Candidacy, Appointment of Advisory Committee, and Proposed Program Graduate Study [Revised 3/9/98]
3. Thesis Defense form for graduate students in the Thesis Option.
4. Final Comprehensive Examination form for graduate students pursuing the Non Thesis Option.
5. Copy of the departmental web page http://www.math.tntech.edu/TTUthesis/thesis.html where a LaTeX2e template for a master thesis is posted.

MASTER'S CHECKLIST

On your way to the Master's Degree

There are several points or responsibilities of which you should be aware as you move toward your projected graduation date. Please use the following checklist as a guide in helping you meet the requirements for your degree. The list appears in order of priority, except for some variation which may be caused by the status of your admission or which may be required by your Advisory Committee or by the Graduate School Office. Please do not hesitate to correspond with the Graduate School, 306 Derryberry Hall, 372-3233, or your Advisory Committee in regards to these or other requirements. It is important that a student be in Full Standing and these requirements met in order to be eligible for graduation.

_____1. **Standardized Examinations.** Admission to graduate study requires that results from an approved standardized examination (see Graduate Catalog for individual college requirements) be present no later than the first term of enrollment.

_____2. **Reclassification.** This step is necessary for any student admitted in Provisional Standing and must be completed before admission to candidacy may be declared. Student must apply for reclassification. (Forms available.)

_____3. **Appointment of an Advisory Committee.** Should be initiated during the term in which 9 semester hours will be completed. (Forms available.)

_____4. **Program of Study.** Should be developed as soon as an advisory committee is selected. A hold will be placed on a student's registration if the program of study has not been filed by the time 15 semester hours have been completed. (Forms available.)

_____5. **Candidacy.** Application for candidacy should be made no later than the term in which 15 hours of graduate credit have been completed. (Forms available.)

_____6. **Application for Graduation.** Initiated by candidate by the end of the first week of the semester in which conferral of the degree is expected. All of the above steps, plus course substitutions, should be completed prior to application. (Forms available.)

_____7. **Comprehensive Examination.** Schedule examinations with Advisory Committee and notify Graduate School Office of date and time. Results must be submitted to Graduate School at least three weeks prior to graduation. (Forms available.)

_____8. **Thesis to Graduate School Office.** Thesis must be submitted in final form at least one week prior to graduation. Preliminary copies must be submitted three weeks prior to graduation.

_____9. **Graduation.** Student is required to be present for the conferral of the degree unless written notification is on file in the Graduate School Office. Students graduating in absentia may have diplomas mailed and assume the risks involved for faulty mail delivery of diploma.

APPLICATION FOR ADMISSION TO CANDIDACY AND APPOINTMENT OF ADVISORY COMMITTEE FORM

TTU Master Thesis LaTeX Files

This page is a resource for mathematics graduate students who use LaTeX2e to compose and write their master theses. The TTU thesis style file ttuthesis.sty, which conforms to all requirements of the Graduate School as of July 2000, was originally written by Paul Tsai. During summer 2000 this file was modified by Rafal Ablamowicz, Department of Mathematics, and Mike Baswell, Graduate Student in the Department of Electrical Engineering. The instructions how to use this and all remaining files listed on this page can be found in Thesis.tex, which provides a skeleton for the entire thesis. Additional comments and instructions are contained in ttuthesis.sty. By selecting appropriate options in the style file ttuthesis.sty one can create also a TTU doctoral thesis. The skeleton file Thesis.tex uses a 12-pt-report style from LaTeX2e, which is modified by ttuthesis.sty. Its preamble begins as follows:

```
\documentclass[12pt]{report}
\usepackage{ttuthesis}          % TTU thesis/dissertation style file
\usepackage{latexsym}           % additional packages that may be read in
\usepackage{amssymb}            % to augment generic LaTeX; needed for \mathbb font
\usepackage{amsfonts}           % reading in some AMS fonts
\usepackage{amsthm}             % reading AMS theorem macro package
\usepackage{amsmath}            % needed for AMS-LaTeX environments like \begin{align}... \end{align}
```

It is recommended that you download Thesis.tex and open it in any editor to see the structure of the entire thesis.

All files needed to compose a master thesis under LaTeX2e using any LaTeX2e composer (for example, PCTEX32 available in Bruner 305 and other PC labs on campus) can be downloaded as a single file Thesis.zip (288KB). The latter contains the following files (all needed to compose Thesis.tex) divided into four categories:

- TeX source (input) files, which contain the actual text of the thesis:
  - abstract.tex - abstract of the thesis,
  - appendix.tex - appendix of the thesis,
  - chapter1.tex - chapter 1 of the thesis,
  - chapter2.tex - chapter 2 of the thesis,
  - chapter3.tex - chapter 3 of the thesis,
  - chapter4.tex - chapter 4 of the thesis,
  - dedication.tex - optional dedication page,
  - preface.tex - page of acknowledgments,
  - references.tex - file with references,
  - symbols.tex - file containing a listing of symbols used in the thesis,
  - Thesis.tex - skeleton file of the entire thesis,
  - vita.tex - page with student's vita,

- Various files with macros, TTU style file, etc.:
  - psfig.tex - public domain macro package used to include Postscript pictures of type PS,
  - setbmp.tex - used to include pictures of type BMP,
  - seteps.tex - used to include pictures of type Encapsulated Postscript,
  - setwmf.tex - used to include pictures of type WMF (Windows MetaFile),
  - ttuthesis.sty - TTU master thesis and doctoral dissertation style file,

- Picture files used in Thesis.tex:
  - braid.eps - Encapsulated Postscript file [format also used by MAPLE],
  - plot03.eps - Encapsulated Postscript file,
  - sin.bmp - Windows bitmap file, or BMP,
  - sin.emf - Windows Metafile, or WMF [format also used by MATLAB],
  - sin.eps - Encapsulated Postscript file,

- Output files obtained after composing Thesis.tex:
  - Thesis.dvi - .dvi file [pictures are not part of this file],
  - Thesis.ps - .ps version of Thesis.dvi [all pictures are part of this file],
  - Thesis.lof - file with contents lines listing all figures,
  - Thesis.lot - file with contents lines listing all tables,
  - Thesis.toc - file with Table of Contents.

There are several user-controlled features that are built into the style file ttuthesis.sty. In order to change any of the options described below, you will need to edit file Thesis.tex and set appropriate switches. More detailed information can be found in Thesis.tex. The following is a list of some of these features:

- Ability to select "Thesis" or "Dissertation" option (default is "Thesis"),
- Adjustable number of lines for the Graduate Committee members (default is three lines),
- Ability to print, when needed, an extra line for a co-chair of the Graduate Committee (default is no co-chair line),
- Ability to print a separate page with a list of figures (default is to print the page),
- Ability to print a separate page with a list of tables (default is to print the page),
- Ability to print a separate page with permissions, if needed (default is to print this page),
- Ability to print a separate page with copyrights, if needed (default is not to print this page),
- Ability to print a separate page with symbols (default is to print this page).

Furthermore, all features of LaTeX are supported including:

- Automatic formatting of all pages: margins, spacing (single or double), etc.,
- Automatic numbering and referencing of pages (roman and arabic), equations, displays, tables, figures, etc.,
- Automatic referencing of bibliographical entries.

Finally, the LaTeX document portion of Thesis.tex has the following structure:

```
\begin{document}
\include{abstract}          % reads in your abstract file abstract.tex
\beforepreface              % creates all pages before the permission page
\permissionpage             % creates the permission page
\include{dedication}        % reads in your dedication file dedication.tex
\include{preface}           % reads in your preface file
\afterpreface               % creates pages after the preface but before the text
\ttutext                    % sets parameters for the actual text, e.g., spacing
\include{chapter1}          % reads in your chapter 1 file chapter1.tex
\include{chapter2}          % reads in your chapter 2 file chapter2.tex
\include{chapter3}          % reads in your chapter 3 file chapter3.tex
\include{chapter4}          % reads in your chapter 4 file chapter4.tex
\include{references}        % reads in your file with references references.tex
\include{appendix}          % reads in your appendix file appendix.tex
\include{vita}              % reads in your vita file vita.tex
\end{document}
```