DEPARTMENT OF MATHEMATICS

THE UNIVERSITY OF TENNESSEE AT CHATTANOOGA

MASTER OF SCIENCE
IN APPLIED MATHEMATICS

PROGRAM REVIEW
FALL 2009 – FALL 2014
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Preface and History

1.1 Background

The University of Tennessee at Chattanooga, a part of the University of Tennessee system, offers forty-five Baccalaureate, fifteen Graduate Certificates, twenty Master's Degrees, one Education Specialist, and four Doctoral Degree programs. Founded in 1886 as Chattanooga University, a private school affiliated with the Methodist Episcopal Church, it soon merged with another church-related school in Athens, Tennessee, to become Grant University. In 1904, the College of Liberal Arts was moved from Athens to Chattanooga and in 1907, the institution became the University of Chattanooga. It remained so until 1969 when it merged with Chattanooga City College to become one of the primary campuses of the University of Tennessee System. It was at this time that the name was changed to The University of Tennessee at Chattanooga. During all of these years there has been a strong commitment to the Liberal Arts and the Department of Mathematics has been a strong part of that commitment.

1.2 History of the program

The M.S. program in Applied Mathematics was developed due to the perceived need for a graduate program in Mathematics (there is no such graduate program within a 2-hour drive from Chattanooga). It was felt that community college instructors, high school teachers, and local companies would benefit from such a program. This is especially so for the local insurance companies.

Work on a proposal to offer a Master of Science Degree in Mathematics began in the fall of 2006. The work was completed and the on-campus review was conducted in December of 2008. The proposal was approved by the Board of Trustees of The University of Tennessee in the spring of 2009, and in August of 2009, the proposal received final approval from the Tennessee Higher Education Commission to offer the degree beginning in the Fall 2009 semester. This was the only new degree program approved in the state of Tennessee in 2009.

The program is very flexible in that students enter the program with backgrounds in such diverse areas as Computer Science, Engineering, and Mathematics, and leave with a
Master’s degree in four semesters (the time can be shortened by taking 12 hours/semester or by taking summer graduate courses). Other Master’s programs, such as Environmental Science, benefits from interaction with mathematicians and statisticians.

Graduate students in the program can earn a M.S. degree in Applied Mathematics under four concentrations: Applied Mathematics, Applied Statistics, Pre-professional Mathematics, and Mathematics Education. The Pre-professional concentration is tailored for students who plan to pursue a Ph.D. program after graduation.

1.3 Faculty changes

A list of graduate faculty at the inception of the program in 2009-10 was as follows.

- Professors: Boris Belinskiy, Betsy Darken, Aniekan Ebiefung, Billy Edwards, John Graef (Head), Stephen Kuhn, Edward Rozema, Eugene Schlereth, Ronald Smith
- Associate Professors: Stan Byrd, Irene Loomis, Ossama Saleh, Lucas Van der Merwe, Terry Walters
- Assistant Professors: Sumith Gunasekera, Lingju Kong, John Matthews
- Visiting Assistant Professors: Francesco Barioli
- Unfilled Positions: UNUM Chair of Excellence in Applied Mathematics

The following changes took place in the interim.

- New Appointments:
  - In Fall 2011 Francesco Barioli was hired as a tenure-track Assistant Professor.
  - In Fall 2012 Andrew Ledoan, Min Wang, Cuilan Gao, Roger Nichols, and Xuhua Liu were hired as tenure-track Assistant Professors. Sergei Avdonin was hired as Chair of Excellence in Applied Mathematics. He resigned in 2013.
  - In Spring 2014 John Matthews was appointed as Interim Head of the Math Department.
  - In Fall 2014 Jin Wang was hired as Chair of Excellence in Applied Mathematics.
- Promotions and Tenure:
  - In Fall 2009, Lingju Kong was granted tenure and promoted to Associate Professor.
  - In Fall 2010, John Matthews was granted tenure.
  - In Fall 2012, John Matthews was promoted to Associate Professor.
  - In Fall 2013, Ossama Saleh and Terry Walters were promoted to Professor.
In Fall 2014, Lingju Kong and Lucas Van der Merwe were promoted to Professors, and Francesco Barioli was granted tenure and promoted to Associate Professor.

- Retirements and Resignations:
  - In Spring 2012 Billy Edwards retired.
  - In Spring 2013 Irene Loomis retired, and Sergei Avdonin resigned.
  - In Spring 2014 Edward Rozema retired, John Graef stepped down as Head of the Math Department and went back to a 9-month faculty position at the rank of Professor.
  - In Fall 2014 Min Wang resigned.

As of July 1st, 2014 the graduate faculty is as follows: eleven full professors, three associate professors, six assistant professors, plus the Chair of Excellence in Applied Mathematics. The complete list of the graduate faculty as of July 1st, 2014 is included in Section 4.1.

1.4 Trends

1.4.1 Placement of students in occupational positions related to mathematics

Every graduate of our program that we have been able to contact is either in a Ph.D. program in Mathematics, is applying for a Ph.D. program in Mathematics, or is in an occupational position related to Mathematics. A complete analysis of our graduates is given in Section 3.6.

1.4.2 Student research activity

In Fall 2012 we began requiring a capstone project consisting of a written report and an oral presentation of an application of Mathematics or of an internship. Thus, each graduate of the program does some research in Mathematics while working closely with a professor.

1.4.3 Enrollment growth, credit hour production, and degrees awarded

There has been a steady increase in the number of graduate students from 2 since the inception of the program in Fall 2009 to 16 in Spring 2014. We predicted that we would produce 13 FTE in Fall 2014 and we have met the prediction: we had 13 full-time graduate students in Fall 2014.
The enrollment growth trend in the five year period is displayed in the following figure.

**Figure 1: Enrollment trend**

<table>
<thead>
<tr>
<th></th>
<th>Fall 2009</th>
<th>Fall 2010</th>
<th>Fall 2011</th>
<th>Fall 2012</th>
<th>Fall 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Applied Mathematics</td>
<td>2</td>
<td>13</td>
<td>16</td>
<td>17</td>
<td>16</td>
</tr>
</tbody>
</table>

*Source: Office of Planning, Evaluation, and Institutional Research.*

The total number of graduate credit hours produced in Fall 2009 was 69, while the figure for Fall 2013 is 222. This represents a 222% increase from the first year to the fifth year.

**Figure 2: Graduate credit hour production**

<table>
<thead>
<tr>
<th></th>
<th>2009-10</th>
<th>2010-11</th>
<th>2011-12</th>
<th>2012-13</th>
<th>2013-14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>69</td>
<td>129</td>
<td>246</td>
<td>168</td>
<td>222</td>
</tr>
<tr>
<td>Spring</td>
<td>57</td>
<td>132</td>
<td>150</td>
<td>147</td>
<td>141</td>
</tr>
</tbody>
</table>

*Source: Office of Planning, Evaluation, and Institutional Research.*

There has been a corresponding increase in the number of Master’s degrees awarded, as shown in the following figure.
1.4.4 Diversity

Of the twenty-one (permanent) full time faculty lines in 2014-15, two of these are held by women. Five faculty members are Chinese, one is Nigerian, one is Russian, one is Egyptian, one is South African, one is Sri Lankan, one is Italian, while the rest are from the United States. When advertising for new faculty positions, the Department sends a letter with a copy of its advertisement to all of the historically Black institutions in the United States encouraging applicants and nominations. Informal contacts with colleagues at such institutions are also used in an effort to attract minority applicants.

Diversity data for both graduate faculty and graduate students is presented in the following figures.

1.4.5 Faculty Scholarship

Eighteen out of the twenty-one graduate faculty have published in the last five years. For the five calendar years 2009 through 2013, the number of papers and books that have appeared in print each year and the number of presentations by faculty at national and international conferences and meetings are presented in the table below.

<table>
<thead>
<tr>
<th>Table 1: Graduate faculty publications and presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Presentations</td>
<td>6</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>21</td>
</tr>
<tr>
<td>Journal Articles</td>
<td>40</td>
<td>43</td>
<td>51</td>
<td>65</td>
<td>85</td>
</tr>
<tr>
<td>Books Authored</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Books Edited</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

These are especially impressive numbers for a non-PhD granting Mathematics Department.

John Graef, Lingju Kong, Min Wang, and Andrew Ledoan were awarded a three-year $290,000 NSF Grant Research Experiences for Undergraduates in Mathematics entitled Differential/Difference Equation Models and Number Theory. This grant began in 2012-13, and has resulted in eight publications and ten presentations, and has attracted undergraduate students from throughout the Southeast.
### 1.4.6 Student Retention

Since the inception of the program until Spring 2014, 35 students have enrolled in the program. Of these students, 27 have either graduated or else are continuing students in good standing. Thus, the retention rate is 77%. The following table lists the number of students who have graduated, who are continuing student, who left the program in good standing, and who left the program on probation, with each category subdivided by gender and ethnicity.

<table>
<thead>
<tr>
<th></th>
<th>Asian</th>
<th>Black</th>
<th>White</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F M</td>
<td>F M</td>
<td>F M</td>
<td>F M</td>
</tr>
<tr>
<td>Graduated</td>
<td>1 1</td>
<td>0 0</td>
<td>5 14</td>
<td>21</td>
</tr>
<tr>
<td>Continuing</td>
<td>0 1</td>
<td>0 0</td>
<td>1 4</td>
<td>6</td>
</tr>
<tr>
<td>Left the program in good standing</td>
<td>0 0</td>
<td>0 0</td>
<td>0 1</td>
<td>1</td>
</tr>
<tr>
<td>Left the program on probation</td>
<td>1 0</td>
<td>0 1</td>
<td>2 3</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>2 2</td>
<td>0 1</td>
<td>8 22</td>
<td>35</td>
</tr>
</tbody>
</table>

*Source: Matt Matthews, Department of Mathematics*

### 1.4.7 Student Enrichment Activities

Each graduate student receives a yearly Mathematical Association of America free membership and The American Mathematical Monthly, which contains articles appropriate for a graduate student. The local chapter of Pi Mu Epsilon, the Math honorary is very active and, together with the Student Relations Committee, provides showings of Math-oriented movies such as “Proof” or “A Beautiful Mind”, as well as Sudoku competitions. A number of social events are provided throughout the academic year.

### 1.5 Findings of the Previous Review

Since the MS program in Applied Math was begun in the fall of 2009, there is no previous program review.
Curriculum

The MS Program was started with the following concentrations: Applied Mathematics, Applied Statistics, Pre-Professional Mathematics, and Mathematics Education. In the original proposal the Pre-professional concentration was listed as Algebra-Discrete Mathematics.

2.1 Description of the Program

The following discussion is taken from the 2014-15 UTC Undergraduate and Graduate Catalogs. [http://catalog.utc.edu](http://catalog.utc.edu)

Mathematics, M.S.
Dr. John V Matthews, Interim Head
(423) 425-4719 or email at Matt-Matthews@utc.edu
Dr. Ronald Smith, Graduate Program Coordinator
(423) 425-4569 or email at Ronald-Smith@utc.edu

The Department of Mathematics at The University of Tennessee at Chattanooga offers a Master’s of Science degree in mathematics with concentrations in Applied Mathematics, Applied Statistics, Pre-Professional Mathematics, and Mathematics Education. This program is designed to provide individuals with an in-depth understanding in their chosen area, further preparing them for work in industry, government, and education, or for further graduate studies. Completion of the program requires thirty-six (36) semester credit hours, which includes an area of application or an internship. There is also an option of composing a final thesis. Students must maintain a minimum institutional cumulative GPA of 3.0, and are subject to all regulations of the UTC Graduate School. The intent is to give the MS student maximum flexibility in choosing his/her courses to many different topics, methods of proofs, and methods of problem solving.

2.2 Faculty and the Department

The Department of Mathematics has 21 full time faculty members holding professorial rank. All hold the Ph.D. degree and are members of the graduate faculty. Their research interests span a wide variety of mathematical interests. These include linear algebra and
matrix theory, modern algebra, graph theory, numerical analysis, functional analysis, ordinary and partial differential equations and difference equations, operations research, statistics, and mathematics education. The Department is highly active in research as demonstrated by publications in national and international refereed journals, invited and contributed presentations at national and international conferences, service on editorial boards, and refereeing and reviewing activities. See Table 1: Graduate faculty publications and presentations for a summary of the research activities of the graduate faculty.

2.3 Admission

Individuals must meet the admission requirements of the UTC Graduate School as stated in the Graduate Catalog Admissions Requirements. In addition, students must have a strong mathematical background at the undergraduate level, as evidenced by successful completion of critical coursework or by a baccalaureate degree in mathematics from a regionally accredited institution. Requirements may be higher for a graduate of an unaccredited institution.

Admission to the MS Program is done through the UTC Graduate School. Application to the Graduate School can be done online and requires submission of:

- A letter of application explaining reasons why the candidate wishes to pursue graduate study in Mathematics,
- Two letters of recommendation from individuals who are familiar with the applicant’s scholastic ability and/or professional experience.
- The scores on the scores on the verbal and quantitative part of the GRE exam, if the applicant is applying for assistantships or fellowships.

Application materials should be sent to Jessica Dickerson (Jessica-Dickerson@utc.edu) at the Graduate School: The University of Tennessee at Chattanooga, The Graduate School, 103 Race Hall, Dept. 5305, 615 McCallie Avenue, Chattanooga, TN 37403. Email submission of application letters of recommendation is acceptable.

Once the candidate has been accepted by the Graduate School, the complete application will be sent to the Mathematics Graduate Program Coordinator, Ronald L. Smith, for approval. Application for assistantship should be sent to the department.
2.4 Critical Undergraduate Coursework Required For Admission

Differential and Integral Calculus with Laboratory (8 hours); Multivariable Calculus (3 hours); Differential Equations (3 hours); Elementary Linear Algebra (3 hours); Analysis (3 hours); Probability and Statistics (3 hours); Modern Algebra (3 hours); a course in Computer Science (3 hours); and two additional upper-level mathematics courses (6 hours). In addition, at least one course should emphasize mathematical proofs. Students whose academic background is considered inadequate may be asked to complete additional coursework. In addition, a GPA of 3.0 (on a 4.0 scale) is required on all upper-level mathematics courses.

2.5 General Requirements for the Degree

2.5.1 Credit hours:

A minimum of thirty six (36) semester hours is required. At least twenty four (24) must be in mathematics at the 5000 level.

2.5.2 Core Courses:

- Zero (0) to nine (9) hours depending on whether these courses were taken at the undergraduate level:
- Introduction to Analysis II (MATH 4510 at UTC or equivalent)
- Linear Algebra and Matrix Theory (MATH 4200 at UTC or equivalent)
- Complex Analysis Math (MATH 4570 at UTC or equivalent)

2.5.3 Concentration requirements

Students must choose one of the following four concentrations: Applied Mathematics, Applied Statistics, Pre-Professional Mathematics, Mathematics Education.

Twelve (12) hours must be chosen from one of four concentrations above, including at least one two-semester sequence as defined under that concentration.

The requirements for the various concentrations and sample course schedule are listed below as described in the Graduate Catalog http://catalog.utc.edu.

A. Applied Mathematics
- One of the following six-hour sequences:
  1. Numerical Analysis I and II
     - MATH 5600 - Numerical Analysis I
• MATH 5610 - Numerical Analysis II
2. Numerical Solutions of PDEs I and II
  • MATH 5620 - Numerical Solution of Partial Differential Equations I
  • MATH 5630 - Numerical Solution of Partial Differential Equations II
3. Applied Math for Science and Engineering I and II
  • MATH 5470 - Applied Mathematics for Science and Engineering I
  • MATH 5480 - Applied Mathematics for Science and Engineering II
4. Differential Equations
  • MATH 5450 - Ordinary Differential Equations
  • MATH 5460 - Partial Differential Equations
  • Plus six additional hours chosen from
    • MATH 5580 - Transform Methods
    • MATH 5700 - Techniques of Applied Mathematics
    • MATH 5910 - Special Topics
• Sample Course Schedule
  1. First Year (Fall):
    • MATH 5570 - Complex Analysis (core)
    • MATH 5600 - Numerical Analysis I (concentration sequence)
    • MATH 5450 - Ordinary Differential Equations (elective)
  2. First Year (Spring):
    • MATH 5610 - Numerical Analysis II (concentration sequence)
    • MATH 5460 - Partial Differential Equation (elective)
    • MATH 5500 - Introduction to Analysis II (elective)
  3. Second Year (Fall):
    • MATH 5620 - Numerical Solution of Partial Differential Equations I
    • MATH 5470 - Applied Mathematics for Science and Engineering I (elective)
    • ENCM 5010 - Introduction to Computational Fluid Dynamics (application)
  4. Second Year (Spring):
    • MATH 5630 - Numerical Solution of Partial Differential Equations II
    • MATH 5480 - Applied Mathematics for Science and Engineering II (elective)
    • ENCM 5100 - Computational Fluid Dynamics I (application)

B. Applied Statistics
  • One six-hour sequence consisting of two courses chosen from:
    • MATH 5160 - Applied Statistical Methods
    • MATH 5180 - Analysis of Variance
    • MATH 5190 - Design of Experiments
  • Plus six additional hours chosen from
    • MATH 5140 - Mathematical Statistics
    • MATH 5150 - Introduction to Biostatistics
    • MATH 5160 - Applied Statistical Methods
    • MATH 5170 - Non Parametric Statistics
    • MATH 5180 - Analysis of Variance
    • MATH 5190 - Design of Experiments
- MATH 5310 - Operations Research (Linear)
- MATH 5320 - Operations Research (Nonlinear)
- MATH 5330 - Optimization
- MATH 5910 - Special Topics

Sample Course Schedule

1. First Year (Fall):
   - MATH 5320 - Operations Research (Nonlinear) (concentration)
   - MATH 5180 - Analysis of Variance (concentration sequence)
   - MATH 5300 - Mathematics of Interest

2. First Year (Spring):
   - MATH 5140 - Mathematical Statistics
   - MATH 5190 - Design of Experiments (concentration sequence)
   - MATH 5350 - Financial Mathematics

3. Second Year (Fall):
   - MATH 5330 - Optimization (concentration)
   - MATH 5160 - Applied Statistical Methods
   - MATH 5150 - Introduction to Biostatistics (elective)

4. Second Year (Spring):
   - MATH 5170 - Non Parametric Statistics
   - MATH 5920 - Graduate Internship in Mathematics (6 hours)

C. Pre-Professional Mathematics

- This concentration is recommended for students wishing to pursue the Ph.D. in Mathematics. It is strongly suggested that students choosing this concentration consider writing a Master’s thesis. Two six-hour sequences are required to give the student both breadth and depth in Mathematics. In addition to the sequences described under the Applied Mathematics and Applied Statistics concentrations, the following serve as appropriate sequences for this concentration (only):
  1. Graph Theory and Number Theory
     - MATH 5720 - Graph Theory
     - MATH 5270 - Number Theory
  2. Linear Algebra and Matrix Theory
     - MATH 5210 - Linear Algebra and Matrix Theory
     - MATH 5220 - Advanced Matrix Theory
  3. Modern Algebra
     - MATH 5250 - Modern Algebra I
     - MATH 5260 - Modern Algebra II
  4. Differential Equations
     - MATH 5450 - Ordinary Differential Equations
     - MATH 5460 - Partial Differential Equations
  5. Operation Research
     - MATH 5310 - Operations Research (Linear)
     and one of
     - MATH 5320 - Operations Research (Non-Linear)
     - MATH 5330 – Optimization (Operation Research III)
Sample Course Schedule

1. First Year (Fall):
   - MATH 5210 - Linear Algebra and Matrix Theory (core)
   - MATH 5250 - Modern Algebra I (concentration sequence)
   - MATH 5600 - Numerical Analysis I (elective)

2. First Year (Spring):
   - MATH 5260 - Modern Algebra II (concentration sequence)
   - MATH 5220 - Advanced Matrix Theory
   - MATH 5310 - Operations Research (Linear)

3. Second Year (Fall):
   - ECON 5010 - Concepts in Economics (application)
   - MATH 5300 - Mathematics of Interest (elective)
   - MATH 5999 - Thesis (3 hours)

4. Second Year (Spring):
   - ECON 5100 - Macroeconomic Analysis for Business (application)
   - MATH 5270 - Number Theory
   - MATH 5999 - Thesis (3 hours)

D. Mathematics Education

In order to ensure that students choosing the Education concentration have a broad mathematics background, they must complete at least one course selected from a required sequence in each of the other three concentrations (9 hours total), plus a second course (3 hours) to complete one of those sequences. In addition, students must complete 12 hours of Education courses; two of these courses (6 hours) count as the Area of Application described below. If not already taken, it is strongly recommended that these twelve hours be chosen from the following list of courses, since these are required for teacher licensure in Tennessee:

- EDUC 5140 - Teaching in Diverse Classrooms
- EDUC 5200 - Social and Historical Foundations of Education
- EDUC 5210 - Human Development Applied to Education
- EDUC 5220 - Instructional Planning and Evaluation
- EDUC 5630 - Literacy Instruction for Middle/High School Learners
- EDUC 5750 - Educational Technology

Additional Information and Notes

If all of the above courses have been completed, other graduate courses from the College of Health, Education and Professional Studies may be chosen with the consent of the student’s graduate program committee to complete the twelve hours.

Sample Course Schedule

1. First Year (Fall):
   - MATH 5210 - Linear Algebra and Matrix Theory (core)
   - MATH 5250 - Modern Algebra I (concentration sequence)
   - MATH 5300 – Mathematics of Interest (concentration)

2. First Year (Spring):
   - EDUC 5200 - Social and Historical Foundations of Education (concentration)
• EDUC 5210 - Human Development Applied to Education (concentration)
• MATH 5260 - Modern Algebra II (concentration sequence)

3. Second Year (Fall):
• EDUC 5220 - Instructional Planning and Evaluation (concentration)
• MATH 5000 - The Historical Development of Mathematics
• MATH 5600 - Numerical Analysis I (concentration)

4. Second Year (Spring):
• EDUC 5140 - Teaching in Diverse Classrooms (concentration)
• MATH 5010 - Basic Concepts of Geometry
• MATH 5150 - Introduction to Biostatistics (concentration)

2.5.4 Area of Application or Internship

Students must complete a minimum of six (6) credit hours in an area of application or an internship. The student and his or her graduate program committee will jointly decide upon the area of application or internship, and must be approved by the Graduate Coordinating Committee. It should be consonant with the chosen concentration. An oral presentation and a written report on the internship or area of application are required. Typically, students choosing an area of application will complete coursework in another department or college such as Business, Economics, Computer Science, Engineering, Physics, Chemistry, or Biology. In keeping with the interdisciplinary nature of this program, if a student chooses an area of application, the Graduate Coordinating Committee will ask that a representative from the outside area be added as an additional member of the student’s graduate program committee. Students choosing the internship option will usually collaborate with a local business. Options include businesses in the health insurance field, industrial and manufacturing industries, engineering firms, etc.

2.5.5 Electives

Students must complete additional elective hours as needed to complete the degree. Any of the courses listed under the concentrations may serve as electives. In addition, a special project (0-3 hours) or a thesis (6 hours) may be chosen to fulfill part of these elective hours. Prior to enrolling in MATH 5900 (Special Project in Mathematics), MATH 5998 (Research), or MATH 5999 (Thesis), a student choosing to do a project or thesis must have the topic approved by his or her graduate program committee and the Graduate Coordinating Committee, and must submit the committee form to the Graduate School for final approval.

2.5.6 Course Scheduling
A full-time student can complete the degree requirements in four semesters. Courses will typically be offered at times to maximize their availability for employed students.

2.5.7 Program of Study

Students must submit a Program of Study during the first semester of graduate coursework. The Program of Study consist of all core courses and any electives and establishes the courses the student must take for partial fulfillment of the degree requirements. The Program of Study form must include all core courses and electives, if known at the time that the student will take. The Program of Study form is located at http://www.utc.edu/graduate-school/student-resources/forms.php.

2.5.8 Admission to Candidacy

The application for admission to candidacy is typically filed in the semester prior to a student’s anticipated graduation semester and should list all courses not listed on the Program of Study and any changes in coursework. Please refer to Application for Admission to Candidacy section. The appropriate form may be obtained from the Graduate School Web site at www.utc.edu/graduate-school.

2.6 List of courses

In the original proposal the following courses were included. In parenthesis the course number according to the new numbering system.

- Math 512 (5210) Linear Algebra and Matrix Theory
- Math 520 (5150) Introduction to Biostatistics
- Math 521 (5180) Analysis of Variance
- Math 522 (5190) Design of Experiments
- Math 531 (5250) Modern Algebra I
- Math 532 (5260) Modern Algebra II
- Math 535 (5220) Advanced Matrix Theory
- Math 546 (5460) Partial Differential Equations
- Math 555 (5550) Introduction to Analysis II
- Math 570 (5570) Complex Analysis
As the program developed over time, the following additional courses were added to the curriculum.

- Math 5000 - The Historical Development of Mathematics
- Math 5050 - Introduction to Point Set Topology
- Math 5130 - Introduction to Probability and Statistics
- Math 5140 - Mathematical Statistics
- Math 5160 - Applied Statistical Methods
- Math 5270 - Introduction to Number Theory
- Math 5300 - Mathematics of Interest
- Math 5310 - Operations Research (Linear)
- Math 5320 - Operations Research (Nonlinear)
- Math 5330 - Optimization (Operation Research III)
- Math 5450 - Ordinary Differential Equations
- Math 5470 - Applied Mathematics for Science and Engineering I
- Math 5480 - Applied Mathematics for Science and Engineering II
- Math 5580 - Transform Methods
- Math 5600 - Numerical Analysis I
- Math 5610 - Numerical Analysis II
- Math 5620 - Numerical Solution of Partial Differential Equations I
- Math 5630 - Numerical Solution of Partial Differential Equations II
- Math 5700 - Techniques of Applied Mathematics
- Math 5720 - Graph Theory

### 2.7 Description of the courses

Description of the courses is also included in the Graduate Catalog, available on [http://catalog.utc.edu](http://catalog.utc.edu). For each of these courses the student will be assigned a Standard Letter Grade, with the exception of MATH 5997, MATH 5998, and MATH 5999.

**MATH 5000 - The Historical Development of Mathematics** - (3) Credit Hours
Examination of central ideas, major developments, and important issues in mathematics from ancient times to the present; particular emphasis on currents of activity which have loomed largest in the development of mathematics and have been most influential in promoting and shaping subsequent mathematical and scientific activity. Prerequisite: Department Head approval.

**MATH 5010 - Basic Concepts of Geometry** - (3) Credit Hours
Deficiencies in Euclidean geometry, Euclid’s parallel postulate, introduction to non-Euclidean geometry, consistency and validity of non-Euclidean geometry, incidence geometries, affine geometries, linear, planar, and spatial order properties. Prerequisite: Department Head approval.
MATH 5050 - Introduction to Point Set Topology - (3) Credit Hours
Introductory set theory, topologies and topological spaces, continuous mappings, compactness, connectedness, separation axioms and metric spaces. Prerequisite: Department Head approval.

MATH 5130 - Introduction to Probability and Statistics - (3) Credit Hours
Introduction to the theory of probability and its applications, counting techniques, discrete and continuous random variables and their distributions, mathematical expectation, moment generating functions. Prerequisite: Department Head approval.

MATH 5140 - Mathematical Statistics - (3) Credit Hours
A continuation of MATH 4130/5130 with an introduction to the Central Limit Theorem, statistical inference, probability distributions of functions of random variables. Theories. Prerequisite: Department Head approval.

MATH 5150 - Introduction to Biostatistics - (3) Credit Hours
An intermediate course suitable for students in a variety of health and science disciplines. The course will cover descriptive and inferential statistics, including parametric and non-parametric hypothesis testing methods, sample size, statistical significance and power, survival curve analysis, relative risk, and odds ratios. Data will be analyzed using Excel and/or SAS statistical software.

MATH 5160 - Applied Statistical Methods - (3) Credit Hours
One and two factor ANOVA, simple and multiple regression and correlation, and time-series analysis. This course is recommended for students planning to take actuarial exams. Prerequisite: Department Head approval.

MATH 5170 - Nonparametric Statistics - (3) Credit Hours
Theory of distribution-free statistics, ranking statistics, rank correlation, U-statistics, nonparametric point and interval estimation, empirical distribution function methods, combinatorial problems; runs, matching, occupancy; limiting distributions. Prerequisites: Department head approval.

MATH 5180 - Analysis of Variance - (3) Credit Hours
One-way and factorial designs, repeated measures; fixed, random, and mixed effects models; analysis of covariance (ANCOVA), and an introduction to multivariate analysis of variance (MANOVA).

MATH 5190 - Design of Experiments - (3) Credit Hours
A study of methods for the design and analysis of experiments. Randomization, blocking, replication, and confounding. Complete and incomplete block designs, Fractional Factorial experiments

MATH 5210 - Linear Algebra and Matrix Theory - (3) Credit Hours
Vector spaces, linear transformations, eigenvalue and similarity transformations, orthogonal and unitary transformations, normal matrices, Jordan form. Background in elementary linear algebra and logic and proof at the level of UTC MATH 2200 and MATH 3000 required.

MATH 5220 - Advanced Matrix Theory - (3) Credit Hours
Eigenvalues, unitary equivalence and Schur’s theorem. Normal, Hermitian and symmetric real matrices. Positive definite matrices, polar and singular value factorizations, and selected topics at the discretion of the instructor. Prerequisite: MATH 5210 or department head approval.

MATH 5250 - Modern Algebra I - (3) Credit Hours
Groups, subgroups, quotient groups, homomorphisms, simple groups, group actions, Sylow theorems and the fundamental theorem of finitely generated abelian groups. Background assumed to be at the level of UTC MATH 3250 or equivalent.

MATH 5260 - Modern Algebra II - (3) Credit Hours
Rings, ideals, quotient rings, ring homomorphisms, Euclidean domains, unique factorization domains, polynomial rings, automorphisms, field theory and Galois Theory. Prerequisite: MATH 5250 or department head approval.

**MATH 5270 - Elementary Number Theory** - (3) Credit Hours
Topics include divisibility, primes and unique factorization, Euclid’s algorithm, congruences, arithmetic functions, theorems of Fermat, Euler and Wilson, primitive roots, and quadratic reciprocity. Prerequisite: Department head approval.

**MATH 5300 - Mathematics of Interest** - (3) Credit Hours
Mathematical theory of interest with applications, including accumulated and present value factors, annuities, yield rates, amortization schedules and sinking funds, depreciation, bonds and related securities. Background in logic and proof at the level of UTC MATH 3000 required.

**MATH 5310 - Operations Research (Linear)** - (3) Credit Hours
Introduction to linear programming, duality, transportation and assignment problems, and integer programming. Prerequisite: department head approval. Background in elementary linear algebra and logic and proof at the level of UTC MATH 2200 and MATH 3000 required.

**MATH 5320 - Operations Research (Nonlinear)** - (3) Credit Hours
Network flows, Markov chains and applications, queuing theory and applications, inventory theory, decision theory and games. Prerequisite: MATH 5310 or department head approval. A background in statistics at the level of UTC MATH 3100 or MATH 4100 required.

**MATH 5330 - Optimization** - (3) Credit Hours
Topics in integer programming, Markov models, dynamic programming, and nonlinear programming and optimization. Course will be an extensive coverage of one or more of the above areas. Prerequisite: 4310 or 4320 with minimum grade of C or consent of instructor.

**MATH 5450 - Ordinary Differential Equations** - (3) Credit Hours
Systems of differential equations; existence and uniqueness theorems; linear systems; phase plane analysis; stability theory; applications. Fall semester alternate years. Prerequisites: Department Head approval.

**MATH 5460 - Partial Differential Equations** - (3) Credit Hours
Classification and derivation of some elementary partial differential equations arising in applications. Separation of variables, Sturm-Liouville problems and orthogonality, Fourier Series. Diffusion, wave, and Laplace’s equations in various coordinate systems with various boundary and initial conditions. Laplace transform methods and D’Alembert’s solution. First order equations and weak solutions.

**MATH 5470 - Applied Mathematics for Science and Engineering I** - (3) Credit Hours
Topics in applied mathematics to be selected from series solution of ordinary differential equations including a treatment of the higher functions; Legendre polynomials, Bessel functions, Laguerre and Hermite polynomials, the Hypergeometric function; Sturm-Liouville problems; orthogonality; eigenfunction expansions and the generalized Fourier Series; solution of partial differential equations of physics and engineering; Fourier, Laplace, and other integral transforms; first order PDE systems via characteristics; special functions. Prerequisite: 4550 with minimum grade of C or consent of instructor.

**MATH 5480 - Applied Mathematics for Science and Engineering II** - (3) Credit Hours
Advanced topics in applied mathematics to be selected from partial differential equations with a discussion of quasi-linear systems and shock waves, integral equations, generalized and weak solutions; calculus of variations and control theory; nonlinear waves and evolution equations and hyperbolic conservation laws. Prerequisite: 5470 or consent of instructor.

**MATH 5500 - Introduction to Analysis II** - (3) Credit Hours
Rigorous development of the derivative, the definite integral, sequences and series of functions, and improper integrals. Prerequisite: Department Head approval.

**MATH 5570 - Complex Analysis** - (3) Credit Hours
Complex numbers; differentiation and integration of functions of a complex variable; analytic functions; Cauchy’s Theorem; power series; residues and poles; conformal mapping; countour integration.

**MATH 5580 - Transform Methods** - (3) Credit Hours
The Laplace and Fourier Transforms and solution methods of boundary and initial value problems in ordinary and partial differential equations, integral equations, and difference equations. Existence and characteristics of these transforms, inversion formulas, special functions, and generalized functions. Construction of other transforms via Sturm-Liouville theory and orthogonality. Prerequisites: 2550, 2450 with minimum grades of C and graduate standing, or consent of instructor.

**MATH 5600 - Numerical Analysis I** - (3) Credit Hours
Numerical solutions of equations in one variable; interpolation and polynomial approximation; numerical differentiation and integration; initial value problems for ordinary differential equations; direct methods for solving systems of linear equations. Prerequisites: Math 2200, 2450, with minimum grades of C, and Computer Science 1020 or 1100 or approval of the Mathematics Department Head.

**MATH 5610 - Numerical Analysis II** - (3) Credit Hours
Iterative techniques for solving systems of linear equations; approximation theory; eigenvalue and eigenvector approximation; boundary value problems for ordinary differential equations; numerical solution to partial differential equations. Prerequisite: Math 5600 or consent of instructor.

**MATH 5620 - Numerical Solution of Partial Differential Equations I** - (3) Credit Hours
Finite difference methods for solving elliptic, parabolic, and hyperbolic equations; stability analysis; convergence properties; consistency of numerical schemes. Prerequisite: Math 5610.

**MATH 5630 - Numerical Solution of Partial Differential Equations II** - (3) Credit Hours
A continuation of topics covered in Math 5620: Numerical Solution of Partial Differential Equations I with additional applications. Prerequisite: Math 5620.

**MATH 5700 - Techniques of Applied Mathematics** - (3) Credit Hours
Additional topics in vector calculus; series of orthogonal functions; integral transforms; treatment of some elementary partial differential equations arising in applications. Prerequisite: department head approval.

**MATH 5720 - Graph Theory** - (3) Credit Hours
An overview of Graph Theory and its applications with emphasis on well-studied topics such as connectedness, planarity, isomorphisms, Hamiltonicity, and group representations in graphs. Prerequisite: department head approval.

**MATH 5900 - Special Project in Mathematics** - (3) Credit Hours
A study and formal written report on a topic in mathematics usually conducted during the last term of work towards the master's degree. Prerequisite: approval of student’s Graduate Program Committee and the Mathematics Graduate Coordinating Committee.

**MATH 5910 - Special Topics** - (1-4) Credit Hours
Selected advanced topics of current interest. Ordinarily topics will cover those not available in other graduate courses. May be repeated. Prerequisite: approval of instructor and department head.

**MATH 5920 - Graduate Internship in Mathematics** - (1-6) Credit Hours
A supervised professional experience in industry at the graduate level, this course provides the structure and focus for a graduate intern field assignment, ensuring that the internship experience is appropriate and consistent with the student’s course of study and professional development. A written report and oral presentation on the internship are required.

**MATH 5997 - Individual Studies** - (1-9) Credit Hours
Designed to enable a student to study selected topics in depth. Requires a written outline of work to be done, a statement describing the competencies to be developed and the method of assessment to be used in evaluation. Prerequisite: approval of instructor and department head.

**MATH 5998 - Research** - (1-9) Credit Hours
Enables students to conduct independent research. Credit hours allowed toward the degree may be limited. Individual studies contract required at the time of registration. Prerequisite: Approval of department head.

**MATH 5999 - Thesis** - (1-6) Credit Hours
Master Thesis. Oral defense required. Maximum graded credit of six hours to be applied toward degree. Must register for course continuously until thesis is complete. Prerequisite: Approval of department head.

### 2.8 Frequency of Offering and Enrollments

Math 5210 (core) offered every fall. Math 5500 (core) is offered each spring. Math 5570 (core) is offered every other fall. Also, Math 5000, Math 5010, Math 5130, and Math 5140 are offered once a year. The rest of the graduate courses are offered on a 2-year cycle, depending on demand. Brochures with the course offerings over a 2-year period are available to students and advisors. Thus students can easily graduate in 4 semesters (and in 3 semesters if they take summer courses and/or 12 hours during some semesters).

The following table displays the course offerings on the last few semesters.

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Summer 2013</th>
<th>Fall 2013</th>
<th>Spring 2014</th>
<th>Summer 2014</th>
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</thead>
<tbody>
<tr>
<td>MATH 5000</td>
<td>The Historical Development of Math</td>
<td>X</td>
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<tr>
<td>MATH 5010</td>
<td>Basic Concepts of Geometry</td>
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<tr>
<td>MATH 5050</td>
<td>Introduction to Point Set Topology</td>
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<tr>
<td>MATH 5130</td>
<td>Introduction to Probability and Statistics</td>
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<tr>
<td>MATH 5140</td>
<td>Mathematical Statistics</td>
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<td>MATH 5150</td>
<td>Introduction to Biostatistics</td>
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<tr>
<td>MATH 5160</td>
<td>Applied Statistical Methods</td>
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<tr>
<td>MATH 5180</td>
<td>Analysis of Variance</td>
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<tr>
<td>MATH 5190</td>
<td>Design of Experiments</td>
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<td>MATH 5210</td>
<td>Linear Algebra and Matrix Theory</td>
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<tr>
<td>MATH 5220</td>
<td>Advanced Matrix Theory</td>
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<tr>
<td>MATH 5250</td>
<td>Modern Algebra I</td>
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<tr>
<td>MATH 5270</td>
<td>Introduction to Number Theory</td>
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<tr>
<td>MATH 5300</td>
<td>Mathematics of Interest</td>
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<tr>
<td>MATH 5310</td>
<td>Operation Research (Linear)</td>
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<tr>
<td>MATH 5320</td>
<td>Operations Research (Nonlinear)</td>
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<tr>
<td>MATH 5450</td>
<td>Ordinary Differential Equations</td>
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<td>MATH 5460</td>
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<tr>
<td>MATH 5470</td>
<td>Applied Math for Science and Engineering I</td>
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<tr>
<td>MATH 5480</td>
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<tr>
<td>MATH 5500</td>
<td>Introduction to Analysis II</td>
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<tr>
<td>MATH 5570</td>
<td>Complex Analysis</td>
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<tr>
<td>MATH 5600</td>
<td>Numerical Analysis I</td>
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<tr>
<td>MATH 5610</td>
<td>Numerical Analysis II</td>
<td>X</td>
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<tr>
<td>MATH 5620</td>
<td>Numeric Solutions of PDE I</td>
<td>X</td>
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<tr>
<td>MATH 5700</td>
<td>Techniques of Applied Mathematics</td>
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<tr>
<td>MATH 5720</td>
<td>Graph Theory</td>
<td>X</td>
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<tr>
<td>MATH 5997</td>
<td>Real Analysis</td>
<td>X</td>
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</tbody>
</table>

Source: Self Service Banner, UTC.
3

Student Experience

3.1 Student Enrichment Opportunities

In addition to the student enrichment opportunities noted in Section 1.4.7, a monthly problem competition is sponsored by one of the graduate faculty. Support for a student to attend or give a talk at a conference is available, as well as remuneration for the cost of an actuarial exam, provided the student passes the exam. Students are invited to attend the Department of Mathematics Colloquium series of talks, for which there is support available for outside speakers, as well as for any other research/teaching talk. In the past three students, Michael Sherman, Cory Leming, and Jonathan D. Taylor gave Colloquium talks on their research. There are a number of university-wide Lecture Series for students at no cost, such as the Burkett Miller Distinguished Lecture Series, Globalization Lecture Series, Accounting and Finance Lecture Series, and Women’s Studies Annual Lecture Series. Also, every year the university organizes a Research Day for students and faculty to display and talk about their projects, no matter what discipline they are from. Previous displays have included robots, artwork, architectural models, research results, musical compositions, and information about various centers on campus.

The departmental Student Relations Committee apprises the students of events, internship programs, and other undergraduate and graduate research programs of interest, and hosts scholarly events for the mathematics majors and graduate students, including a presentation by Unum Insurance Company, and another by Blue Cross/Blue Shield. Several “Socials” are held throughout the academic year giving students opportunities to interact with faculty members and learn about the mathematical interests of the faculty. The Student Relations Committee, together with Pi Mu Epsilon, sponsors “Sudoku Competitions” with the proceeds donated to the Community Food Kitchen in Chattanooga. Also, several “movie nights” are held each year where movies related to mathematics, e.g., “A Beautiful Mind,” or “Fermat’s Room” are viewed.

The Department maintains a “math friends” list, an email list consisting of mathematics majors, graduate math students, mathematics faculty, and other students who are interested in mathematics and ask to be added to the list. The beginning of fall semester each year, the department hosts a “Welcome to the new Academic Year” pizza party for “math friends.” This gives the students an opportunity to interact with the faculty as well as with their fellow students. In each spring semester, the Department hosts a
Mathematics Honors Day celebration for its students. At this event, the department’s awards to outstanding undergraduate students are presented. In addition, there is an award for the Outstanding Graduate Student. These monetary awards are provided by the Department of Mathematics. Induction of new members into Pi Mu Epsilon, the national mathematics honorary society, also takes place at this ceremony. Families of all the award and scholarship recipients and members of the University administration are invited to the reception each year. The event has become very popular with the students and their families.

The Department makes a conscientious effort to include students in some of the decision making processes. This effort has been especially effective in the hiring process. All of the candidates interviewed for tenure-track positions are asked to give a short presentation to an upper division class. A questionnaire is distributed to the students on which they are asked their opinion on the effectiveness of the presentation and whether they would like to take a course from this candidate. Graduate students serve on the departmental curriculum committee and student relations committee.

Our graduate program serves as an incentive for students to major in mathematics. This is evidenced by the excellent jobs that our recent graduates have taken (see Section 3.6). The Mathematics Department has also a Facebook page to help keep in touch with students and graduates [https://www.facebook.com/UTCMathematics](https://www.facebook.com/UTCMathematics).

Each semester there is an advisement party in which faculty advise graduate students on their course of study. Recently, we adopted the following advisement policy, which enable students to start their graduate project in a timely fashion.

**Graduate Advisor Policy**

The purpose of this proposal is to institute a policy that requires each student admitted to the Mathematics Graduate Program to choose a faculty advisor upon completion of nine credit hours. (Students currently enrolled in the graduate program who completed nine hours of coursework prior to August 1, 2014 should each choose a faculty advisor by October 1, 2014.) Only members of the graduate faculty may serve as a faculty advisor.

At the beginning of the student's first term, the student should begin consulting with members of the graduate faculty to choose an appropriate graduate faculty advisor. Each student is required to complete a Master’s thesis or a Master’s project, and it is recommended that the thesis/project advisor serve as the student's faculty advisor.

The formal process of choosing a faculty advisor requires the student to complete the Faculty Advisor Form and have the form signed by the proposed faculty advisor and the graduate program director. The student should turn the completed form in to the graduate program director. A student may change faculty advisors at any point by submitting another form to the graduate program director.

Responsibilities of the Student:
1. The student should choose a faculty advisor and submit a complete Faculty Advisor Form upon the successful completion of nine credit hours (or by October 1, 2014).

2. The student should meet with the faculty advisor at least once per term, and at other times dictated by the faculty advisor, to discuss progress toward the degree and future plans for course work.

Responsibilities of the Faculty Advisor:

1. The faculty advisor should meet with the student at least once per semester to discuss the student’s progress toward the degree, future plans for course work, and the possibility of completing a thesis or Master’s project.

2. The faculty advisor should plan to direct the student’s Master’s project or thesis.

3. At the end of each term, the faculty advisor should review the student’s final grades for the completed term and communicate the student’s grades to the Graduate Program Director through email or a paper copy.

3.2 Graduate student recruitment

The department has done an excellent job in attracting more graduate students. We recruit outstanding students who are already in our courses to consider a MS in Applied Mathematics. The department has made a concerted effort to attract additional graduate students by attending job fairs, contacting surrounding colleges and universities, and sending out flyers explaining the program to several local insurance companies. Also, the Department received a $290,000 Research Experience for Undergraduate Research (REU) grant which attracts students to the Master’s program.

The following table shows the enrollment in graduate courses in the last two academic years.

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Summer 2013</th>
<th>Fall 2013</th>
<th>Spring 2014</th>
<th>Summer 2014</th>
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<tbody>
<tr>
<td>MATH 5000</td>
<td>The Historical Development of Math</td>
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<tr>
<td>MATH 5010</td>
<td>Basic Concepts of Geometry</td>
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<tr>
<td>MATH 5050</td>
<td>Introduction to Point Set Topology</td>
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<tr>
<td>MATH 5130</td>
<td>Introduction to Probability and Statistics</td>
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<tr>
<td>MATH 5140</td>
<td>Mathematical Statistics</td>
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<td>MATH 5150</td>
<td>Introduction to Biostatistics</td>
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<tr>
<td>MATH 5160</td>
<td>Applied Statistical Methods</td>
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<tr>
<td>MATH 5180</td>
<td>Analysis of Variance</td>
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<tr>
<td>MATH 5190</td>
<td>Design of Experiments</td>
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<tr>
<td>MATH 5210</td>
<td>Linear Algebra and Matrix Theory</td>
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</tbody>
</table>
### 3.3 Duties of the graduate teaching assistants

The graduate teaching assistants attend classes, lead recitation sections, tutor in the Math Plaza, teach regular classes (after completing 18 hours at the graduate level), grade quizzes, hold office hours, and proctor exams. These activities total at most twenty hours per week.

### 3.4 Student research

In Spring 2014, Michael Corley, an MS student in Applied Math, began work on a thesis with Prof. Francesco Barioli. This will be the first Master’s thesis in the Department. In his work, Michael studies a certain class of matrices, with a specified zero-pattern, and determines the minimum rank that can be attained by matrices in such class. His work combines tools and results from Graph Theory to establish lower and/or upper bounds for the rank of a matrix. His results will be included in a paper that will be submitted for publication.

In Spring 2014, Ashley Holcombe worked on her Master's project under the supervision of Andrew Ledoan from December 2013 to May 2014. For her research project, Ashley
studied the work of Richard Hall and Peter Shiu on the distribution of Farey fractions and learned their techniques. Farey fractions are interesting because they are connected to the zeroes of the Riemann zeta-function, which encodes arithmetic information about the prime numbers, and they also have applications to mathematical physics such as billiards. In 2003, Hall and Shiu introduced the notion of a Farey index, which is the ratio of the sums of the denominators of two adjacent Farey fractions to the sums of the numerators of these fractions, and established an exact formula for the first moment of the index. They also established an asymptotic formula for the second moment of the index, using methods from complex analysis. For her research project, Ashley extended the work of Hall and Shiu by establishing asymptotic formulas for all higher moments of the Farey index. Her results are currently available as a preprint.

The Cauchy Interlacing Theorem states that a matrix is Hermitian if and only if its eigenvalues are “interlaced” by those of any principal submatrix. The complex case was proved in the 1950’s, and led to the following question: Does some version of Cauchy’s beautiful interlacing theorem hold for some class of matrices that include the Hermitian matrices? In 2012-13 Michael Sherman, an MS student in Applied Math, in joint work with Ron Smith, settled this question by showing that a normal matrix has the “interlacing” property if and only if the matrix is principally normal, i.e., every principal submatrix is normal. These results were published in the paper “Principally Normal Matrices” appeared in Linear Algebra and its Applications (LAA), the most prestigious journal in the field. A second joint paper, “Completely Normal Matrices” was also published in LAA. This paper characterizes those matrices in which every submatrix is normal. Michael’s programming skill and insight was very useful in all of the work.

In 2012, Jonathan Taylor worked on a Research Project with Prof. Lucas Van der Merwe on Edge-covering of Hypercube Graphs, and some other problems concerning connected domination critical graphs. The results of this research have been included in the preprint A note on connected domination critical graphs, which will be submitted for publication.

3.5 Internships

In Summer 2014, Christopher Thornton, an MS student in Applied Math, completed an Actuarial internship at UNUM.

3.6 Placement of students in occupational positions related to mathematics
The following table shows that the impact of our program of the region we serve.

Table 5: Current employment of former MS students

<table>
<thead>
<tr>
<th>Name</th>
<th>Degree</th>
<th>Grad Term</th>
<th>Current employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sadre-Marandi, Farrah</td>
<td>MS Math: Applied Statistics</td>
<td>Fall 2010</td>
<td>PhD student in Mathematics, Colorado State University Fort Colum, CO</td>
</tr>
<tr>
<td>Holcomb, Jason</td>
<td>MS Mathematics Education</td>
<td>Spring 2011</td>
<td>Lecturer, Department of Mathematics, UTC, Chattanooga, TN</td>
</tr>
<tr>
<td>Debter, David</td>
<td>MS Mathematics Education</td>
<td>Spring 2012</td>
<td>Lecturer, Department of Mathematics, UTC, Chattanooga, TN</td>
</tr>
<tr>
<td>Murphy, Rebecca</td>
<td>MS Math: Applied Statistics</td>
<td>Spring 2012</td>
<td>Unable to contact</td>
</tr>
<tr>
<td>Sherman, Michael</td>
<td>MS Math: Pre-professional</td>
<td>Spring 2012</td>
<td>Math instructor at Notre Dame High School, Elmira, NY</td>
</tr>
<tr>
<td>Walker, Shaun</td>
<td>MS Math: Applied Statistics</td>
<td>Spring 2012</td>
<td>Actuarial analyst at BlueCross, Chattanooga, TN</td>
</tr>
<tr>
<td>Jaynes, Erin</td>
<td>MS Mathematics Education</td>
<td>Summer 2012</td>
<td>Math teacher at Hixson High School, Hixson, TN</td>
</tr>
<tr>
<td>Taylor, Jonathan D.</td>
<td>MS Math: Pre-professional</td>
<td>Summer 2012</td>
<td>Master in Actuarial Science and Mathematical Risk Management, Georgia State University, Atlanta GA</td>
</tr>
<tr>
<td>Beck, Ian N.</td>
<td>MS Math: Pre-professional</td>
<td>Fall 2012</td>
<td>Math teacher at Ft Oglethorpe High School, Fort Oglethorpe, GA</td>
</tr>
<tr>
<td>McCoy, James</td>
<td>MS Math: Applied Mathematics</td>
<td>Fall 2012</td>
<td>Math Instructor at Chattanooga State Community College, Chattanooga, TN</td>
</tr>
<tr>
<td>Sawyer, Paula</td>
<td>MS Math: Applied Statistics</td>
<td>Spring 2013</td>
<td>Unable to contact</td>
</tr>
<tr>
<td>Hale, Jeremy C.</td>
<td>MS Math: Pre-professional</td>
<td>Summer 2013</td>
<td>Math teacher at Charleston Collegiate School, Charleston, SC</td>
</tr>
<tr>
<td>Leming, William C.</td>
<td>MS Math: Applied Mathematics</td>
<td>Fall 2013</td>
<td>Instructor at Georgia Northwestern Technical College, Tunnel Hill, GA</td>
</tr>
<tr>
<td>Ballow, Robert B.</td>
<td>MS Math: Pre-professional</td>
<td>Spring 2014</td>
<td>Ph.D. student at Auburn University, Auburn, AL</td>
</tr>
<tr>
<td>Fowler, Samuel E.</td>
<td>MS Math: Applied Mathematics</td>
<td>Spring 2014</td>
<td>Unable to contact</td>
</tr>
<tr>
<td>Fraser, Caroline</td>
<td>MS Math: Applied Statistics</td>
<td>Spring 2014</td>
<td>Underwriting Senior Associate at CIGNA Chattanooga, TN</td>
</tr>
<tr>
<td>Ho, Phu L.</td>
<td>MS Math: Pre-professional</td>
<td>Spring 2014</td>
<td>Planning to attend a PhD granting Graduate School</td>
</tr>
<tr>
<td>Holcombe, Ashley E.</td>
<td>MS Mathematics Education</td>
<td>Spring 2014</td>
<td>Math teacher at Tunnel Hill High School, Tunnel Hill, GA</td>
</tr>
<tr>
<td>Thornton, Christopher J.</td>
<td>MS Math: Applied Statistics</td>
<td>Spring 2014</td>
<td>Actuarial internship at UNUM, Chattanooga, TN</td>
</tr>
</tbody>
</table>
3.7 The future

The program was designed assuming that each graduate teaching assistant would receive a yearly stipend of $12,000 plus tuition and fees. When the Developmental Mathematics program was phased out at UTC, the money traditionally spent directly out of Academic Affairs on adjuncts in Mathematics was moved over to pay for Graduate Teaching Assistantships. However, those funds were gradually reduced over time from $152,000 in FY13 to $128,000 in FY14. For FY15 the expected amount of support was $98,000, which would already stretch the limits of the budget for the Department of Mathematics. In fact, the final support provided was $13,000 – a decrease of $85,000. Including stipend, maintenance (tuition), and fees the cost of each student was previously around $20,000 - $21,000 per year, or over $200,000 for 10 full-year students. In Spring 2014, the decreasing level of funding forced the Department to reduce the stipends to $7,500 while continuing to pay maintenance (tuition) and fees. This reduced the cost of each full-year GTA to around $17,000 and permitted students to continue to take classes without cost. Also it did ensure the solvency of the program for at least another two academic years while adjustments are made to ensure the long-term funding of the program.

While these changes altered the competitiveness of the graduate program, they are still in line with programs like the one at MTSU ($6,900 stipend and almost all tuition paid for a full year) and Appalachian State University ($9,000 stipend with no coverage for tuition or fees).
4.1 Personnel

At the program’s inception in the academic year 2009-10, there were eighteen (permanent) full time faculty lines (filled either permanently or on a one year basis). The breakdown was as follows: nine full Professors, five Associate Professors, three Assistant Professors, and one Visiting Assistant Professor.

For the 2014-15 academic year, the composition of the Graduate Faculty is as follows: eleven full Professors, three Associate Professors, six Assistant Professors, and one Chair of Excellence in Applied Mathematics. Staffing remains a serious problem that needs to be addressed by the University administration. For instance, in the last two years we have lost three senior Professors through retirement, one tenure-track Assistant Professor, and one secretary without a replacement for any of their lines. This has coincided with the record enrollment increases during the last five years. As of this writing, the Department has not even been given permission to advertise for possible positions for 2015-16. This is extremely unfortunate since if such approval would be forthcoming, there would be no pool of applicants from which to make a selection. Serving this influx of students has been accomplished in part by using larger classes, and, in part, by using graduate students to teach recitation sections and perform other duties.

A list of graduate faculty at the inception of the Program can be found in Section 1.3. A complete list of graduate faculty for the 2014-15 academic year is as follows.

- Associate Professors: Francesco Barioli, Stan Byrd, John Matthews (interim Head)
- Assistant Professors: Cuilan Gao, Sumith Gunasekera, Andrew Ledoan, Xuhua Liu, Roger Nichols, Min Wang (resigned during the fall of 2014).
- UNUM Chair of Excellence in Applied Mathematics: Jin Wang

The following list subdivides the graduate faculty according to the concentration they teach, providing information about the institution where they earned their terminal
degree, current research interests, and a list of journals in which they published. All the professors listed below are researchers in Applied Mathematics.

A. Applied Mathematics concentration:

- **Belinskiy, Boris:** PhD, St. Petersburg State University (Russia);

- **Graef, John:** PhD, Southern Illinois University at Carbondale;

Kong, Lingju: PhD, Northern Illinois University; Research interests: Applied Math, Differential Equations, Dynamical Systems; Biomathematical Modeling.

Matthews, John: PhD, North Carolina State University; Research interests: Applied Math, Numerical Analysis, Granular Materials.

Nichols, Roger: PhD, University of Alabama at Birmingham; Research interests: Applied Math, Spectral Theory, Operator Theory.

Schlereth, Eugene: PhD, Washington University (St. Louis); Research interests: Differential Equations.

Wang, Jin: PhD, Ohio State University;
Research interests: Applied Math, Numerical Analysis; Mathematical Biology.

B. Applied Statistics concentration

- **Gao, Lani;** PhD, University of Mississippi; 
  Research interests: Statistics; Bioinformatics. 
  Journals: *Bioinformatics*, *BMC Bioinformatics*, *Cancer Cell*, *IEEE Engineering in medicine and Biology Society*, *Infection Control and Hospital Epidemiology*, *Statistical Applications in Genetics and Molecular Biology*.

- **Gunasekera, Sumith;** PhD, University of Nevada Las Vegas; 
  Research interests: Statistical Inferences, Reliability, Survivability, Bayesian Analysis, Experimental Designs. 

C. Pre-professional Mathematics concentration:

- **Barioli, Francesco;** PhD, University of Padua (Italy); 
  Research interests: Matrix Theory; Graph Theory. 

- **Byrd, Stan;** PhD, Florida State University; Functional Analysis; 
  Research interests: Functional Analysis. 

- **Ebiefung, Aniekan;** PhD, Clemson University; 
  Research interests: Operation Research; Input-Output Analysis. 
• **Kuhn, Steve**: PhD, University of Georgia;
  Research interests: Algebra, Mathematics Education;

• **Ledoan, Andrew**: PhD, University of Illinois at Urbana-Champaign;
  Research interests: Number Theory.

• **Liu, Xuhua**: PhD, Auburn University;
  Research interests: Matrix Theory, Lie Groups.

• **Saleh, Ossama**: PhD, University of Nebraska-Lincoln;
  Research interests: Operation Research.

• **Smith, Ronald**: PhD, Auburn University;
  Research interests: Matrix Theory.

• **Van der Merwe, Lucas**: PhD, University of South Africa-Pretoria;
  Research interests: Graph Theory.

• **Walters, Terry**: PhD, University of South Florida;
  Research interests: Differential Equations, Graph Theory.

D. Mathematics Education concentration


There is a wide range of academic training and backgrounds among the graduate faculty. As one can see, the research specialties in the Department fit well with the needs of the Master of Science in Applied Math program.

The official teaching load responsibility for the University remains at 24 semester hours over the course of an academic year. However, the teaching load for graduate faculty in our department is nine hours per semester. 100% of the graduate courses have been taught graduate faculty with a terminal degree. The use of adjunct faculties was significantly reduce in 2010 by using graduate teaching assistants, and completely eliminated in 2012, when the Developmental Math Program was discontinued.

4.2 Research Activities

The research output from the graduate faculty has been remarkably strong considering that, until 2009, the department only granted an undergraduate degree. For the five calendar years 2009 through 2013, the numbers of papers and books that have appeared in print each year and the number of presentations by faculty at national and international conferences and meetings are displayed in Table 1 in Section 1.4.5.

In addition, colloquium and special audience type presentations have averaged more than eighteen per year. Between 2009-10 and 2013-14 the Department received $290,000 in external grants.

Graduate Faculty in the Math Department have also been very successful in obtaining grants from various internal sources to support their research efforts. These take the form of Faculty Development Grants, Faculty Research Grants, and Research Associateships from the Office of Grants and Program Review. Monies from these sources are used to release faculty from teaching and/or support travel to conferences. Also, the Provost
Student Research Award is given jointly to an undergraduate or graduate student and to the faculty member he/she works with. Specific details can be found on individual faculty member’s curriculum vitae.

Table 6: Internal (UC Foundation) Support – FY2010-2014

<table>
<thead>
<tr>
<th>Dept. Awards</th>
<th>Total Awards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty Development Grants</td>
<td>38</td>
</tr>
<tr>
<td>Faculty Research Grants</td>
<td>11</td>
</tr>
<tr>
<td>Faculty Summer Fellowships</td>
<td>2</td>
</tr>
<tr>
<td>Faculty Sabbatical and Study Leaves</td>
<td>3</td>
</tr>
<tr>
<td>Provost Student Research Award</td>
<td>2(*)</td>
</tr>
</tbody>
</table>

Source: Walker Center for Teaching and Learning; Provost Office; Office for Partnerships & Sponsored Programs.

(*) Data not available for FY 2011

Figure 6: Dept. awards as % of total awards (FY 2010-2014)

Source: Walker Center for Teaching and Learning; Provost Office; Office for Partnerships & Sponsored Programs.

Noteworthy Items:

Editors of this special volume of papers were Paul Eloe of the University of Dayton and Johnny Henderson of Baylor University. This special volume contains thirty-two papers by some of the world’s leading experts in differential equations. John was presented with a special bound volume of these papers.

- The paper “Periodic solutions of first order functional differential equations” written by John Graef and L. Kong and published in Applied Mathematics Letters 24 (2011), 1981--1985 was listed on the journal website as one of the most read articles in Applied Mathematics Letters.
- John Graef received the 2012 University of Tennessee at Chattanooga Outstanding Research Award.
- Ron Smith was selected for the Thomson-Reuters original list of highly cited researchers in 2012 (http://highlycited.com)
- John Graef is the Editor-in-Chief of a journal (Communications in Applied Analysis); he also serves as an Associate Editor of more than twenty other journals. Several members of the faculty regularly referee papers for journals in their area of expertise and serve as reviewers for Mathematical Reviews.
- Lingju Kong was selected for the UTC Council of Scholars in Spring 2014.
- All members of the graduate faculty belong to at least one professional organization appropriate to their interests.

Beginning in the fall 2000 semester, with the support of the Dean of the College of Arts & Sciences, the Department has maintained a program of releasing one faculty member per semester from teaching one course in order to devote additional time to his or her research program. This course release is rotated among those faculty members who have an ongoing research program. Faculty are added or removed from the rotation based on their on their productivity. This was expanded to two faculty members per semester in 2006, and that is the current status today.

4.3 Student satisfaction with graduate instruction

Student satisfaction is high, based upon the excellent student evaluations obtained by the graduate faculty in the graduate courses.
Table 7: Student ratings of faculty

<table>
<thead>
<tr>
<th>University-level questions (max 7 points)</th>
<th>Points</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>The instructor is willing to help students.</td>
<td>6.70</td>
<td>158</td>
</tr>
<tr>
<td>The instructor encourages students to be actively engaged in learning the content of this course.</td>
<td>6.45</td>
<td>158</td>
</tr>
<tr>
<td>The instructor provides timely feedback on assignments and exams.</td>
<td>6.40</td>
<td>157</td>
</tr>
<tr>
<td>The instructor includes activities and assignments that help students learn the content of this course.</td>
<td>6.49</td>
<td>158</td>
</tr>
<tr>
<td>The instructor clearly communicates expectations of students for this class.</td>
<td>6.38</td>
<td>157</td>
</tr>
<tr>
<td>The instructor expects high quality work from students.</td>
<td>6.70</td>
<td>157</td>
</tr>
<tr>
<td>Overall, this class has provided an excellent opportunity for me to increase my knowledge and competence in its subject.</td>
<td>6.41</td>
<td>158</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Department-level questions (max 6 points)</th>
<th>Points</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>My instructor is approachable.</td>
<td>5.69</td>
<td>158</td>
</tr>
<tr>
<td>My instructor shows respect for students.</td>
<td>5.83</td>
<td>157</td>
</tr>
<tr>
<td>My instructor has aided my comprehension of the material in this course.</td>
<td>5.52</td>
<td>156</td>
</tr>
<tr>
<td>My instructor is meeting the objectives specified in the course syllabus.</td>
<td>5.81</td>
<td>153</td>
</tr>
<tr>
<td>My instructor is following the policies specified in the course syllabus.</td>
<td>5.83</td>
<td>155</td>
</tr>
</tbody>
</table>


4.4 Service Activities

As indicated in other parts of this document, a number of graduate faculty members are involved in different ways in service to their profession in the form of serving on editorial boards, refereeing for journals, reviewing for Mathematical Reviews, organizing conferences, organizing special sessions at regional and national meetings, etc. Details concerning involvement of faculty in various community organizations can be found on their curriculum vitae included as part of this document. Graduate faculty members in the Mathematics often serve on College and University wide committees. For example, in 2014-15, two members of the Department (Barioli and Ledoan) are serving on the UTC Faculty Senate. Lingju Kong is a member of the Graduate Council. Over the last few
years, virtually every university committee has included at least one graduate mathematics faculty member. In particular they have served on such major committees as the Faculty Development Grant Committee, the Faculty Research Committee, and Library Committee. In a number of cases graduate faculty members of the Mathematics department have served as chairpersons for these committees. In particular Gene Schlereth served in the Art & Science Curriculum Committee, and Matt Matthews served in the Art & Science Executive Committee.

4.5 Retirement outlook

At present the department has five faculty members who have been at UTC for 35 or more years, and five who have been at UTC for five or less years. This is clearly a bimodal distribution and we would expect some turn over the next five years, but very little in the subsequent thirty years.

4.6 The future

The state has installed the Tennessee Promise Program, which provides free tuition for two years at community college to all graduating Tennessee high school seniors. It is too early to tell what effect this will have on our MS program. On one hand, a significant decrease in enrollment at the freshman/sophomore level will reduce the need for GTA’s to teach them, while, on the other hand, there will be an increase in the need for more math instructors at the community colleges and, hence, the need for more training in graduate level Mathematics.

4.7 Summary

In summary the overall faculty quality is excellent, based upon
1) the excellent students evaluations and capstone projects,
2) excellent job placement for our graduates,
3) the number of graduate faculty members maintaining a research program together with the recognition given to this research by the University, national, and international bodies, and
4) the overall service by the graduate faculty both to the University and the profession itself.
5 Resources

5.1 Faculty support

The IT center provides technological support to maintain the network, computer lab, and faculty computers.

The Grayson H. Walker Center for Teaching and Learning supports UTC’s strategic planning and academic initiatives to facilitate excellence in university instruction by providing information, learning sessions, and consultation in the areas of teaching, learning, and technology integration.

In the part, library support at UTC has been lacking, although the new library that opened in January 2015 has served to rectify this situation. The library does receive the full journal packages from the AMS and SIAM and the library does subscribe to MathSciNet. A bright spot is the Inter Library Loan Service that faculty can access electronically from their offices to request materials. The ILL office does a good job in locating materials in a timely fashion. Each year the Department recommends purchases to the UTC Library in excess of the funds allocated to it for new materials; this amount has remained at $2,500 per year for a number of years. The Library does have a program where individual faculty members may request up to $500 in additional purchases for specially needed items. The awards are made on a competitive basis; journal purchases are always excluded.

The Department has one Administrative Support person in the person of Heather Heinlein. The Department had a three-quarter time support person until the budget cuts in 2008 removed the funding for that position. The funding has still not been restored. The Mathematics Department is far too large for just one Administrative Support person. Several students help her with the office work. Other than this there is little or no clerical support for the rank-and-file professors. A second full time person is definitely needed.

The operating budget for the Department is highly insufficient as it is for every other department on campus. The size of the faculty and the number of mathematics students taught each semester strain resources to the limit. The fact that faculty have been successful in obtaining travel support from other sources on and off campus has helped a great deal, but this does not absolve the university from adequately supporting their mission.
No discussion of resources would be complete without some mention of the relative cost of a program. The Mathematics Department is the second largest producer of credit hours in the University. In the past it also had the next to lowest cost per credit hour of any department or unit on campus. However the elimination of the Developmental Program in 2012 led to an increase to the cost per student credit hour. The following table gives some comparisons in the cost in dollars per credit hour between the Mathematics Department, the Department of English, the College of Arts & Sciences, and the University.

Table 8: Cost per Student Credit Hour


Permission to fill vacant tenure-track lines has not been granted even though we will have lost four senior faculty members due to retirement by the end of the current fiscal year.

State mandated across-the-board (ATB) faculty raises for fiscal years 2010-2014 are displayed in Table 9. The ATB percentage raise was also 0% for fiscal years 2008 and 2009.

Table 9: State mandated ATB salary % raise
(effective date July 1st)

<table>
<thead>
<tr>
<th>% raise</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>2.5</td>
<td>2.0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: UTC Payroll Office.
5.2 Technology support

Certain graduate courses are taught using a computer algebra system as Maple and/or Matlab. Tutorials and assignments are written within Maple or Matlab by faculty, and students then learn from those materials. Other graduate courses are taught using calculators, Microsoft Excel, or other computer software as a significant part of their curricula.

Many graduate faculty use the internet to distribute class materials to graduate students. Some graduate faculty also use individually authored web pages hosted on University servers (outside the Blackboard system) to communicate with their students.

One very serious problem the department faces is that many of the staff computers and all of the lab computers are quite old and there is no university or college plan for regular replacements. However, in 2014, 40% of the graduate faculty computers were replaced out of the departmental funds. Also, all of the computers in the computer Math lab are in constant use by students, often break down, and require a lot of maintenance to keep them working. There are serious delays when students save documents, run two- and three dimensional graphics and animations, and even send jobs to the printers; there seem to be no avenues on campus for replacements but in the meantime these difficulties frustrate both students and faculty and interfere with student learning.
6 Mission and Goals

6.1 Department Mission

The mission of the Department of Mathematics is to support the mission of the University of Tennessee at Chattanooga as it relates to the teaching and research of mathematics and service to the profession and the community.

6.2 Department Goals that relate to the MS degree

The items listed here represent overall goals for the Department. They appear as part of the annual goals statements developed each year.

1. Provide evidence to make the appropriate administrators aware that:
   a. Salaries in the Department seriously lag behind regional and national averages.
   b. There are problems of equity and salary compression that need be addressed as soon as possible;
2. Continue efforts to increase the visibility of the Department on campus as well as at the state, regional, national, and international levels. Promote the achievements and activities of the Department to the local media.
3. Advertise and recruit students for the Master of Science in Applied Mathematics degree program.
4. Continue our program to incorporate the use of mathematical software into our courses as appropriate.
5. Provide caring and effective advising for our graduate students as well as other students who seek our counsel. Continue to actively involve majors in the academic and social life of the Department.
6. Vigorously recruit new Mathematics graduate students and develop innovative ways of attracting students to our program. Use professional contacts to aid graduates in finding suitable employment or gaining admission to graduate or professional schools.
7. Strongly encourage individual professional development of our faculty in both the areas of research and pedagogy. Encourage faculty to become involved in service to their discipline, the University, and the community. Emphasize the importance of being a good Department citizen, value each other as colleagues, and respect our individual rights to disagree professionally without its affecting our personal relationships.

8. Cultivate and expand the relationship between the Mathematics Department and other departments and colleges on campus. Continue existing, as well as develop new, cooperative efforts with schools and colleges in the region.
The mission of the UTC Library is to support the teaching and research of the faculty and students of the University of Tennessee at Chattanooga through the development of collections and services that promote and enhance the University's curriculum and research endeavors.

Information about the UTC Library is available at [www.utc.edu/library](http://www.utc.edu/library).

**Library Personnel, Budget and Facilities**

The Library engages 20 faculty librarians and 12 support staff specialists to support the UTC community. The Library budget for 2013-2014 was approximately $3.3 million dollars. The Library building is 116,349 square feet, has a book shelving capacity of 500,000 volumes, and a seating capacity of 675 readers. The building was first occupied in 1974 and is typically open over 88 hours a week. The campus is currently in the final building phase of a new library with an anticipated opening date of January 2015; there is a one-page summary of new building features in Appendix A.

**Library Collections**

As of June 2014, the Library’s monograph collection consists of 463,762 unique titles, of which 11,243 of the books bear the call numbers QA, appropriate to the study of mathematics. The Library’s collection of audiovisual material consists of 21,853 unique titles, and 135 of those deal with mathematics. The 2013-2014 allocation for one-time expenditures for the Mathematics Department was $3,450 from a total allocation to Academic Affairs of $197,050.

As of June 2014, the Library, through subscriptions to full-text resources, databases, journal packages, and individual journals makes available over 25,000 serial titles, including open access titles. Of those, over 13,000 titles are direct subscriptions, mostly in digital form. The Library has identified 33 currently received journal subscriptions supporting the Mathematics department’s curricular and research needs; a list of these titles is included at the end of this document in Appendix B. All electronic subscriptions are accessible 24/7 from any internet connection.

The primary discovery tools used to identify mathematics and related topics journal articles and other materials are: MathSciNet, ACM Digital Library, Safari, Web of Science, JSTOR, ScienceDirect, and the Springer Journal Collection. In addition, the Library subscribes to databases such as Academic One File, JSTOR, Project Muse, Omnifile Full Text and other useful full-text titles. In 2013-2014, the Library paid $1,089,475 for direct subscriptions, journal packages, and databases, of which $34,082 was for mathematic-specific subscriptions subject focused databases, not including the cost of multi-disciplinary journal packages and databases.
Library Services

The Library has a Subject Specialist Program where a librarian is assigned to each academic department to enhance communication, collection development, and general support for students and faculty. The Subject Specialist assigned to the Mathematics Department is Andrea Schurr. Professor Schurr has worked closely with faculty in the department in support of resources and services.

The Library has created a research guide for students studying Mathematics to easily access relevant databases, journals, electronic books, and helpful information, including citing sources. The guide is available on the Library web site at: http://guides.lib.utc.edu/math.

The Library has a robust and well-respected Instruction program. Last year, the Instruction Team taught 321 courses and reached 5,731 students. Library faculty work closely with discipline faculty to design instruction sessions tailored to course and assignment objectives. The Library did not conduct instruction for the Mathematics Department.

The Library offers free interlibrary loan (ILL) service to students and faculty who need to acquire materials that are not owned by the Library. The electronic ILL management system, ILLiad, allows patrons to submit and track the progress of requests, receive email notification of arrival dates, and receive articles electronically. The Library also participates in a program called Rapid ILL which expedites the delivery of the requests to the patron. In 2013-2014, 12,153 interlibrary loan borrowing requests were filled for the UTC community of scholars; of those, 161 were filled for faculty or students in the Mathematics Department.

The Library’s Reference Desk is open 88 hours per week to assist faculty and students with research queries. Last year the Reference Desk fielded 14,714 questions and consultations. In addition to physical assistance, the Library offers online reference services in the form of real-time instant messaging assistance and an email reference service. One-on-one research consultations are available to students and faculty seeking in-depth assistance. The Library also staffs information desks on the 2nd and 3rd floors to provide assistance in the use of the print periodical and circulating book collections.

The Library offers a well-utilized course reserve service for faculty and students so that faculty may place high demand materials on electronic or print reserves to ensure they are available to students. Last year, 3 faculty members from the Mathematics Department made 6 materials available via Course Reserves in 5 courses.

The Library has friendly borrowing policies and allows semester-long borrowing of monographs for students and year-long borrowing for faculty members. In 2013-2014 total monograph and audio-visual circulation was 31,909. In addition, the Library circulates more than 100 laptop computers, other equipment (cameras, calculators, e-book readers, and more), and group study rooms to students. Last year the laptops and other equipment circulated 36,877 times, while our 12 group study rooms were used 7,168 times.
Appendix A
New University Library

The Facts:
- 180,000 square feet
- 5 floors
- Planned opening: January 2015

The Details:
The new LEED-certified library is chockful of new strategic campus partnerships and is envisioned as the premier location for student academic needs outside the classroom. New and expanded partnerships represented in the new building include: Art Department, Center for Advisement and Student Success, Copy Services, Graduate Student Association, Information Technology Division, Office of Students with Disabilities, Online Education, Southern Writers, Teaching Resource Center, and Writing Center. Designed with a robust technological infrastructure and themes of transparency, collaboration, and flexibility, student access and success was at the center of building planning processes.

- 37 study rooms (29 small, 7 medium, 1 large)
- 2 practice presentation rooms
- 24 hour student study space
- 4 lounges (2 quiet, computer and graduate student)
- Café (a big one!)
- Information commons
- Gig City Studio 305: advanced media studio and creator space
- Over 200 desktop computers (and a yet to be determined number of laptops)
- Seating for over 2,100
- 7 classrooms
- 8 seminar and conference rooms
- 29 faculty and graduate student carrels
- 2 visiting scholar rooms
- Grand reading room
- Moveable compact stacks with storage for ~600,000 volumes
- New materials browsing area (think more Barnes and Noble)
- Expanded special collections storage with unique climate controls
- New auditorium housing 2 lecture halls of ~225 seats each adjacent to the new library.

Appendix B
Journals Supporting the Mathematics Department
Abstract and applied analysis
Abstracts of papers presented to the American Mathematical Society
ACM SIGMAP bulletin
ACM Signum newsletter
ACM SIGSAM bulletin
Acta applicandae mathematicae
Acta mathematica
Acta mathematica Hungarica
Acta mathematica Sinica
Acta mathematicae applicatae Sinica
Advances in applied Clifford algebras
Advances in applied mathematics
Advances in applied probability
Advances in computational mathematics
Advances in data analysis and classification
Advances in dynamical systems and applications ADSA
Advances in fuzzy systems
Advances in mathematics
Advances in numerical analysis
Advances in theoretical and applied mathematics
Aequationes mathematicae
Algebra and logic
Algebra universalis
Algebras and representation theory
American journal of mathematics
American Mathematical Society translations
Analysis mathematica
Annales de l'Institut Henri Poincarè
Annales Polonici mathematici
Annali di matematica pura ed applicata
Annals of functional analysis
Annals of global analysis and geometry
Annals of mathematics
Annals of pure and applied logic
Annals of the Institute of Statistical Mathematics
Applicable algebra in engineering, communication and computing
Applicable analysis
Applications of mathematics
Applied categorical structures
Applied mathematical modelling
Applied mathematics a journal of Chinese universities
Applied mathematics and computation
Applied mathematics and optimization
Applied mathematics letters
Applied numerical mathematics
Applied stochastic models and data analysis
Electronic journal of differential equations
European journal of control
Evolutionary computation
Experimental mathematics
Expositiones mathematicae
Focus on learning problems in mathematics
Foundations and trends in stochastic systems
Foundations of computational mathematics
Fractional calculus & applied analysis
Functional analysis and its applications
Fundamenta mathematicae
Fuzzy optimization and decision making
Fuzzy sets and systems
Geometriae dedicata
Geometric and functional analysis GAFA
Graphs and combinatorics
Historia mathematica
Illinois journal of mathematics
Indagationes mathematicae
Indian journal of pure and applied mathematics
Indiana University mathematics journal
Integral equations and operator theory
Integral transforms and special functions
International journal of difference equations
International journal of differential equations
International journal of mathematical combinatorics
International journal of mathematical education in science and technology
International journal of mathematics and mathematical sciences
International journal of non-linear mechanics
International journal of statistics and probability
International journal of systems science
Inventiones mathematicae
Israel journal of mathematics
ISRN applied mathematics
ISRN mathematical analysis
Jahresbericht der Deutschen Mathematiker-Vereinigung
Japan journal of industrial and applied mathematics
Japanese journal of mathematics
Journal for research in mathematics education
Journal for research in mathematics education (NCTM)
Journal of advanced studies in topology
Journal of algebra
Journal of algebraic combinatorics
Journal of applied and industrial mathematics
Journal of applied mathematics and bioinformatics
Journal of applied mathematics and simulation
Journal of applied probability
Journal of applied statistics
Journal of approximation theory
Journal of classification
Journal of combinatorial optimization
Journal of combinatorial theory
Journal of computational and applied mathematics
Journal of computational and graphical statistics
Journal of contemporary mathematical analysis
Journal of control science and engineering
Journal of control theory and applications
Journal of differential equations
Journal of dynamics and differential equations
Journal of fixed point theory and applications
Journal of fourier analysis & applications
Journal of functional analysis
Journal of geometric analysis
Journal of graph theory
Journal of mathematical analysis and applications
Journal of mathematical sciences
Journal of mathematics
Journal of mathematics and mechanics
Journal of mathematics teacher education
Journal of modern methods in numerical mathematics
Journal of multivariate analysis
Journal of nonparametric statistics
Journal of number theory
Journal of optimization theory & applications
Journal of optimization theory and applications
Journal of probability and statistics
Journal of pure and applied algebra
Journal of rational mechanics and analysis
Journal of research of the National Bureau of Standards
Journal of statistical computation and simulation
Journal of statistical planning and inference
Journal of statistics and mathematics
Journal of the American Mathematical Society
Journal of the Australian Mathematical Society
Journal of the London Mathematical Society
Journal of the Society for Industrial and Applied Mathematics
Journal of theoretical probability
Journal of time series analysis
Journal of undergraduate mathematics
Lecture notes series
Lecture notes-monograph series
Libertas mathematica
Linear & multilinear algebra
Linear algebra & its applications
Linear algebra and its applications
Lithuanian mathematical journal
Lobachevskii journal of mathematics
Logica universalis
Manuscripta mathematica
Math horizons
Mathematica Slovaca
Mathematical and computer modelling
Mathematical gazette
Mathematical intelligencer
Mathematical logic quarterly MLQ
Mathematical methods in the applied sciences
Mathematical methods of statistics
Mathematical modelling
Mathematical proceedings of the Royal Irish Academy
Mathematical programming study
Mathematical spectrum
Mathematical systems theory
Mathematical tables and other aids to computation
Mathematical thinking & learning
Mathematics and computer education
Mathematics education research journal
Mathematics magazine
Mathematics teacher
Mathematics teaching
Mathematics teaching in the middle school
Metrika
Moscow University computational mathematics and cybernetics
Moscow University mathematics bulletin
National mathematics magazine
Nonlinear analysis
Nonlinear analysis theory, methods & applications
Notices of the American Mathematical Society
Numerical algorithms
Numerical functional analysis and optimization
Numerical linear algebra with applications
Numerical methods for partial differential equations
Optimization and engineering
Optimization methods & software
OR insight
Pacific journal of mathematics
Periodica mathematica hungarica
Philosophia Mathematica
Probability theory and related fields
Progress in mathematics
Pythagoras
Quality control & applied statistics
Quarterly of applied mathematics
Random structures & algorithms
Regional conference series in probability and statistics
Rendiconti del Circolo matematico di Palermo
Representation theory an electronic journal of the AMS
Research in mathematics education
Resultate der Mathematik Mathematical results
Ricerche di matematica
Russian mathematics
Scandinavian journal of statistics
Selecta mathematica, new series
Semigroup forum
Sequential analysis
Set-valued and variational analysis
SIAM journal on algebraic and discrete methods
SIAM journal on applied mathematics
SIAM journal on control
SIAM journal on control and optimization
SIAM journal on mathematical analysis
SIAM journal on matrix analysis and applications
SIAM journal on matrix analysis and applications: a publication of the Society for Industrial and Applied Mathematics
SIAM journal on numerical analysis: a publication of the Society of Industrial and Applied Mathematics
SIAM journal on optimization
SIAM journal on optimization: a publication of the Society for Industrial and Applied Mathematics
SIAM journal on scientific and statistical computing
SIAM journal on scientific computing
SIAM journal on scientific computing: a publication of the Society for Industrial and Applied Mathematics
SIAM news
Soviet mathematics - Doklady
Statistical inference for stochastic processes
Statistical modelling
Statistical science a review journal of the Institute of Mathematical Statistics
Statistics
Statistics & probability letters
Statistics and computing
Stochastic analysis and applications
Stochastic models
Stochastic processes and their applications
Structural equation modeling a multidisciplinary journal
Studia mathematica
Studies in applied mathematics
System dynamics review
Tamsui Oxford University journal of mathematical sciences
Teaching children mathematics
Teaching mathematics in the middle school
Teaching statistics
Technology, knowledge and learning
Technometrics
The arithmetic teacher
The Australian mathematics teacher
The college mathematics journal
The electronic journal of mathematics & technology
The journal of mathematical behavior
The journal of the Australian Mathematical Society
The mathematical gazette
The mathematical intelligencer
The Mathematics educator
The Mathematics teacher
The Michigan mathematical journal
The quarterly journal of mathematics
The quarterly journal of mechanics and applied mathematics
The Ramanujan journal
The Rocky Mountain journal of mathematics
Theory of probability and its applications
Topology and its applications
Transactions of the American Mathematical Society
Transformation groups
Ukrainian mathematical journal
UMAP ILAP modules tools for teaching
UMAP modules
Utilitas mathematica
Yearbook (National council of teachers of mathematics)
Appendix 2

The mission of the Grayson H. Walker Center for Teaching and Learning at the University of Tennessee at Chattanooga is to support UTC's strategic planning and academic initiatives to facilitate excellence in university instruction by providing information, learning sessions, and consultation in the areas of teaching, learning and technology integration.

Walker Center for Teaching & Learning Resource Collection

**FACULTY DEVELOPMENT**
(personal & professional development) resources (print, video, etc.) to help faculty improve in the job as faculty as well as some personal development opportunities--time management, articulating teaching philosophies, setting a research agenda, help on preparing promotion and tenure dossiers. The WCTL resource collection is catalogued through the UTC Library.

**LEARNING**
(student learning information) student learning resources include information on diverse learning styles and other student-related learning issues.

**TECHNOLOGY INTEGRATION**
(integrating technology into the curriculum/discipline/classroom) many print, online, and video resources are available to promote best practices on the integration of technology into the classroom: seminars, books, articles and video resources

**ORIENTATION**
(orienation to UTC for faculty -- full time and adjunct) orientation information for new faculty, adjunct faculty and department heads--books, and articles

**TEACHING • ASSESSMENT**
(teaching strategies/testing/assessment) journals, newsletters, books, articles, and videotapes are available on many teaching, testing, and assessment techniques

**PRODUCTION TECHNIQUES**
(multimedia production techniques and software applications) how-to manuals, step-by-step instruction and trade publications available
SOFTWARE APPLICATIONS

(software applications to teach better) over 80 software applications, trade