Academic Program Review

Department of Mathematics
B.S. & M.S. Programs Self-Study

Academic Years 2015-2020

Table of Contents

List of Figures

List of Tables

Preface and History

A. History of the University of Tennessee at Chattanooga

The University of Tennessee at Chattanooga is a metropolitan university located in the southeastern corner of the state of Tennessee. Chattanooga's metro area has a population of approximately 500,000 people that includes not only Chattanooga, but also portions of North Georgia and Northeastern Alabama.

The University of Tennessee at Chattanooga (UTC) became part of the University of Tennessee System in 1969. The System consists of five campuses: UTC in Chattanooga, the University of Tennessee, Knoxville, University of Tennessee at Martin, plus the University of Tennessee Health Science Center in Memphis and the University of Tennessee Space Institute in Tullahoma. Governance is provided through a UT System President, Chancellors on each campus, and a UT Board of Trustees. The Governor of the State appoints Board members and serves as Chairman of the Board.

Prior to becoming a part of the UT System (in 1969), the university was a private university known as the University of Chattanooga (UC). UC was founded in 1886. It later merged with East Tennessee Wesleyan University of Athens and became Grant University. In 1907 the name was changed to University of Chattanooga. Other institutions in the Chattanooga area, including Chattanooga City College (CCC), a predominately African American University, became a part of the UT System merger in 1969.

At the time of the merger in 1969, UC's student population was slightly more than 2,200. Now, UTC, as a public institution, serves more than 11,000 students. Approximately 11 percent of UTC's students are enrolled in graduate programs. Overall, UTC's students represent not only Tennessee (coming from 70 Tennessee counties), but they also come from more than 40 states and 60 foreign countries.

B. Summary Recommendations from Previous Program Review

The recommendations from the previous program review, in their entirety, are provided in Appendix A. The highest priority recommendations are summarized here (with quotes in italics), along with some comments.

<u>Undergraduate Program</u>

- *Continue the progress that has already been made toward improving the department's image within the university*. The reviewer was responding to a *generally somewhat negative* perception of the department within the university.
- *Take a serious look at the teaching of . . . all lower level courses [including] . . . some alternative methods of teaching . . . that might improve the success rate*. Data that may shed light on this recommendation was recently provided by the engineering college, showing that in 2014-2015, the DFW percentages for engineering majors was quite high. There are three precalculus courses that engineering majors may take depending on their background: MATH 1710, Precalculus I (similar to College Algebra), MATH 1720, Precalculus II (3 credit hours), and MATH 1730, Combined Precalculus (4 credit hours). In 2014-2015, the DFW percentages for those three courses, along with MATH 1950 (Calculus I) were 38.1%, 38.2%, 56.5%, and 45.75, respectively. In subsequent years, the trend was towards more favorable numbers, with the corresponding percentages in 2019-2020 being 25.8%, 26%, 24%, and 19%.

- *Explore additional ways to encourage, support, and reward successful teaching, particularly among the new faculty*. A positive change in this direction occurred in Summer 2015 when UTC adopted the Quality Matters (QM) standards-based program for the design of online and hybrid courses. Campus-wide implementation of QM for faculty development and certification of online/hybrid course was formalized in April 2018, with stipends provided for completing the QM course certification process and for the development and certification of new courses.
- *[D]evelop a replacement plan for new equipment that will allow the department to plan for the future*. The University has a computer refresh plan, on a four-year cycle. The department has to cover the difference in cost between what the University pays and the cost of the computer the faculty member chooses, with approval of the department head. During Summer 2020, the 100 computers in the Math Plaza tutoring and testing center were replaced, for the first time in eight years, using departmental reserve funds (generated from lab and online course fees).

Graduate Program

- *Determine how to take advantage of the expected increase in demand for qualified community college mathematics teachers that should result from recent changes in state law*. The reviewer is referring to the Tennessee Promise program, begun in 2014, that offers two years of free tuition to community and technical colleges.
- *Consider whether or not the department wants to pursue the development of an online graduate program*. This suggestion is related to helping to meet the increased need for community college teachers – by allowing aspiring instructors to pursue a degree while still working and without relocating. The reviewer also suggested consideration of a certificate program to accompany the Master's program – e.g. for someone who has a Master's degree in another area.
- *Fill existing and future vacant positions with highly qualified and well-rounded faculty*. There were unfilled faculty positions at the time of the review, with more vacancies anticipated in the near future.

C. Recent Changes and Developments in the Programs

In the 2014 -2015 program review, this comment was made by the outside reviewer:

The department is undergoing a significant transition.

This trend continued at multiple levels in the University.

C.1. Changes at the Department Level and Above

There has been significant turnover in leadership since the last department review. During this time there have been:

- Four Provosts (including two as interim)
- Four College of Arts & Sciences Deans (including 2 as interim)
- Four Math Department Heads (only one permanent).

The current Provost, Dean, and Department Head are all permanent. Anticipated changes in faculty also occurred during this period, with 5 tenured faculty retiring, another tenure-track (TT)

faculty member leaving UTC, and a full professor moving to the Provost's office. Three new faculty members (2 TT and one full professor/department head) were hired, resulting in a net decrease of 4 active TT/T faculty members. There were 9 full-time non-tenure-track (NTT) faculty in Fall 2014 and that count is the same currently. Another significant change for the department occurred in Summer 2020, with the move from the Engineering, Math, and Computer Science building to the newly renovated former library, Lupton Hall.

C.2. Changes in the Undergraduate Program

The 2015-2016 UTC Undergraduate Catalog indicates two changes that occurred in the bachelor's degree program: (1) the B.A. in Mathematics was dropped and (2) the name of the B.S. degree was changed from 'Applied Mathematics' to 'Mathematics', with the three concentrations (Actuarial Science, General Mathematics, and STEM Education) remaining the same. Three courses appeared for the first time in the 2016-2017 catalog:

- MATH 3820 - Communicating Mathematics
- MATH 4260 - Modern Algebra II
- MATH 4280 - Analytic Number Theory

MATH 3820, now required for math majors, will soon be granted capstone course status.

The course MATH 4350, Mathematics of Finance, in support of the Actuarial Science concentration, first appeared in the 2017-2018 catalog.

The system for advising undergraduate students changed, since the previous review, with the introduction of the College of Arts and Sciences student success center, 'The Hub' in Summer 2019. The Hub complements UTC's Center for Academic Support and Advisement, which advises all first-time students in their first year, and departmental advisors.

C.3. Changes in the Graduate Program

These courses have been added since the last department program review:

- MATH 5131 – Statistical Computation and Programming
- MATH 5170 – Nonparametric Statistics
- MATH 5280 – Analytic Number Theory
- MATH 5350 – Mathematics of Finance
- MATH 5530 – Calculus of Variations
- MATH 5560 – Real Analysis
- MATH 5590 – Functional Analysis

Three of these courses (MATH 4170, MATH 5280, and MATH 5350) have corresponding 4000-level courses.

The 2017-2018 Graduate Catalog reveals two program-level additions: a post-baccalaureate certificate in Computational and Applied Statistics and a PhD opportunity - the Computational and Applied Mathematics concentration - one of three in the Computational Science PhD program. Though the Computational Science PhD program is housed in the College of Engineering and Computer Science, students in the Computational and Applied Mathematics concentration are advised primarily by faculty in the Mathematics Department. This

concentration first appeared in the 2017-2018 Graduate Catalog. The first PhD awarded with this concentration was in Summer 2020. There are currently 4 students in the Computational and Applied Mathematics concentration. In 2017-2018, twelve 7000-level MATH courses were added to the Graduate Catalog, including the courses Special Topics in Computational and Applied Mathematics, Graduate Seminar, Doctoral Research, Individual Studies, and Doctoral Dissertation.

D. Summary and Opportunities for the Next Five Years

In this section, the main points of the self-study are articulated and plans for the next five years are proposed.

D.1. Undergraduate Program

Indicators of success for the Undergraduate Program include:

- The number of math majors grew by more than 25% from Fall 2014 to Fall 2020.
- Levels of student satisfaction, measured by UTC evaluations of instruction and the National Survey of Student Engagement (NSSE), are similar to those for the College of Arts and Sciences and the University.
- Our majors are receiving notice outside of UTC, for example:
    - Alexis Jackson (Financial Math Concentration, graduated Spring 2019) was featured in a 2018 Chattanooga Times Free Press article on internships.
    - Pascale Haug (Math Stem Education, graduated Spring 2018) was profiled on the the national Robert Noyce Teacher Scholarship Program website (https://www.nsfnoyce.org/profiles/haug-pascale/)
- The curriculum is regularly reviewed and updated to meet the needs of students, for example the course MATH 3820, Communicating Mathematics, was introduced since the previous program review.
- Academic support services are evolving to better serve students. For example, the College of Arts and Sciences recently established its own student success center (The Hub).
- Courses are offered in a variety of modalities and faculty are ensuring that recognized standards are being applied. For example, several online courses are being, or have been certified using the Quality Matters program facilitated through UTC's Walker Center for Teaching and Learning.
- The Department is working with other programs on campus to improve retention and success of UTC students. For example, the high DFW rate for engineering majors in lower-level courses was pointed out by the outside reviewer in the previous program review. Table 1 shows that improvements have been made in the past six years. The Step Ahead summer bridge program for College Algebra is ongoing and there are plans for a summer calculus bootcamp, especially but not exclusively for new engineering students, in July 2021.

Table 1. DFW Rates in Lower-Level Courses for Engineering Majors

	MATH 1710 Precalculus I	MATH 1720 Precalculus II	MATH 1730 Precalculus III	MATH 1950 Calculus I	MATH 2450 Ordinary Differential Equations
2014-15	38.10%	38.18%	56.52%	45.71%	22.22%
2015-16	50.00%	26.32%	23.08%	29.55%	20.59%
2016-17	65.22%	31.25%	25.00%	38.89%	41.10%
2017-18	29.11%	32.93%	52.38%	34.17%	37.67%
2018-19	31.25%	32.69%	38.03%	29.68%	28.57%
2019-20	25.76%	26.00%	24.00%	19.00%	17.00%

Areas for growth and improvement are:

- Continue to consider opportunities to improve retention and success of students, including alternative methods of teaching, as suggested by the previous reviewer. Math faculty are participating in a multi-disciplinary discussion group on campus that meets periodically to discuss pedagogical improvements.
- Engage in collaborative efforts with programs at UTC and beyond. Math faculty are investigators on interdisciplinary proposals, e.g. with colleagues in STEM Education and the College of Engineering and Computer Science, that aim to strengthen connections with high schools and postsecondary institutions to help better prepare students for success in their college studies.
- Implement placement exams and pretests, along with supplemental learning aides, to ensure that students have the prerequisite skills needed for success. In Summer 2020, an online placement exam for College Algebra was implemented in Canvas. Efforts are underway to develop a placement exam for precalculus and calculus.
- Other avenues to consider, in addition to placement, for improving student retention and success are provided in the report *Recommendations from the MAA National Study of College Calculus,* Bressoud, Mesa, & Rasmussen (eds.), 2015, MAA Press. While this study focused on calculus, it provides strategies that apply to other large-enrollment introductory math courses as well. Highly effective approaches include placement, appropriate student support, coordination of instruction, and engaging teaching and learning formats including active learning.
- Work to improve the diversity of math majors through active recruitment and by enhancing diversity among those who are role models, i.e. faculty and graduate students.
- Broaden the variety of Beyond the Classroom (https://new.utc.edu/academic-affairs/walker-center-for-teaching-and-learning/thinkachieve/beyond) opportunities for math majors, including experiential learning, internships, and international exchanges.
- Communicate regularly with the CAS Hub advising center to make sure that student advising needs are being met.

D.2. Graduate Program

The investment by UTC in 2009 to establish a master's program in mathematics has proven fruitful, based on the following observations.

- The program is enabling student success at UTC and beyond, with curricular emphasis in areas that serve a variety of student interests and needs. The program has launched

students to careers in education and the private sector as well as PhD studies at UTC and other institutions.
- Master's students have helped grow the department's participation in interdisciplinary research including disease modeling.
- While there was a drop in the number of master's students during the review period, this trend has reversed itself and been complemented by the advent of the Computational and Applied Mathematics concentration in the Computational Science PhD program. Enrollment in graduate math courses has grown steadily in recent years.
- A nationally recognized need is being met by students obtaining the graduate education offered by this program. In the 2018 article, *The Master's as the New Bachelor's Degree: In Search of the Labor Market Payoff*, published by the American Enterprise Institute, comparisons are made among three States of master's degrees that result in the lowest average earnings and the highest average earnings. In the table of highest average earnings in Florida, the second highest earning master's degree is in Applied Mathematics.
- When interviewing prospective faculty members in 2019-2020, a universal response from candidates when asked the question 'What attracts you to the UTC Math Department?' was a recognition of the opportunity to work with graduate students.

Continued success of the Master's Program will be facilitated by the following efforts.

- Secure a stable, sustainable means of funding master's students. Teaching assistants contribute to the undergraduate instructional program in both direct and subtle (and still important) ways. TA's with sufficient graduate credits are teaching freshman introductory courses: others are leading recitations and assisting faculty. Teaching assistants often serve also as mentors and role models for undergraduate students. The benefits to graduate students who are TA's are many as well, besides the obvious financial support.
- Seek support for graduate students from the private sector – e.g. internships, research assistantships, and fellowships.
- Foster 'pipelines' with colleges and universities, building relationships with departments at other institutions to increase the pool of applications and grow the master's program.
- Explore the possibility of one or more international exchange programs.
- Develop a five-year bachelor's-master's program for high-achieving students.
- Increase the diversity of students, including possibly reaching out to HBCU institutions.
- Any growth in the number of students on financial support (as is desired and needed) will require finding more office space for TA's.
- Promote the existing certificate program and consider options for new programs, e.g. an online degree (as suggested by the previous reviewer) and one or more additional concentrations.

D.3. The Department

The department is highly successful in fulfilling its mission in each of the areas of teaching, research, and service:

- The department is delivering an effective set of courses, very efficiently in terms of the cost per SCH.
- Recent improvements have been made in outreach and communication efforts, including through social media.
- Faculty members are very productive in research (even with a relatively high teaching load) that spans pure and applied areas, with growing interdisciplinary collaborations.
- The Department has benefitted from an increasing level of interactions with the UTC SimCenter, including proposal assistance (particularly for young faculty), new linkages with faculty and students in other disciplines, and a variety of other resources to support research.
- Research funding is very strong, with the department playing a leading role over multiple years in the College of Arts and Sciences. Students at both the undergraduate and graduate levels are participating in this work.
- While ability to hire has not kept up with the need, the department has managed to hire four highly research-active assistant professors (including one who will start in August 2021) since the last review.
- Service activities by faculty members take many forms including refereeing article submissions and proposals, organizing conferences, and serving on committees at all levels at UTC.

Below are some ways in which the department can position itself for an even greater impact on students, the UTC community, and beyond.

- Nurture connections with high schools and community colleges to enhance student pathways to UTC and to realize other mutual beneficial results, including a growth in the education concentration of the master's program.
- Consider strategic areas in which to hire, including preparation to take advantage of 'cluster hiring' that is an increasing trend among universities.
- Look for opportunities to increase faculty diversity with respect to ethnicity and gender. The UTC 'Grow Your Own' program may be helpful in this regard.
- Continue strengthening interdisciplinary collaborations, such as with STEM education, engineering, and the health sciences.
- Encourage and support innovative teaching strategies, including active learning, that increase student engagement.
- Strategically consider Princeton University professor Weinan E's article *The Dawning of a New Era in Applied Mathematics* in the April 2021 issue of Notices of the American Mathematical Society (https://www.ams.org/journals/notices/202104/rnoti-p565.pdf). Some of the key points in that article are:
    - *The integration of machine learning into applied math will change both disciplines in a fundamental way,*

- *With machine learning coming into the picture, . . ., applied math is finally ready to become a mature scientific discipline,* and
- *The lack of mature applied math undergraduate programs is the one single most important obstacle for applied math.*

Professor E does not suggest that an emphasis on applied math will diminish the need for pure math; in fact, he points out that machine learning has introduced new problems in analysis (in particular), approximation, and probability, at least. Those bullet points raise the question of whether an applied math concentration at the undergraduate level should be implemented, and also how might the applied math M.S. concentration be enhanced?

- It would be advantageous for the department to build stronger relationships with local industries that hire math majors, starting with Unum Insurance and BlueCross BlueShield of Tennessee.
- In the previous self-study a significant administrative staff shortage was pointed out. This was acknowledged by the external reviewer in the suggestion

  Seek ways to get additional support to relieve existing support staff.

  There is still only one administrative specialist serving the department. Additional support is being provided by student office assistants. Any growth in needs that require a trained administrative specialist, (budgeting, webpage development and maintenance, record keeping, . . .) will require the hiring of another staff member.

D.4. Challenges as Opportunities

A unifying theme for the degree programs' path forward is to turn challenges into opportunities for growth.

Universities are relying more and more heavily on transfer students to maintain undergraduate enrollments. As recognized by the previous program reviewer, in 2014 the State initiated the Tennessee Promise program, providing free community college tuition for two years to all graduating Tennessee high school seniors. While this has not resulted in a decrease in enrollment at UTC in the past five years, there is a perceived decrease in preparedness for college courses. This challenge can be met through careful placement and instructional learning tools (such as help sessions, corequisite courses, and online preparatory materials). In the long run, cooperative efforts with high schools and community colleges will help to ensure that students are receiving the preparation needed before coming to UTC. As also pointed out by the previous reviewer, the growing need for instructors in community colleges provides an opportunity for growth of the master's program.

The graduate program may be better positioned for growth by the consideration of new directions that complement, rather than compete with, other universities such as UTK, UGA, Georgia Tech, and Vanderbilt in the Southeast. Department faculty have the expertise necessary to facilitate research at the intersection of pure and applied mathematics with an emphasis on interdisciplinary research. This ability to bridge the gap between mathematics and other disciplines is a strength that sets the department apart from the typical, traditional math department. For example, computational mathematics and statistics are both vital to

interdisciplinary research and provide research topics that are suitable for a master's student. These fields can also serve as a basis upon which to build a PhD degree. Educating students at the intersection of pure and applied mathematics will provide them with a highly sought-after background applicable in many contexts. Experience indicates that courses in these areas also attract graduate students from other departments.

Part 1: Learning Outcomes

1.1. Missions of the Institution, College and Department

University Mission

The mission of UTC is stated in its 2015-2020 Strategic Plan:

> *The University of Tennessee at Chattanooga is a driving force for achieving excellence by actively engaging students, faculty, and staff; embracing diversity and inclusion; inspiring positive change; and enriching and sustaining our community.*

Mission of the UTC Graduate School

> *The mission of The Graduate School is to provide rigorous advanced instruction, applied research opportunities, financial support, and other support services for graduate students. The Graduate School upholds high program and academic standards in serving the needs of the region, state, and nation. The Graduate School also takes into account the increasing availability of information and the resultant creation of knowledge made possible by advances in technology.*

College Mission

The mission of the UTC College of Arts and Science, according to its bylaws is the following:

> *Putting our values into practice, we collectively…*
>
> - *provide and foster an environment for intellectual curiosity and a foundation for life-long learning, thinking, reflection, and growth;*
> - *equip students with transferrable skills – critical thinking, communication, and complex problem-solving skills – that are needed to adapt and succeed in a rapidly evolving world;*
> - *advance cultural and intellectual diversity;*
> - *advance new knowledge through research (theoretical and applied) and creative activities;*
> - *advance integrated service as a part of personal and social responsibility.*

Department Mission

> *The mission of the Department of Mathematics at The University of Tennessee at Chattanooga (UTC) is to teach mathematics and to engage in active scholarship and service.*

1.2. Undergraduate Program

1.2.1. Student Learning Outcomes

Students in the department participate in a learning environment characterized by exemplary teaching, innovative scholarship, creative expression, undergraduate research, engaged service, and practical experience. Below is the list of six Student Learning Outcomes for our mathematics majors.

- **Conceptual Understanding**. Students are able to assimilate and consolidate abstract and novel ideas within the core areas of mathematics (including geometry, algebra, analysis, discrete mathematics, numerical analysis, and statistics), to develop a functional grasp of the fundamental concepts and methods of solution, and are able to critique and write clear logical arguments using standard notation in various proof techniques.
- **Computational Skills**. Students are able to correctly and efficiently perform the basic computations and algebraic manipulations within the core areas of mathematics.
- **Modeling and Applications**. Students are able to rigorously apply mathematical principles to advanced problems within the core areas of mathematics and use mathematical modeling to extend these studies to interdisciplinary explorations in the sciences, engineering, business and finance, social sciences, and the health sciences.
- **Disciplinary Values**. Students are able to apply the axiomatic method in their mathematical thought process, to reason accurately without any preconceptions or unnecessary biases enhancing their power of concentration, while developing the patience, persistence and inventive faculties required for independent critical thinking.
- **Written Communication Skills**. Students are able to read and understand the conventions for writing mathematics using the proper mathematical notation, including equations, charts, graphs, and tables, to generate and communicate their ideas and findings clearly, effectively and unambiguously, thereby building a deeper conceptual understanding and appreciation of mathematics.
- **Oral Communication Skills**. Students are able to express their mathematical thinking orally in a precise fashion and use an effective presentation style along with a variety of aids (such as visual slides and whiteboards) to communicate formal concepts and results coherently and clearly.

Examples of how these learning outcomes are met are provided in Section 2.1.3.

1.2.2. Program Outcomes

The department has a vested interest in teaching students to communicate mathematical ideas effectively and to use basic computational skills, mathematical models and technology to solve practical problems. The Department of Mathematics regularly offers the course MATH 3820 Communicating Mathematics to help students learn to effectively communicate mathematics in technical writing and oral presentation. This course is required for all math majors and plans are underway to make MATH 3820 the capstone course for math majors, along with raising it to the 4000 level.

In addition to its own degree program, the department provides extensive support for other programs, including engineering, science, and business, requiring mathematics courses and for the university's General Education requirements.

The department is committed to excellence in teaching and research mentoring, attracting and supporting outstanding students, maintaining high standards for student performance, and keeping its curriculum up to date. The department also takes pride in a faculty that is active in scholarship and research, which includes the encouragement and supervision of undergraduate student research projects and honors theses, as well as graduate student projects and theses.

Department faculty actively seek external funding sources to support programs in teaching and research, build and nurture a sense of community among faculty and students, and engage in active outreach efforts with community partners in education and industry.

1.2.3. Course Syllabi

The department adheres to the course syllabus template provided by the Walker Center for Teaching and Learning. The department maintains an online repository of syllabi for courses taught from Fall 2016 to Spring 2021 (with the exception of Spring 2017).

A representative sampling of undergraduate syllabi is on the Department SharePoint site at https://mocsutc0.sharepoint.com/:f:/s/mathematics/EpmvFm4heZRItPs4URDnnVUB2mGXEVTmiHIybvj7lTHZ5w?e=xi2euP in the folder 'undergraduate_syllabi'.

Syllabi from these courses were chosen to reflect a range of General Education courses and courses taken by math majors:

- MATH 1010 - Mathematics in Our Modern World
- MATH 1130 - College Algebra
- MATH 1830 - Calculus for Management, Life, and Social Sciences
- MATH 1950 - Calculus with Analytic Geometry I
- MATH 2100 - Introductory Statistics
- MATH 2450 - Introduction to Differential and Difference Equations
- MATH 3100 - Applied Statistics
- MATH 3820 – Communicating Mathematics
- MATH 4250 - Modern Algebra I
- MATH 4350 - Mathematics of Finance

These syllabi clearly articulate learning objectives and how they will be assessed. Further details about the syllabi as they meet curriculum criteria are presented in Part 2, Section 2.1.2.

1.2.4. Results of Institutional Survey

UTC administers the National Survey of Student Engagement (NSSE) each year to first year and senior students. Results from the 2020 survey, provided by the UTC Office of Planning, Evaluation, and Institutional Research (OPEIR), are shown in Tables 1.1 and 1.2. Some observations based on these results are:

- Overall satisfaction levels for math majors are comparable to those for students in the College and the UTC student body. Math majors rate the curriculum as comparable or

favorable, in comparison to feedback from students at broader levels, except for Questions 7 and 9, on the topics of how the institution contributes to *developing or clarifying a personal code of values and ethics* and *being an informed and active citizen*.

- The less favorable results for Questions 7 and 9 are cause for some reflection. A possible contribution to these scores is a perception among students of a lapse in academic integrity.
- The results for the questions in the Faculty Involvement category (in Table 1.2), for the Department, indicate trends similar to those in the College and University-level results. The scores suggest that some attention to how faculty mentor and advise students is warranted. As mentioned in Section C.2 of the Preface/History section, the College of Arts and Sciences set up the Hub advising center in Summer 2019. Departments in CAS and the Hub are still developing a plan for how to most effectively advise and mentor students. Hopefully, this will result in improved scores in related categories in future surveys.
- Numbers in the Cultural Experience group of questions indicate that math majors have somewhat less exposure to socio/economic diversity than students in other majors in the university. This reflects a recognized need for more diversity in students and faculty in the department, evidenced further by demographic tables in later parts of this self-study.

1.3. Graduate Program

1.3.1. Student Learning Outcomes

Student learning outcomes for the M.S. Program in Mathematics are as follows:

- Communication: be able to effectively communicate and present mathematical concepts
- Mathematical Fundamentals: be able to understand fundamental mathematical theory and methods and apply them in complex problem solving
- Technical Writing: be able to document research findings and write up a thesis or project report

1.3.2. Program Outcomes

The **goals** of the Department related to the M.S. Degree in Mathematics include:

- Advertise and recruit students for the Master of Science in Mathematics degree program.
- Incorporate the use of mathematical software into our courses as appropriate.
- 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.
- 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.
- Cultivate and expand the relationship between the Mathematics Department and other departments and colleges on campus. Continue ongoing, as well as develop new, cooperative efforts with schools and colleges in the region.

Table 1.1. 2020 NSSE Survey Part 1

Student Survey Results (NSSE)					
QUESTION/STATEMENT	RESPONSE OPTIONS	PERCENTAGES			VALID N: (DEPT.)*
		UTC	COLLEGE	DEPT.	
SATISFACTION WITH UTC					
1. How would you evaluate your entire educational experience at this institution?	Poor	1.9	2.3	0.0	19
	Fair	13.8	12.9	21.1	
	Good	53.8	55.0	57.9	
	Excellent	30.6	29.8	21.1	
2. If you could start over again, would you go to the same institution you are now attending?	Definitely no	3.8	4.6	10.5	19
	Probably no	13.6	14.6	10.5	
	Probably yes	44.8	44.1	47.4	
	Definitely yes	37.8	36.7	31.6	
CURRICULUM					
1. Institution contributes to you acquiring job or work related knowledge and skills.	Very little	11.6	12.7	15.8	19
	Sometimes	30.8	36.0	26.3	
	Quite a bit	33.2	30.8	21.1	
	Very much	24.4	20.5	36.8	
2. Institution contributed in developing clear and effective speaking skills.	Very little	9.8	7.9	10.5	19
	Sometimes	30.6	33.1	21.1	
	Quite a bit	34.4	33.7	26.3	
	Very much	25.3	25.3	42.1	
3. Institution contributed in developing clear and effective writing skills.	Very little	6.0	4.9	5.3	19
	Sometimes	25.7	23.4	21.1	
	Quite a bit	40.6	40.9	47.4	
	Very much	27.7	30.8	26.3	
4. Institution contributed to your ability to solve complex real-world problems.	Very little	10.4	10.8	15.8	19
	Sometimes	31.7	34.1	26.3	
	Quite a bit	35.2	35.8	36.8	
	Very much	22.7	19.4	21.1	
5. Institution contributed to thinking critically and analytically.	Very little	3.0	3.0	5.3	19
	Sometimes	16.1	16.6	15.8	
	Quite a bit	42.8	41.8	26.3	
	Very much	38.1	38.6	52.6	
6. Institution contributed to working effectively with others.	Very little	5.3	5.3	15.8	19
	Sometimes	26.2	29.1	21.1	
	Quite a bit	41.2	42.3	36.8	
	Very much	27.2	23.3	26.3	
7. Institution contributed to developing or clarifying a personal code of values and ethics.	Very little	12.1	11.3	15.8	19
	Sometimes	28.8	32.2	42.1	
	Quite a bit	35.9	34.7	31.6	
	Very much	23.3	21.9	10.5	
8. Institution contributed to encouraging contact among students from different backgrounds (social, racial/ethnic, religious, etc).	Very little	12.7	11.9	15.8	19
	Sometimes	29.5	32.1	21.1	
	Quite a bit	3.6.4	36.2	26.3	
	Very much	21.5	19.8	36.8	
9. Institution contributed to being an informed and active citizen.	Very little	13.3	13.3	10.5	19
	Sometimes	32.4	32.8	47.4	
	Quite a bit	31.6	31.5	26.3	
	Very much	22.7	22.4	15.8	

*__Valid N__ = the number of majors answering the question on the NSSE Survey

**Not enough evaluations completed to analyze data

Scale: 1 to 7; 1 = Unavailable, unhelpful, and unsympathetic; 7 = Available, helpful, and sympathetic

Table 1.2. 2020 NSSE Survey Part 2

Student Survey Results (NSSE)					
QUESTION/STATEMENT	RESPONSE OPTIONS	PERCENTAGES			VALID N: (DEPT.)*
		UTC	COLLEGE	DEPT.	
FACULTY INVOLVEMENT					
1. Quality of interactions with faculty members.	1	1.6	1.8	0.0	19
	2	2.4	1.7	10.5	
	3	5.8	4.5	0.0	
	4	15.7	12.9	10.5	
	5	25.8	26.6	36.8	
	6	26.8	28.3	21.1	
	7	22.0	24.2	21.1	
2. Talked about career plans with a faculty member or advisor.	Never	13.0	14.1	21.1	19
	Sometimes	39.8	40.6	36.8	
	Often	27.7	29.1	36.8	
	Very Often	18.8	16.2	5.3	
3. Worked with a faculty member on activities other than coursework (committees, student groups, etc.)	Never	45.4	47.3	68.4	19
	Sometimes	30.3	29.6	15.8	
	Often	14.7	13.8	10.5	
	Very Often	9.5	9.2	5.3	
4. Discussed course topics, ideas, or concepts with a faculty member outside of class	Never	29.4	29.1	26.3	19
	Sometimes	40.8	41.6	42.1	
	Often	20.4	19.2	31.6	
	Very Often	9.5	10.0	0.0	
CULTURAL EXPERIENCE AT UTC					
1. Had discussions with students of a different race or ethnicity than your own.	Never	3.0	2.7	5.3	19
	Sometimes	23.6	25.0	47.4	
	Often	34.1	35.3	15.8	
	Very Often	39.4	37.0	31.6	
2. Had discussions with students from different economic background other than your own.	Never	2.7	2.4	0.0	19
	Sometimes	20.2	20.0	36.8	
	Often	38.1	39.7	31.6	
	Very Often	39.0	37.8	31.6	
3. Had discussions with students who are very different from you in terms of their religious beliefs or personal values.	Never	4.3	2.9	0.0	19
	Sometimes	24.5	23.4	47.4	
	Often	34.4	34.6	15.8	
	Very Often	36.7	39.1	36.8	
4. Had discussions with students who are very different from you in terms of their political opinions or personal values.	Never	3.7	2.9	0.0	19
	Sometimes	24.5	25.6	47.4	
	Often	34.9	36.0	21.1	
	Very Often	36.9	35.5	31.6	

*__Valid N__ = the number of majors answering the question on the NSSE Survey

**Not enough evaluations completed to analyze data

Scale: 1 to 7; 1 = Unavailable, unhelpful, and unsympathetic; 7 = Available, helpful, and sympathetic

Program outcomes corresponding to these goals are

- The program will attract a cohort of students, sufficient in number and preparation, to maintain the viability of the program.
- Students in the program will have a high-quality experience in terms of advising, study, and research.
- Graduates will be prepared for successful employment and/or further study.

1.3.3. Course Syllabi

A representative sample of recent syllabi, listed below, is available at the Department SharePoint site at

https://mocsutc0.sharepoint.com/:f:/s/mathematics/EpmvFm4heZRItPs4URDnnVUB2mGXEVTmiHIybvj7lTHZ5w?e=xi2euP in the folder 'graduate_syllabi'.

- MATH 5130 - Introduction to Probability and Statistics
- MATH 5210 - Linear Algebra and Matrix Theory
- MATH 5530 - Calculus of Variations
- MATH 5560 - Real Analysis
- MATH 7560 - Asymptotic Analysis

1.3.4. Program Evaluation

The outcomes of the M.S. Mathematics program are regularly evaluated by the Department to measure students' mastery of mathematical fundamentals and their proficiency in communication and writing.

The Graduate School, the University Library and the Writing and Communication Center at UTC offer a number of workshops, tutorials and consultations to help graduate students with their professional writing and communication skills. Both face-to-face and virtual (online) sessions are available to students. Each graduate student in the Math Department is required to take at least 3-6 research/thesis credits to allow adequate time for them to work on their research projects, meet and communicate with their faculty advisors, and write up their findings. Moreover, the Math Department holds an Advising Night every semester, where all faculty members teaching upper-level courses are present to interact with students and help them to choose courses that best meet their needs.

Additionally, students who pursue a master's degree in mathematics without an undergraduate math degree are required to take additional undergraduate courses prior to beginning graduate-level math courses to ensure that they acquire vital foundational skills in mathematics.

Student Assessment

The performance of each graduate student in the Department of Mathematics is assessed based on the three learning outcomes stated in Section 1.3.1. The assessment results for the M.S. students are reviewed by their faculty advisors and the Graduate Committee of the Math Department. Corrective actions, if necessary, are made to help the students to better achieve their learning goals. Details related to evaluation of the learning outcomes are given below.

- Communication: M.S. students in the Math Department often have the opportunity to teach an undergraduate class (as a Teaching Associate) at some point. The quality of their teaching, particularly their knowledge and skills in communicating mathematics, is rigorously evaluated by faculty supervisors through classroom visits and by undergraduate students through teaching evaluations. The communication skills of the

M.S. students are also evaluated when they present their theses or project reports. The thesis/project committee, which typically consists of the student's advisor and three other faculty members, makes an assessment on the quality of the student's oral presentation and interaction with the audience through questions and answers.

- Mathematical Fundamentals: A faculty member who teaches a graduate course in the Math Department is responsible for evaluating students' understanding of fundamental mathematical concepts, theory and methods. Meanwhile, each faculty advisor who mentors a graduate student is responsible for assessing the student's performance on the project or thesis, particularly the student's mastery of fundamental knowledge in mathematics.

- Technical Writing: The technical writing skills of the M.S. students are evaluated based on their theses or project reports. The thesis/project committee makes an assessment on several key components such as the content of writing, organization of materials, illustration of concepts, rigor of analysis, and validation of results. Additionally, some M.S. students may be able to write up and submit a journal paper based on their research findings, which provides another opportunity for the students to practice, and for the faculty members to evaluate, their skills in technical writing.

UTC archives assessment data (outcomes and associated information including assessment results and links to the CAS Strategic Plan, UTC Strategic Plan, and UTC's vision, mission, and values) using Campus Labs/Anthology.

Theses and Projects

Each graduate student is required to complete a project or a thesis in order to receive the M.S. degree. A project normally takes at least one semester and is more application oriented, whereas a thesis is usually more comprehensive, involving both theory and applications, and takes at least one academic year to complete. Documentation of professional quality and an oral presentation/defense are required for both the thesis and project options. Below are the steps that graduate students must follow to complete their theses/projects:

- Identify a potential thesis/project topic and discuss it with the faculty advisor
- Conduct a literature review
- Develop a timeline
- Write a proposal which needs to be approved by the Graduate Committee
- Select thesis/project committee members
- Conduct research, which may include mathematical analysis, methodology development, data analysis and validation, and applications
- Summarize findings and draw conclusions
- Write up the thesis or project report
- Present the thesis or project report

In recent years, graduate students in the Department of Mathematics completed a variety of research projects and theses under the direction of faculty advisors. The following is a selected list of recent M.S. theses:

- John Murphy, “Vague convergence of spectral shift functions for periodic restrictions of one-dimensional Schrödinger operators”. (Adviser: Roger Nichols)

- Chayu Yang, “Impact of awareness programs on cholera dynamics: two modeling approaches”. (Adviser: Jin Wang)

- Oluwakorede Ajumobi, “On estimating the reliability in a multicomponent system based on progressively-censored data from Chen distribution”. (Adviser: Sumith Gunasekera)

- Jeffrey Christopher, “Induced path number for the complementary prism of a grid graph”. (Adviser: Terry Walters)

- Lisa Nanni, “Modeling zero-inflated and overdispersed count data: application to in-hospital mortality data”. (Adviser: Lanni Gao)

- Daniel Plaisted, “On a graph parameter related to vertex labelings and its application to minimum rank problems in graph theory”. (Adviser: Francesco Barioli)

- Blake Smith, “Robust optimization of linear optimization problems and an approximation approach to solve robust Knapsack Problem”. (Adviser: Lakmali Weerasena)

1.4. Alignment of Program and Institutional Goals

The Mathematics Department strives to create a community of innovative thinkers who can work collaboratively to solve complex problems, including those related to the rapidly changing conditions of our global society. To accomplish this goal, the department offers undergraduate and graduate degrees in mathematics that prepare students to work in industry, to teach in secondary schools or community colleges, or pursue continuing graduate study. The department aspires to become a significant entity in the state of Tennessee for the preparation of diverse and highly qualified professionals for a variety pf successful careers including mathematicians, mathematics educators, engineers, scientists, financial analysts, economists, and business entrepreneurs.

When needed, appropriate changes to our undergraduate and graduate curricula are made. The Curriculum Committee, which consists of six department faculty members and is chaired by the Associate Department Head for Undergraduate Studies and Scheduling, reviews and makes necessary changes in the curriculum every year based on student evaluations, assessment results and faculty recommendations. The Graduate Committee, which consists of five faculty members in the Department and is chaired by the department Graduate Director, regularly reviews student performance, recruitment practice, and program assessment, and makes recommendations to the Department to ensure continuous improvement of the M.S. program. The Graduate Committee works with faculty advisors to ensure that graduate students successfully complete their degree requirements.

Part 2: Curriculum

2.1. Undergraduate Program

The Department of Mathematics offers the Bachelor of Science degree in Mathematics with three concentrations: Actuarial Science, General Mathematics, and STEM Education. These three concentrations offer students a broad set of specializations, with paths from the university to business, industry, education, or a post-graduate degree program.

2.1.1. Bachelor of Science

A. General Education Requirements

General Education requirements for the Bachelor of Science degree in Mathematics are in line with the requirements for other undergraduate degrees at UTC, namely 40-41 hours subdivided among the categories listed below. For a complete set of courses approved in each category, see the list of Certified General Education Courses at http://catalog.utc.edu/preview_program.php?catoid=32&poid=6009.

- Rhetoric and Writing (6 hours)
- Fine Arts and Humanities:
    - Historical Understanding (3 hours)
    - Literature (3 hours)
    - Thought, Values and Beliefs (3 hours)
    - Visual and Performing Arts (3 hours)
- Natural Sciences (7-8 hours)
- Behavioral and Social Sciences (6 hours)
- Mathematics (3 hours)
- Statistics (3 hours)
- Non-Western Culture (3 hours)

However, the Mathematics and Statistics categories, and, for the STEM Education concentration, the Natural Science category, can be fulfilled by selecting suitable coursework included in the program requirements.

B. Core Requirements

All majors in the B.S. in Mathematics program are required to take the following core coursework, regardless of their concentration. This coursework provides all students with a foundational educational experience.

- CPSC 1100 - Fundamentals of Computer Science (4 hours)
- MATH 1950 - Calculus with Analytic Geometry I (4 hours)
- MATH 1960 - Calculus with Analytic Geometry II (4 hours)
- MATH 2200 - Elementary Linear Algebra (3 hours)
- MATH 2450 - Introduction to Differential and Difference Equations (3 hours)
- MATH 2560 - Calculus with Analytic Geometry III (4 hours)
- MATH 3000 - Introduction to Logic and Proof (3 hours)
- MATH 3510 - Introduction to Analysis I (3 hours)

- MATH 3820 - Communicating Mathematics (3 hours)

Because MATH 1950 fulfills the 3-hour Gen Ed requirement for the Mathematics category, the overall core requirements constitute 24 hours of additional coursework. This coursework covers three semesters of differential and integral calculus, one semester of basic linear algebra, and one semester of differential equations. Then, beyond the level of study for a typical student in Engineering or the Sciences, math majors learn about how a mathematician thinks and works in the course MATH 3000 - Introduction to Logic and Proof. Math majors are then prepared for three major areas of Analysis, Algebra, and Statistics, where, for the two latter areas, requirements are slightly different depending on the specific concentration, as described subsequently. All majors are also required to have an introduction to modern computing through the CPSC 1100 - Fundamentals of Computer Science course. In that course, they are introduced to programming through a compiled language such as Java.

Other general requirements are

- 2.0 GPA in all required major and related courses (including specified General Education courses).
- Minimum of 39 hours of 3000 and 4000 level courses
- In addition to concentration requirements (see below), electives to complete 120 hours.

C. Concentration in Actuarial Science

Students in the Actuarial Science concentration are required to complete the following additional coursework.

- MATH 4130 - Introduction to Probability and Statistics (3 hours)
- MATH 4140 - Mathematical Statistics (3 hours)
- MATH 4200 - Linear Algebra and Matrix Theory (3 hours)
- MATH 4600 - Numerical Analysis I (3 hours)
- One course (3 hours) from:
    - MATH 4160 - Applied Statistical Methods
    - MATH 4310 - Operations Research (Linear)
    - MATH 4320 - Operations Research (Non-Linear)
- Three additional courses (9 hours) in Mathematics at the 3000-4000 level, excluding MATH 3100
- ACC 2010 - Principles of Accounting I (3 hours)
- ACC 2020 - Principles of Accounting II (3 hours)
- ECON 1010 - Principles of Economics: Macroeconomics (3 hours)
- ECON 1020 - Principles of Economics: Microeconomics (3 hours)
- ECON 3240 - Intermediate Microeconomic Theory (3 hours)
- ECON 3250 - Intermediate Macroeconomic Theory (3 hours)
- FIN 3020 - Essentials of Managerial Finance (3 hours)
- FIN 3370 - Principles of Insurance (3 hours)
- One course (3 hours) from:
    - THSP 1090 - Public Speaking

  - THSP 2090 - Business and Professional Speech Communication

Since MATH 4140 fulfills the 3-hour Gen Ed requirement for the Statistics category, altogether the above concentration requirements constitute 48 hours of additional coursework. To complete the 120-hour requirement, students in this concentration need to take an additional 8 hours in electives. Strongly recommended electives for the concentration include MATH 4160 – Applied Statistical Methods, MATH 4300 - Mathematics of Interest, MATH 4510 – Introduction to Analysis II, and ECON 4600 – Introduction to Econometrics.

D. Concentration in General Mathematics

Students in the General Mathematics concentration are required to complete the following additional coursework.

- One course (3 hours) from
  - MATH 3250 - Introduction to Modern Algebra
  - MATH 4200 - Linear Algebra and Matrix Theory
- Five courses (15 hours) from one of the two following options:
  - Option A
    - MATH 3100 - Applied Statistics
    - 12 additional hours in Mathematics at the 3000-4000 level
  - Option B
    - MATH 4130 - Introduction to Probability and Statistics
    - MATH 4140 - Mathematical Statistics
    - 9 additional hours in Mathematics at the 3000-4000 level excluding MATH 3100
- One course (3 hours) from
  - THSP 1090 - Public Speaking
  - THSP 2090 - Business and Professional Speech Communication

In addition, a student must choose an established minor or design a program of study approved by the Mathematics Department Curriculum Committee consisting of 18 hours of courses in other disciplines, including at least 8 hours at the 3000-4000 level. A minimum grade point average of 2.0 must be achieved in these courses. Completion of a second major will satisfy this requirement.

Considering that MATH 3100 and MATH 4140 both fulfill the 3-hour Gen Ed requirement for the Statistics category, altogether the above concentration requirements constitute 39 hours of additional coursework. To complete the 120-hour requirement, students in this concentration need to take an additional 17 hours in electives. MATH 4510 is strongly recommended, particularly for those students who are seeking teaching certification in mathematics and students who are planning graduate study.

E. Concentration in STEM Education

Students in the STEM Education concentration are required to complete the following additional coursework.

- MATH 2300 - Mathematical Models, Functions and Applications (3 hours)
- MATH 4010 - Basic Concepts of Geometry (3 hours)
- One course (3 hours) from
    - MATH 3250 - Introduction to Modern Algebra
    - MATH 4200 - Linear Algebra and Matrix Theory
- Four courses (12 hours) from one of the two following options:
    - Option A
        - MATH 3100 - Applied Statistics
        - 9 additional hours in Mathematics at the 3000-4000 level
    - Option B
        - MATH 4130 - Introduction to Probability and Statistics
        - MATH 4140 - Mathematical Statistics
        - 6 additional hours in Mathematics at the 3000-4000 level excluding Mathematics 3100
- One of the following options (8 hours)
    - PHYS 1030 - General Physics - Mechanics and Heat
    - PHYS 1030L - General Physics Laboratory - Mechanics and Heat
    - PHYS 1040 - General Physics - Electromagnetism and Optics
    - PHYS 1040L - General Physics Laboratory - Electromagnetism and Optics

    or
    - PHYS 2300 - Principles of Physics - Mechanics and Heat
    - PHYS 2300L - Principles of Physics Laboratory-Mechanics and Heat
    - PHYS 2310 - Principles of Physics - Electricity and Magnetism
    - PHYS 2310L - Principles of Physics Laboratory - Electricity and Magnetism
- EDUC 4170 - Technology and Learning (3 hours)
- STEM 1030 - Step One/Step Two: Inquiry-Based Mathematics and Science Teaching (2 hours)
- STEM 2010 - Knowing and Learning (3 hours)
- STEM 2020 - Classroom Interactions (3 hours)
- STEM 3010 - Perspectives on Science and Mathematics (3 hours)
- STEM 3020 - Research Methods in Science (3 hours)
- STEM 4010 - Project-Based Instruction (3 hours)
- STEM 4020 - Apprentice Teaching (6-12 hours)

Because MATH 3100 and MATH 4140 both fulfill the 3-hour Gen Ed requirement for the Statistics category, and both General Physics and Principles of Physics courses fulfill the Natural Science category requirement, in total the above concentration requirements constitute 45 hours of additional coursework. To complete the 120-hour requirement, students in this concentration need to take an additional 11 hours in electives. For admission to the Teacher Education Program

(TEP), students must earn a minimum 2.75 cumulative grade point average, a 2.75 average on all courses taken at UTC, a 2.75 GPA in education courses with no grade lower than C, and a 2.75 in content area courses with no grade lower than C. In addition to the department and university requirements there are the following minimum requirements for graduation with licensure: 2.75 cumulative average, 2.75 at UTC, 2.75 average in STEM courses with no grade lower than C, 2.75 average in courses in licensure content area courses with no grade lower than C.

2.1.2. Course Syllabi and Curriculum Content

A representative sampling of undergraduate syllabi is on the Department SharePoint site at https://mocsutc0.sharepoint.com/:f:/s/mathematics/EpmvFm4heZRItPs4URDnnVUB2mGXEVTmiHIybvj7lTHZ5w?e=xi2euP in the folder 'undergraduate_syllabi'.

Example outcomes from the syllabi will be provided here to demonstrate how criteria for evaluation of curriculum are met.

- Alignment of curriculum with programmatic student learning outcomes
  Examples for this criterion are in Section 2.1.3.
- Content reflects current standards, practices, and issues in the discipline
  - Each of the courses incorporates a well-established and up-to-date textbook, in some cases customized for UTC. The 1000 and 2000-level courses use online homework systems that are widely used.
- Incorporation of appropriate pedagogical and technological methods to enhance student learning
  - All courses use the Canvas learning management system and, as mentioned previously, a widely used online homework system is used in lower level courses.
  - MATH 3820 introduces students to the LaTeX technical writing system which enables publication of equation-based written content.
  - Students use Texas Instruments calculators in MATH 1010, MATH 1130, and MATH 1830
- Opportunities for discipline-specific research methods
  Two of the learning outcomes for MATH 3820 are:
  - *Examine the classification and reviewing system used in the mathematical sciences*
  - *Prepare a research paper and present it to the faculty and students on Mathematics Research day at the end of the semester.*
- Fosters analytical and critical thinking, and problem-solving techniques
  This criterion is met by each of the courses. Here are some specific examples from the learning outcomes.
  - MATH 1010: *Students will analyze and resolve real-world and abstract quantitative situations that require critical thinking, logical reasoning, and the ability to identify assumptions and separate relevant from irrelevant information.*
  - MATH 1130: *[Students will] Apply algebraic concepts to model and solve real-life situations.*
- Development of both oral and written communication skills related to the discipline
  - MATH 1010: *Students will communicate, interpret, and justify results with mathematical formulas and numerical values and regular sentences and explanations*
  - MATH 2100: *[Students will] Communicate, interpret, and justify statistical results with clarity and coherence.*

2.1.3. SACSCOC Outcomes Data

Examples from course syllabi will be used to illustrate how learning outcomes listed in Section 1.2.1. are met.

- Conceptual Understanding

  There are elements of conceptual understanding in each course. Some examples are:
  - MATH 1130: *[Students will] Understand and use basic concepts of functions, including using proper function notation, finding the domain, evaluating, and graphing.*
  - MATH 2450: [*Students will] Understand the basic concept of differential equations, classification, their solutions, and their applications, qualitative techniques for obtaining information about solutions to differential equations.*
- Computational Skills

  MATH 1010: *Students will solve quantitative problems using creativity, logic, and a variety of appropriate mathematical concepts, skills, tools, and methods.*
  - MATH 1950: *[Students will] Apply antiderivatives to compute areas and to solve basic initial value problems.*
  - MATH 3100: *[Students will] know how to compute probabilities associated with many probability distributions*
- Modeling and Applications
  - MATH 1830: *[Students will] Use definite integrals to solve real-world problems involving consumer/producer surplus, inventory control, and Lorentz curves and income analysis.*

    MATH 1950: *[Students will] Analyze information to develop models for solving applications problems involving related rates, optimization, area under curves and velocity/acceleration.*

    MATH 4350: *[Students will be]*
- Disciplinary Values
  - MATH 2100: *[The course aims] To develop the ability of students to think logically and creatively about statistical problems.*
  - MATH 4250: *[Students will] Produce rigorous proofs of propositions arising in the context of abstract algebra.*
- Written and Oral Communication Skills

  These criteria are addressed in the previous section. Here are two further examples from MATH 3820:
  - *Develop awareness of common mistakes in writing mathematics for the reader*
  - *Prepare a resume that can be continuously updated in the future and that can be used for applying for graduate school or for employment in the private or public sector*

  Some assignments in MATH 3820 (e.g. application letter and resume) involve a group critique of submissions. The course is required for all math majors.

2.1.4. Catalog Information

On the Department's Undergraduate Studies webpage, at https://new.utc.edu/arts-and-sciences/mathematics/undergraduate-programs, there are links to the UTC advising **Clear Path** curriculum charts for each concentration for the math major. Those charts are also included in

Appendix B. Each chart includes a link to the undergraduate catalog where the students can access course descriptions.

2.1.5. Curricular Research Opportunities

Undergraduate majors have the opportunity to conduct research with faculty mentors, receiving credit for one of these courses:

- MATH 4750 – Research Seminar
- MATH 4995r – Departmental Thesis
- MATH 4997r – Research
- MATH 4998r – Individual Studies
- MATH 4999r – Group Studies

Examples of research projects in the past two years are:

- Grace Cahill: *Predictive modeling of iPhone 7 charge rates using least squares curve fitting*, mentor: Dr. Aniekan Ebiefung
- Justin Hurd: *Boundary, costs and trade-offs in reserve design systems*, mentor: Dr. Lakmali Weerasena
- Anthony Fine: *Connect the Squares*, mentor: Dr. Lakmali Weerasena
- Matthew McCarver: *Applications of Lagrangian Relaxation in optimization*, mentor: Dr. Lakmali Weerasena
- Drew Woods: mentor: *Algorithm for Emergency Medical Service Vehicle Problem*, mentor: Dr. Lakmali Weerasena

Students are encouraged to present their research at the annual UTC campus-wide conference, ReSEARCH Dialogues, held each April.

2.1.6. General Education

In addition to specific program requirements, the program of study of a baccalaureate degree at UTC includes a substantial amount of focused coursework in General Education, to expand students' fundamental knowledge, abilities, and aesthetic sensibilities, leading to more enriched lives and a more comprehensive view of our global world. Through study in rhetoric and composition, the natural sciences, mathematics, statistics, the behavioral and social sciences, non-Western culture, the humanities, and the fine arts, graduates of the University of Tennessee at Chattanooga will be able to:

- Express a broad knowledge of human cultures and the physical and natural world
- Think critically, analytically, and reflectively
- Employ qualitative and quantitative information to define and defend viewpoints, solve problems, and to make informed decisions
- Communicate effectively, especially in speech and in writing; and collaborate on common tasks, and

- Synthesize information and concepts across general and specific disciplinary studies, demonstrated through the application of knowledge, skills and responsibilities to new settings and situations

The achievement of the five overall general education outcomes listed above will begin by students completing courses in the categories listed below for a total of 40-41 credit hours.

- Rhetoric and Writing (6 hours)
- Fine Arts and Humanities:
    - Historical Understanding (3 hours)
    - Literature (3 hours)
    - Thought, Values and Beliefs (3 hours)
    - Visual and Performing Arts (3 hours)
- Natural Sciences (7-8 hours)
- Behavioral and Social Sciences (6 hours)
- Mathematics (3 hours)
- Statistics (3 hours)
- Non-Western Culture (3 hours)

The Mathematics Department contributes in a fundamental way to the UTC General Education curriculum through nine MATH courses (six in mathematics and 3 in statistics) to provide several options for students to meet the requirements in these areas.

General Education: Mathematics Category

The purpose of the Mathematics category is to develop students' ability to use abstract and deductive reasoning, to think logically and creatively about quantitative phenomena, and to analyze and solve real-world and abstract mathematical problems. Upon completion of the required credit hours in this category, students will be able to:

- Explain key mathematical concepts or prove mathematical statements.
- Describe both the strengths and limitations of mathematics in addressing human problems.
- Use a variety of appropriate mathematical concepts, skills, tools, and methods to solve quantitative problems that arise in students' personal or professional lives.
- Analyze and resolve real-world and abstract quantitative situations that require critical thinking, logical reasoning, and the ability to identify assumptions and separate relevant from irrelevant information.
- Communicate, interpret, and justify results with clarity and coherence.

Currently, the following courses are certified for the Mathematics category within the General Education curriculum:

- MATH 1010 - Mathematics in Our Modern World
- MATH 1130 - College Algebra
- MATH 1710 - Precalculus I
- MATH 1830 - Calculus for Management, Life, and Social Sciences

- MATH 1950 - Calculus with Analytic Geometry I
- MATH 2160 - Mathematics for Elementary and Middle School Teachers II
- UHON 3570r - Topics in Mathematics

All of these courses are taught exclusively by the Department of Mathematics, except for UHON 3570r. The course MATH 1010 is intended for non-technical majors, while MATH 1130 and MATH 1830 are designed for students in the sciences, health sciences, social sciences, and business. MATH 2160 is the best option for education majors in the School of Education within the College of Health, Education, and Professional Studies, while MATH 1950 is a required component for all Math majors and for most students majoring in Engineering. Finally, UHON 3570r is limited to students in the Honors College.

Table 2.1 summarizes the prerequisite requirements for each of the courses satisfying the Gen Ed MATH requirement. Course prerequisites must be satisfied with a minimum grade of C.

A variety of paths are available for students who need to take MATH 1950 (Calculus with Analytic Geometry I), depending on their Math ACT score, as summarized in Table 2.2.

Thus, students with a Math ACT 24-27 who, after completing MATH 1720 or MATH 1730, move to a major that does not require MATH 1950, will still need to complete a Gen Ed Math class. This would suggest a possible need to redesign and certify at least MATH 1730 for General Education in the future.

Table 2.1. Prerequisites for Gen Ed Math courses

Course	Prerequisite
MATH 1010	None
MATH 1130	Math ACT 19 or successful completion of the Step Ahead program
MATH 1710	Math ACT 19 or successful completion of the Step Ahead program
MATH 1830	Math ACT 26, or MATH 1130, or MATH 1710
MATH 1950	Math ACT 28, or MATH 1720, or MATH 1730
MATH 2160	Math ACT 26 or MATH 2150
UHON 3570r	Honors College approval

Table 2.2. Preliminary Coursework for MATH 1950

Math ACT	Preliminary Coursework
19-23	MATH 1710 + MATH 1720 (6 hours) or MATH 1130 + MATH 1730 (7 hours)
24-25	MATH 1730 (4 hours)
26-27	MATH 1720 (3 hours)
28	none required

General Education: Statistics Category

All undergraduate students must also complete three credit hours in the Statistics category. The purpose of this category is to develop students' ability to use statistical reasoning in their personal and professional lives. Upon completion of the required credit hours in this category, students will be able to:

- Apply conceptual understandings of basic statistical principles to real-world situations
- Use statistical thinking
- Explain statistical concepts and interpret statistical results using appropriate statistical vocabulary
- Apply techniques of descriptive and inferential statistics and basic probability principles to real data
- Recognize the strengths and limitations of statistics in addressing human problems and conduct investigations of statistically accessible problems
- Use software packages for data analysis and statistical understanding

Currently, the following courses are certified for the Statistics category within the General Education curriculum:

- ENCE 2220 - Probability and Statistics for Engineering
- HHP 4010 - Measurement and Evaluation in Exercise Science and Leisure Studies
- MATH 2100 - Introductory Statistics
- MATH 3100 - Applied Statistics
- MATH 4140 - Mathematical Statistics
- MGT 2130 - Statistics for Business
- PSPS 2030 - Introduction to Statistics for Public Administration and Nonprofit Management
- PSY 2010 - Research Methodology: Introductory Statistics in Psychology
- SOC 2500 - Social Statistics
- UHON 3580r Topics in Statistics

Unlike the Mathematics category, where all classes for that category are taught by the department, several other departments offer Gen Ed Statistics courses more specifically tailored to their respective disciplines. However, as shown in Table 2.3, the majority (66.9%) of recent students are fulfilling the Gen Ed Statistics requirement by taking one of three classes offered by the Department of Mathematics.

Table 2.3. 2019-2020 Enrollment in Gen Ed Statistics Classes

Course	2019-2020 Enrollment
MATH 2100	1298
MATH 3100	25
MATH 4140	8
ENCE 2200	187
HHP 4010	0
MGT 2130	352
PSPS 2030	0
PSY 2010	245
SOC 2500	107

The UTC General Education Committee is responsible for oversight of General Education coursework and expected learning outcomes. The faculty and staff in each baccalaureate program are responsible for integrating the common general education curriculum and the associated student learning outcomes into the baccalaureate program of study. The General Education Committee reviews Gen Ed courses every five years. The committee examines course syllabi (which must include objectives and goals), tests, and other submitted materials, and compares these items to the General Education Guidelines. In addition to adhering to the overall goal of general education, courses in the Mathematics and Statistics categories are expected to:

- Develop a variety of qualitative problem-solving strategies requiring logical thinking and persistence, including the ability to pose questions, identify and analyze critical information, and test hypotheses or conclusions
- Emphasize basic quantitative concepts, such as number sense, data collection and analysis, the use and interpretation of abstract symbols, variable relationships and rates of change, distributions, graphs, and the properties of geometric shapes
- Develop some mathematical or statistical models of phenomena from the world around us
- Cultivate the use of mathematical reasoning skills
- Develop a sense of the nature of proof and its critical role in mathematical thinking, and explore the strengths and limitations of mathematics and statistics in addressing many human problems
- Foster appreciation for historical, logical, or intuitive aspects of the development of mathematical or statistical concepts
- Communicate using appropriate mathematical and statistical vocabulary and notation
- Include appropriate computational and procedural skills
- Use appropriate technology to aid in the understanding of mathematical and statistical principles and in the solution of realistic mathematical problems
- Include a writing component which counts for at least 1/5 of the grade (*writing* in this category is defined to mean the use of English sentences and symbolic representations,

such as formulas or equations, for the purpose of demonstrating students understanding of the concepts articulated in the above guidelines for this category)

- Statistics courses are expected to include development of the underlying axioms of probability as well as statistical applications

General Education Outcomes Assessment

From the UTC General Education Outcomes webpage, (at https://new.utc.edu/academic-affairs/planning-evaluation-and-institutional-research/student-outcomes-and-satisfaction/general-education-outcomes):

UTC and the other Tennessee Public Universities are required by the Tennessee Higher Education Commission to administer a comprehensive standardized test of general education content areas (writing skills, mathematics, reading, and critical thinking) to all baccalaureate graduates each academic year. Results of the general education exam are used as one criterion for awarding supplemental revenue under Tennessee's Quality Assurance Funding formula. Results are reported within the University community by program and college for use in program planning and evaluation.

Beginning with Academic Year 2010-11, UTC began using the ETS Proficiency Profile for general education outcomes assessment. Both norm-referenced and criterion-referenced, performance scores are reported below from this exam.

Results of the 2019-2020 UTC student proficiency profile are displayed in Table 2.4. There were 1616 students included in these statistics.

Table 2.4. Summary of Scaled Scores for 2019-2020 UTC Student Proficiency Profile

	Possible Range	Mean Score	95% Confidence Limits* for Mean	Standard Deviation	25th Percentile	50th Percentile	75th Percentile
Total Score	400 to 500	446.72	446 to 448	19.96	432	447	462
Skills Subscores:							
Critical Thinking	100 to 130	111.93	111 to 113	6.48	107	112	117
Reading	100 to 130	118.36	118 to 119	7.32	114	120	125
Writing	100 to 130	114.99	114 to 116	5.33	111	115	119
Mathematics	100 to 130	114.14	113 to 115	5.89	110	113	119
Context-Based Subscores:							
Humanities	100 to 130	115.1	114 to 116	6.75	110	115	120
Social Sciences	100 to 130	113.42	113 to 114	6.52	109	113	118
Natural Sciences	100 to 130	115.71	115 to 116	5.94	111	116	120

Table 2.5 Contains Results for 291 Institutions Listed in the Comparative Data Report, (found at https://new.utc.edu/sites/default/files/2021-01/Comparative%20Data%20Report%202019-20_0.pdf). This data corresponds to the period from July 2015 through June 2020.

Table 2.5. Student Proficiency Profile Scores for 2015-2020 from Other Institutions

Skill	Number of Institutions	Mean	Standard Deviation
Critical Thinking	291	110.3	2.5
Reading	291	116.4	3
Writing	291	113.2	2.4
Mathematics	291	112.6	2.7
Humanities	291	113.4	2.4
Social Sciences	291	112	2.3
Natural Sciences	291	114.2	2.4

From the perspective of these scores, math proficiency of UTC students compares to other institutions with trends similar to other skills. The scores also suggest room for improvement, in recognition that the 291 Comparative Institutions represent a broad range of higher education programs. Specifically related to the critical thinking content area, the UTC General Education Outcomes webpage states:

> *UTC also administers the Critical thinking Assessment Test (CAT) to a select group of graduating seniors each year. The CAT is a cognitive measure used to assess four broad areas of critical thinking: evaluating and interpreting information, problem solving, creative thinking and effective communication. UTC's Quality Enhancement Plan (QEP) focuses on five elements of critical thinking and the CAT is the QEP's core assessment measure because the specific skills assessed align closely with four of the five QEP student learning outcomes.*

The chart at that website providing 5 years of CAT results is shown in Table 2.6. This chart serves as a challenge to the Mathematics Department towards helping to raise the critical thinking skills of UTC students. This assessment is no longer administered.

Table 2.6. CAT Results from Years 2014-2015 through 2018-2019

Critical thinking Assessment Test (CAT)*										
	2014-15	N	2015-16	N	2016-17	N	2017-18	N	2018-19	N
College of Arts and Sciences	18.04	86	16.42	174	15.69	151	17.00	143	16.00	162
College of Health, Education, and Professional Studies	16.22	35	15.50	70	14.96	87	15.40	69	14.82	78
College of Business	15.73	28	15.46	82	16.28	86	16.67	94	16.62	77
College of Engineering and Computer Science	20.00	16	19.07	42	17.15	54	16.94	73	16.03	48
Major Not Reported	13.50	2	12.86	14	16.50	8	13.00	1	12.36	10
University Mean	17.41	167	16.21	382	15.88	386	16.61	380	15.78	375
National Mean	19.04		19.04		19.04		19.04		19.04	

*Not all departments are represented within each college
Total scores range from 0 to 38, with the possible number of points for each question varying

2.1.7. Student Internships

As indicated in Table 6.7 in Part 6, three math majors participated in internships in 2017-2018 and five had internships in 2018-2019. One example is Alexis Jackson, who joined the Unum Scholars Program while a junior undergraduate student, in January 2018. Alexis was featured in a July 1st, 2018 article in the Chattanooga Times Free Press, entitled *Internships Can Help College Graduates Fight Unemployment*, *Underemployment*. Alexis is also mentioned in the Graduate Programs section.

2.1.8. Description of Courses

Undergraduate course descriptions, from the 2020-2021 UTC Undergraduate Catalog available at http://catalog.utc.edu/index.php, are in Appendix C. A minimum grade of C must be made on any mathematics course used as a prerequisite for any other mathematics course.

2.2. Graduate Programs

2.2.1. Curriculum Review and Improvement

The Departmental Graduate Committee meets on a regular basis to discuss the state of the M.S. Mathematics program and how it might be improved. The committee collects suggestions from students and faculty and, when appropriate, develops curriculum proposals or asks the relevant faculty to do so. Any proposed changes to the program curriculum are received and discussed by the departmental Curriculum Committee prior to being brought to the attention of the Mathematics Graduate Faculty for discussion and vote. If approved, the proposed changes are submitted in the form of a formal curriculum proposal electronically via the UTC Curriculog system. Proposals are processed through a chain of approvals in the system that includes the Department Head, College Curriculum Committee, Dean of the College, the Graduate Council, the Dean of the Graduate School, and the Associate Provost for Academic Affairs.

Since the previous program review, the Department has made several changes to the graduate curriculum including:

1) A new Computational and Applied Statistics Certificate has been added. This certificate is for working professionals who wish to improve their career opportunities by expanding their knowledge in statistics and data analysis. All of the coursework in this certificate program is university accredited, recorded in a permanent transcript, and thus eligible for transfer credit to the Master of Science in Mathematics degree program.

2) New graduate-level courses (listed in Section C.3 of the Preface/History) have been added to the curriculum as faculty research interests and expertise allow. The addition of new courses increases the depth of the program as well as students' preparation for their future work or study.

2.2.2. Course Scheduling and Offerings

The curriculum has been designed to be flexible and convenient with courses offered regularly, enabling students to make timely progress towards their degrees. Students can finish their master's degrees in two years by taking three courses per semester. It may be possible to finish more quickly by taking an additional fall or spring course, or by taking a summer course(s), subject to availability. In particular, Math 5210 (core) is offered every fall, Math 5500 (core) is

offered each spring, and 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, dependent on demand. A schedule of course offerings over a 2-year cycle is available to students and advisors.

Tables 6.8 and 6.9 in Section 6 display the course offerings in the past two years and the enrollment in each. The numbers in parentheses give the enrollments of undergraduate courses that were taught simultaneously, whenever the coupling of courses occurred. There were no graduate courses taught in Summers 2018 or 2019, other than individual thesis or research courses. As data in Section 6.3 indicates, graduate course enrollment has increased during the most recent three years, including the current year.

2.2.3. Course Syllabi and Curriculum Content Reflected in Learning Outcomes

The master's degree curriculum builds upon the fundamentals taught in undergraduate courses. Graduate coursework delves deeper into conceptual aspects and requires higher order thinking in areas such as analysis, synthesis, and evaluation. Students explore derivations of mathematical approaches rather than only solving problems using those techniques.

When the master's program was created in 2009, several graduate courses were cross-listed with undergraduate sections. Faculty would prefer to teach these courses separately, to better enable students in these graduate courses to explore subjects more deeply using a wider variety of sources. Because of limitations in faculty available to teach upper-level courses and enrollment, several graduate courses are still cross-listed with undergraduate courses. University policy requires that instructors of these courses develop distinct student learning objectives (SLOs) for graduate students that reflect higher-order thinking, along with distinct assessments. For example, students enrolled in the graduate section of a cross-listed course are expected to analyze, synthesize, and evaluate course information more thoroughly than the students enrolled in the undergraduate section. With respect to assessment, graduate students are often required to conduct an independent project not required of undergraduates, write a term paper of greater depth than undergraduates, prepare and lead learning modules, and answer different and/or additional questions on exams. Graduate work is graded with greater rigor than undergraduate work. 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.

Course syllabi undergo review at Departmental and University levels to ensure that graduate sections are sufficiently more advanced than comparable undergraduate sections of cross-listed courses. Consider, for example, the cross-listed graduate/undergraduate course Math 4460/5460 Partial Differential Equations. The SLO's common to all students in the course are:

- Develop a qualitative understanding of the nature of partial differential equations (PDEs), their solutions, and their applications
- Learn how to classify second-order equations as hyperbolic, parabolic, or elliptic
- Become familiar with the heat equation, Laplace's equation, and the wave equation and how they arise from physical problems
- Have an understanding of trigonometric Fourier series and other orthogonal expansions
- Learn how to solve certain PDEs using separation of variables and Fourier Series and apply boundary conditions
- Solve the one-dimensional wave equation using D'Alembert's formula

- Understand basic properties of the Fourier transform of a function, such as its relationship to the Fourier transform of the derivative

Students in MATH 5460 are also expected to:

- Derive basic properties of the Fourier transform of a function, such as its relationship to the Fourier transform of the derivative
- Grasp the notation and language of PDEs and be able to apply the theory discussed to applied problems
- Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from PDE models
- Demonstrate the ability to integrate knowledge and ideas of PDEs in a coherent and meaningful manner and use appropriate techniques for solving related problems and for establishing theoretical results

A sampling of syllabi (as listed in Section 1.3.3) for mathematics graduate courses is on the Department SharePoint site at https://mocsutc0.sharepoint.com/:f:/s/mathematics/EpmvFm4heZRItPs4URDnnVUB2mGXEVTmiHIybvj7lTHZ5w?e=xi2euP, in the folder 'graduate_syllabi'.

2.2.4. Curriculum Structure

A. Master's Degree

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.

Core Courses

Zero (0) to nine (9) hours are required 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)

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 the four concentrations, including at least one two-semester sequence specified for that concentration. Requirements and sample course schedules for each concentration, from the Graduate Catalog (http://catalog.utc.edu), are listed in Appendix D.

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 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 outside area of application, the Graduate 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 companies in the fields of health insurance, industrial manufacturing, or engineering.

Electives

Students must complete additional elective hours as needed for 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 5910 (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 advising committee and the Graduate Committee and must submit the committee form to the Graduate School for final approval.

Program of Study

Students must submit a Program of Study during the first semester of graduate coursework. The Program of Study consists of all core courses and any electives and establishes the courses the student will take for partial fulfillment of the degree requirements. The Program of Study form is located at https://new.utc.edu/research/graduate-school/student-resources/forms.

B. Post-Baccalaureate Certificate

The Department of Mathematics offers a Post-Baccalaureate Certificate in Computational and Applied Statistics. This 15-hour certificate is based on coursework in statistics at the graduate level and is designed for students seeking to expand their statistical knowledge and enhance their expertise in data analysis beyond the undergraduate level. Students are trained with both a rigorous foundation of the theory of probability and statistics, (including regression analysis and analysis of variance), and in the computational tools needed to solve data-analysis problems. The overall objective of the certificate program is to give working professionals the necessary skills to ensure their data-based inferences and decisions are based on sound statistical principles. When only the certificate is being pursued, it must be completed in three years. For students simultaneously pursuing a graduate degree, the certificate must be completed within the timeframe allotted for the graduate degree, while a minimum of 50% of the certificate hours must be course work that is not included as part of the program of study for the graduate degree.

Admission to the Program

Individuals must have a bachelor's degree in a scientific field from an accredited institution and meet the admission requirements.

Undergraduate Coursework Required for Admission

Students are expected to have had Differential and Integral Calculus, Multivariate Calculus, Elementary Linear Algebra, and an upper-level course in Probability and Statistics. Students with a strong mathematical background are encouraged to apply to the M.S. in Mathematics with concentration in Applied Statistics.

Certificate Requirements

15 credit hours of approved coursework with grades of C or better. Students must have at least a 3.0 GPA in certificate courses in order to be awarded a certificate. Courses for the certificate are:

- Required (9 hours)
  - MATH 5130 - Introduction to Probability and Statistics
  - MATH 5131 - Statistical Computation and Programming
  - MATH 5140 - Mathematical Statistics
- One course (3 hours) chosen from
  - MATH 5160 - Applied Statistical Methods
  - MATH 5180 - Analysis of Variance
- One course (3 hours) chosen from
  - MATH 5150 - Introduction to Biostatistics
  - MATH 5170 - Nonparametric Statistics
  - MATH 5190 - Design of Experiments
  - MATH 5300 - Mathematics of Interest
  - MATH 5310 - Operations Research (Linear)
  - MATH 5320 - Operations Research (Nonlinear)
  - MATH 5330 - Optimization

C. PhD Program

While this self-study is focused on department bachelor's and master's level programs, a brief description of the Computational and Applied Mathematics concentration in the Computational Science PhD program is warranted because the students in that concentration are advised by math faculty members and the majority of coursework consists of graduate courses in math. The department has both contributed to and benefitted from this concentration since it began in 2017. Complete details for the concentration are available in the UTC Graduate Catalog, at http://catalog.utc.edu/preview_program.php?catoid=33&poid=6316&returnto=1206.

In summary, the concentration has these features:

- Separate course requirements are specified for students entering with a bachelor's degree and those with a master's degree
- Math courses must include at least six hours at the 7000-level
- At least six hours of study are chosen from 3 graduate-level computer science courses.

The resident college for the Computational Science PhD is the College of Engineering and Computer Science. Details for the program are at the Computational Science Degree Program website:http://catalog.utc.edu/preview_entity.php?catoid=33&ent_oid=1571&returnto=1206.

2.2.5. Alignment with Student Learning Outcomes

The M.S. Mathematics program has clear learning outcomes related to communication skills, mathematics knowledge, and technical writing skills that graduate students must master to successfully complete the program. The outcomes are aligned with the M.S. Mathematics curriculum as shown in Figure 2.1.

2.2.6. Engagement in Research and/or Professional Experience

As stated in Section 2.4, to fulfill the requirements of the M.S. Mathematics degree at UTC, students must complete a 36-hour program of study that includes core courses, concentration requirements, an area of application or internship, and electives. A special project (0-3 hours) or a thesis (6 hours) may be chosen to fulfill part of the elective hours. Therefore, the program of study directly engages students in research and/or professional experiences. The choice of each student should support their academic objectives, research interests, and career goals.

Students in the Pre-Professional Mathematics concentration are strongly recommended to choose the thesis option and write a master's thesis that includes an element of independent original research.

The internship option provides an opportunity to acquire specialized technical/professional knowledge by working on a project with an appropriate sponsoring organization or business. As a form of experiential learning, an internship integrates academic knowledge in mathematical science with its practical application in a workplace setting.

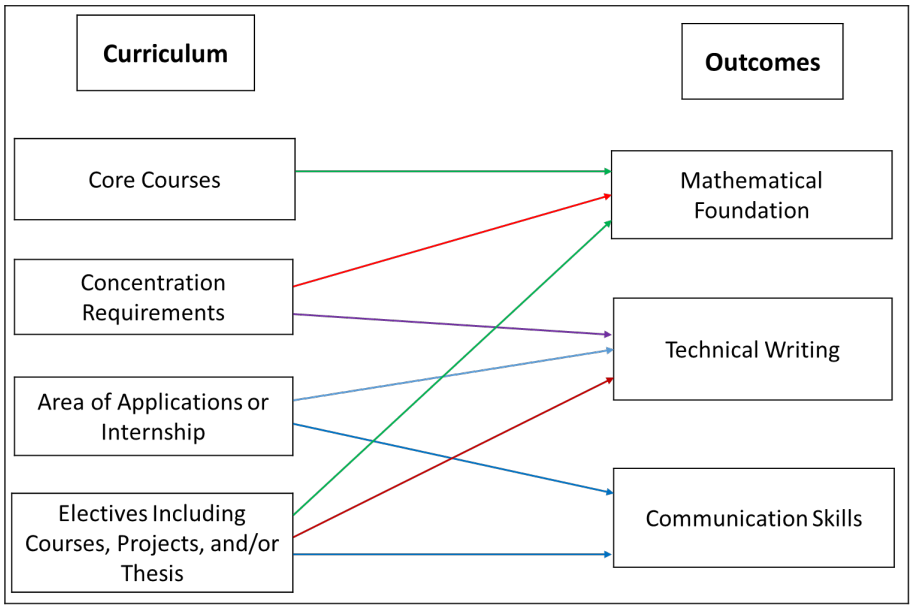


Figure 2.1. M.S. Mathematics Curriculum Alignment with Program Outcomes

2.2.7. Learning Management System and Course Modalities

Historically, most courses in the M.S. Mathematics program have been delivered in face-to-face learning mode. Graduate courses are offered at a variety of times (mid-day, late afternoon, evening) to accommodate working students, as well as those who are full-time on campus. Each course uses the Canvas learning management system (referred to locally as UTC Learn) to display class materials, create discussion boards, and post assignments. This system also helps students keep up with coursework if they are unable to attend class due to work or illness.

For several years, UTC has encouraged the expansion of online and hybrid course and program offerings. Moreover, the coronavirus pandemic has resulted in the use of a wider variety of

modalities for courses at all levels, in particular hybrid and fully online (both synchronous and asynchronous). To ensure the quality of online courses, UTC participates in the Quality Matters (QM) program and faculty who teach online courses are encouraged to have online courses certified using the Quality Matters rubric. The UTC College of Engineering and Computer Science recently asked the Mathematics Department to develop an online version of MATH 5600, Numerical Analysis I, for students in the new online M.S. program in Engineering. The first offering of that online course was in Fall 2020, and steps are underway to have the course QM certified.

Out of necessity during the pandemic, faculty members have developed and sharpened skills for teaching courses remotely. The long-term effect will be enhanced face-to-face classes and stronger potential for growth in the offering of online courses and programs as the opportunity arises.

2.2.8. Description of Courses

Graduate course descriptions, from the 2020-2021 UTC Graduate Catalog available at http://catalog.utc.edu/index.php, are in Appendix C.

Part 3: Student Experience

3.1. Undergraduate Program

3.1.1. Enrollment

Fall semester enrollment for undergraduate math majors, during the period corresponding to this review (and Fall 2020), is shown in Figure 3.1. This data is from the OPEIR Enrollment Dashboard (https://new.utc.edu/academic-affairs/planning-evaluation-and-institutional-research/institutional-dashboards/enrollment). There is a 25% increase in majors from Fall 2014 to Fall 2020.

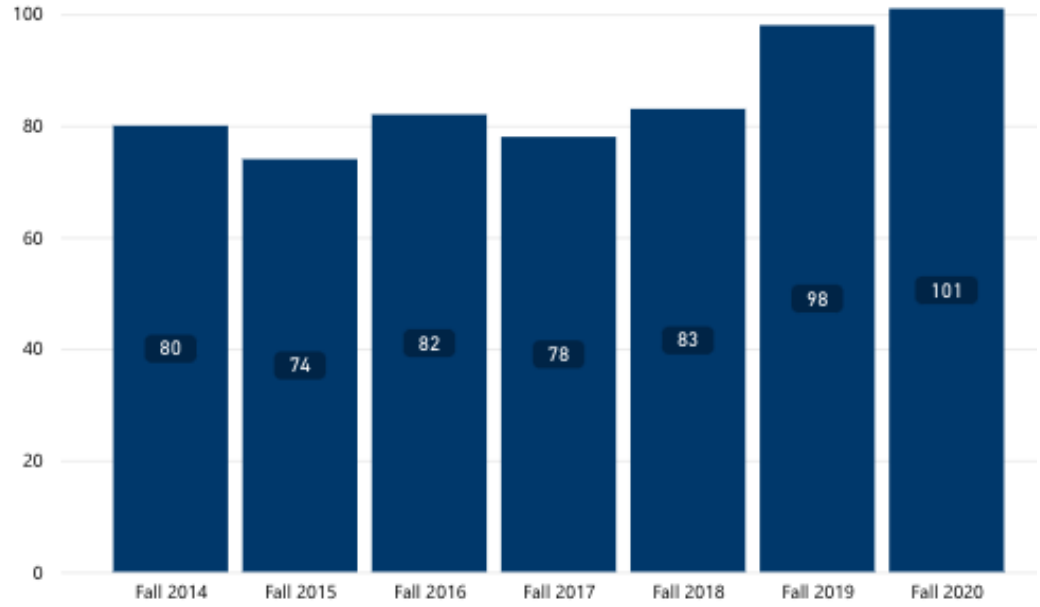


Figure 3.1. Undergraduate Major Enrollment

Diversity statistics for math majors, provided by OPEIR, are displayed in Table 3.1. There is an increase in math majors from underrepresented groups during the period in which this data was collected. Students that represent either African American, Hispanic, or multiple-race populations were 21% of the 2019-2020 cohort of math majors. In fall 2019, just under 18% of the total UTC undergraduate population were from these groups.

3.1.2. Student Evaluation

Tables 3.2, 3.3, and 3.4 display student course evaluation results from Spring 2020 for the Math Department, the College of Arts and Sciences, and the University, respectively.

This data combines undergraduate and graduate course evaluations, though it is dominated by undergraduate feedback because of the proportion of undergraduate (86.6%) to graduate students at UTC. There is not a significant variation in the responses from students in math courses compared to the broader groups of students. For all but three of the questions:

1) *I am achieving the learning outcomes of this course*
2) *I keep up with all course readings and assigned work*
3) *The way this course is delivered encourages me to be actively engaged*

Table 3.1. Undergraduate Major Enrollment by Gender and Ethnicity

Undergraduate Major Enrollment						
	2017-2018		2018-2019		2019-2020	
	Female	Male	Female	Male	Female	Male
African American		1	2	1	5	1
American Indian				1		
Asian	1			2		2
Hispanic		1	2	1	6	5
Multiple Races	1	2	4		4	1
Native Hawaiian or Other Pacific Islander						
Unknown	1			2	1	1
White	23	30	34	35	33	44
Total	**26**	**34**	**42**	**42**	**49**	**54**

results differed by 3 or less percentage points between the Department, the College, and UTC as a whole. Four percent fewer students marked *Agree* for the first question for Math than for UTC. Four percent more students marked *Strongly Agree* for question 2 for math courses than for UTC courses. Combining the *Agree* and *Strongly Agree* responses for those two questions lessens the difference in one case and does not change it for the other. Combining the *Strongly Agree* and *Agree* responses for question 3 results in a six percent difference between the department and UTC, with students in math courses feeling less actively engaged. While it should be noted that this survey corresponds to a semester when most classes were taught online, there is still a suggestion that consideration of strategies to get students more engaged in their math classes is worthwhile. Further feedback from students, relating the relevance of their employment after graduation to their degree, is in the section on Placement in Part 6.

3.1.3. Student Enrichment Opportunities

UTC math majors have a variety of opportunities to engage with peers and faculty members. Students are encouraged to attend the Department of Mathematics colloquia. Students in MATH 3820, Communicating Mathematics, receive grade credits for attending the colloquia. Students are also encouraged to present their research for the Colloquium Series. For example, PhD student Michael Corley gave a talk on his research in the Spring semester, 2019.

In Fall 2018, a joint Department of Mathematics and SimCenter Seminar was established, featuring talks for an interdisciplinary audience (focused on STEM) by distinguished scientists. This provides students with exposure to cutting edge research from a variety of STEM disciplines.

On a broader scale, there are several university-wide lecture series for students at no cost, including the Burkett Miller Distinguished Lecture Series, Globalization Lecture Series, Accounting and Finance Lecture Series, and Women's Studies Annual Lecture Series.

The Department diligently seeks to connect students with meaningful experiences beyond the classroom. 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 math undergraduate and graduate students, including presentations by Unum Insurance Company and BlueCross BlueShield of Tennessee. The Department reimburses the fees for any actuarial exam that a student has passed.

Table 3.2. Course Learning Evaluation for MATH Spring 2020

Course Learning Evaluation
Spring 2020

Mathematics

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	519	73	124	17	42	6	5	1	13	2	0	0	0	0
The course content addresses the learning outcomes of this course.	506	71	142	20	29	4	15	2	9	1	4	1	4	1
The course structure assists me in achieving the learning outcomes of this course.	475	67	112	16	59	8	13	2	25	4	12	2	13	2
I am achieving the learning outcomes of this course.	459	65	115	16	67	9	20	3	24	3	12	2	12	2
I keep up with all course readings and assigned work.	488	69	146	21	51	7	9	1	8	1	4	1	0	0
The course encourages my use of critical thinking skills.	463	65	141	20	61	9	20	3	10	1	12	2	0	0
The way this course is delivered encourages me to be actively engaged.	423	60	115	16	66	9	27	4	26	4	26	4	26	4
The instructor is willing to assist me with achieving the course learning outcomes.	496	71	112	16	33	5	24	3	13	2	11	2	14	2
The instructor provides constructive feedback on my coursework.	434	62	103	15	52	7	46	7	26	4	25	4	17	2
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	492	70	100	14	29	4	52	7	6	1	11	2	13	2

Several social events are held throughout the academic year, giving students an opportunity to interact with faculty members and learn about the mathematical interests of the faculty. The Student Relations Committee, together with Pi Mu Epsilon, sponsors the annual "Sudoku Competition" with proceeds donated to the Community Food Kitchen in Chattanooga. At the beginning of the fall semester each year, the department hosts a "Welcome to the New Academic Year" pizza party for students and faculty.

Every April 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 is very popular with students and their families.

Table 3.3. Course Learning Evaluation for College of Arts and Sciences Spring 2020

Course Learning Evaluation

Spring 2020

College of Arts & Sciences

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	6416	72	1671	19	440	5	111	1	95	1	51	1	74	1
The course content addresses the learning outcomes of this course.	6342	72	1653	19	64	5	152	2	94	1	68	1	85	1
The course structure assists me in achieving the learning outcomes of this course.	5903	67	1557	18	592	7	175	2	260	3	161	2	210	2
I am achieving the learning outcomes of this course.	5718	65	1703	19	663	7	244	3	209	2	141	2	180	2
I keep up with all course readings and assigned work.	5659	64	2056	23	765	9	153	2	112	1	55	1	58	1
The course encourages my use of critical thinking skills.	5769	65	1732	20	706	8	274	3	155	2	117	1	105	1
The way this course is delivered encourages me to be actively engaged.	5584	63	1582	18	707	8	259	3	269	3	216	2	241	3
The instructor is willing to assist me with achieving the course learning outcomes.	6210	71	1469	17	438	5	249	3	162	2	100	1	151	2
The instructor provides constructive feedback on my coursework.	5647	64	1401	16	630	7	420	5	238	3	210	2	227	3
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	6057	69	1431	16	352	4	494	6	121	1	106	1	191	2

The Department maintains several listservs to communicate with students, faculty, and others others who wish to stay in touch with the department. There are separate listservs for undergraduate students, graduate students, faculty, and "math friends" who are not officially active members of the department but who wish to know about upcoming events and news of the department. The Department maintains a presence on social media (Facebook, Instagram, Linkedin), where news about the Department is posted. A department blog (https://blog.utc.edu/mathematics) is also updated frequently and used to publish a newsletter twice a year. Newsletters are published at the website https://new.utc.edu/arts-and-sciences/mathematics/connect-us/newsletter.

Many of the faculty maintain their own webpages, where information about their teaching, research interests, and research opportunities for students are posted.

3.1.4. Student Professional Development Opportunities

In Fall 2020, a new seminar - the Advanced Modeling and Simulation Seminar - was created. This is a seminar held by the Advanced Modeling and Simulation Thrust of the SimCenter. This recently created Thrust brings together an interdisciplinary group with a common interest in applied mathematics. The seminar provides students an opportunity to present their research. Recently, an undergraduate student presented NSF-funded research at a seminar whose audience included several graduate students.

Table 3.4. Course Learning Evaluation for UTC Spring 2020

Course Learning Evaluation Spring 2020 **Total University**														
	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	12705	73	3298	19	832	5	250	1	168	1	97	1	124	1
The course content addresses the learning outcomes of this course.	12520	72	3314	19	859	5	343	2	178	1	118	1	142	1
The course structure assists me in achieving the learning outcomes of this course.	11701	67	3093	18	1193	7	390	2	454	3	282	2	361	2
I am achieving the learning outcomes of this course.	11418	65	3423	20	1255	7	501	3	372	2	222	1	283	2
I keep up with all course readings and assigned work.	11401	65	3968	23	1384	8	326	2	215	1	0	0	94	1
The course encourages my use of critical thinking skills.	11597	66	3467	20	1258	7	516	3	281	2	178	1	177	1
The way this course is delivered encourages me to be actively engaged.	11186	64	3110	18	1352	8	545	3	498	3	362	2	421	2
The instructor is willing to assist me with achieving the course learning outcomes.	12422	72	2908	17	831	5	505	3	257	1	173	1	252	1
The instructor provides constructive feedback on my coursework.	11306	65	2817	16	1210	7	825	5	461	3	340	2	379	2
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	12136	70	2873	17	696	4	891	5	225	1	172	1	314	2

Each Spring, the University organizes a research conference, called Research Dialogues, for students and faculty from all disciplines to present their research. Many math undergraduate and graduate students have presented their work there. UTC internal research grants require supported students to present their work at this conference. The UTC Office for Undergraduate Research and Creative Endeavor (URaCE) provides a variety of opportunities for students to grow professionally, including the following:

- The Summer Undergraduate Research and Professional Development Learning Institute
- The Student SEARCH Award Program, supporting UTC graduate students and undergraduate students across all disciplines who pursue original scholarship under the supervision of UTC faculty.
- Undergraduate Research Training Opportunity Program Scholars (URTOPS), open to incoming freshman, transfer, and continuing UTC students who hold a federal work-study (FWS) award.
- UTC Virtual International Undergraduate Research Internship

UTC math students also have the opportunity and are encouraged to participate in research meetings outside of UTC. Support for a student to attend or give a talk at a conference is available through the Department, as well as from faculty grants. In addition, faculty members organize meetings and conferences where the students will be exposed to cutting edge research. For example, the Department was scheduled to host the American Mathematical Society South Eastern meeting in October 2020. Due to COVID19, the face-to-face meeting has been rescheduled to take place in 2022. A virtual meeting took place during October 10-11, 2020, where department faculty members organized 4 Special Sessions and 2 Discussion Sessions on Interdisciplinary Research in Mathematics. Graduate students from the Department of Mathematics attended this meeting, and students majoring or minoring in mathematics gave talks on their research. Dr. Eleni Panagiotou organized the Workshop on Applied Knot Theory, held in October 2020. This international workshop was attended by many undergraduate and graduate students in Mathematics and other STEM disciplines. Dr. Panagiotou is a co-organizer of the meeting Novel Mathematical Methods in Material Science: Applications to Biomaterials to be held at the Banff (Canada) International Research Station in the period June 13-18, 2021.

Each year, Unum Insurance Company holds a day-long Actuarial Profession Overview meeting for interested students and faculty at their headquarters in Chattanooga. UTC math students and faculty members attended this event in Fall 2019.

3.1.5. Academic Support Services

The UTC Center for Academic Support and Advisement (CASA: https://www.utc.edu/center-academic-support-advisement/index.php) is the primary academic advising resource for freshman and other students who have not chosen a major. CASA also provides services for the broader student body, including tutoring and Supplemental Instruction.

The recently formed College of Arts and Sciences student success center, The Hub (https://new.utc.edu/arts-and-sciences/hub), provides advising support for CAS students in coordination with other advising resources on campus, including CASA and departmental advisors.

The UTC Student Support Services Office (https://new.utc.edu/enrollment-management-and-student-affairs/student-support-services) provides support for students who are (1) financially limited (according to federal income guidelines) or (2) considered first-generation college students (neither parent or guardian has a bachelor's degree), or (3) registered with the Disability

Resource Center (DRC: https://www.utc.edu/disability-resource-center/index.php). This includes tutoring, academic coaching, writing assistance and academic advising.

3.2. Graduate Programs

The majority of the discussion in this section will be focused on students in the master's program.

3.2.1. Enrollment

Figure 3.2 displays enrollment data for the master's degree program over seven fall semesters, from Fall 2014 to Fall 2020 (source: UTC OPEIR website). Master's degree program enrollments for the College and UTCT are shown in Figures 3.2 and 3.3, respectively. The department is making diligent efforts to recruit more students and find sufficient resources for financial aid. Funding is discussed further in Part 6.

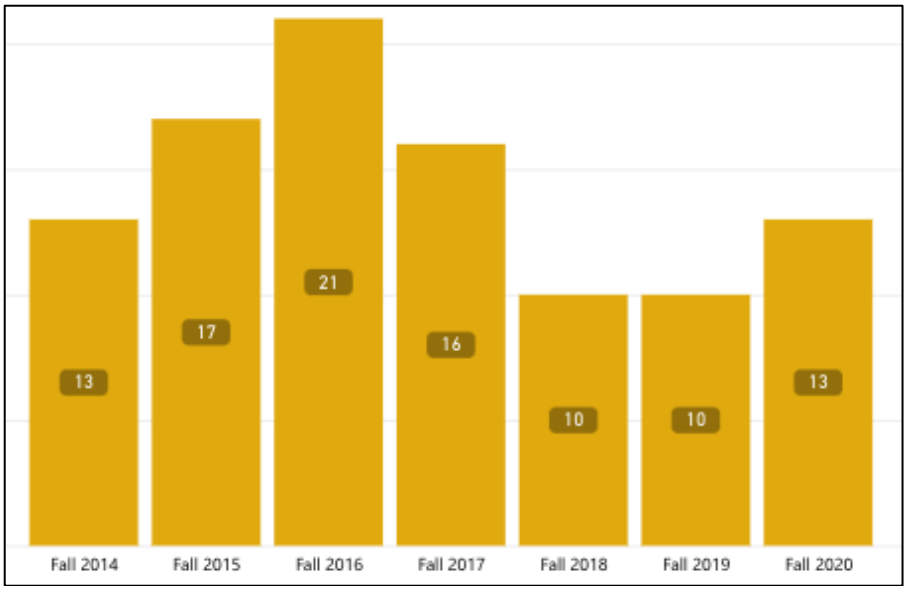


Figure 3.2. Mathematics Master's Program Enrollment

Diversity statistics, provided by OPEIR, are in Table 3.5. The OPEIR data for all graduate students at UTC indicates that 14.4% are identify as African American, Hispanic, or Multiple Races. Math master's student numbers compare favorably (30% in the most recent year) though the sample size is small.

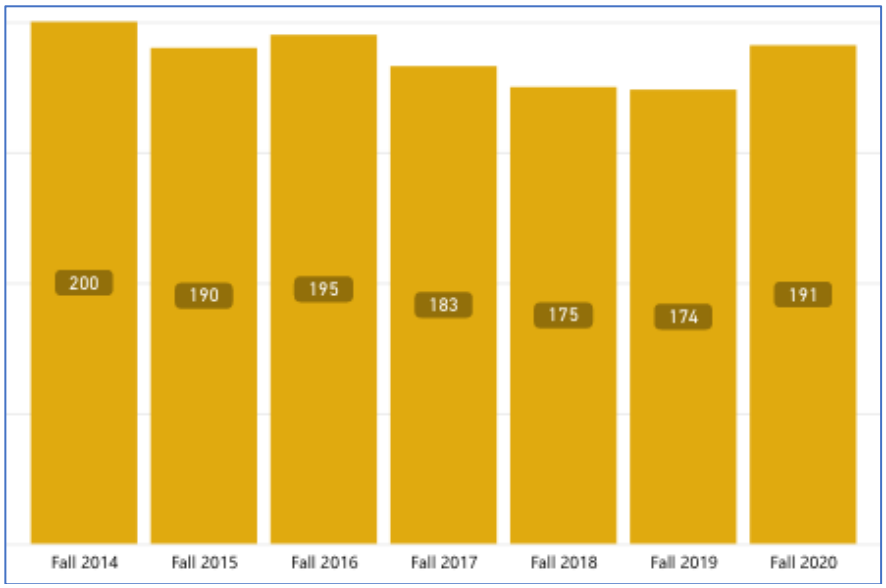


Figure 3.3. College of Arts and Sciences Master's Program Enrollment

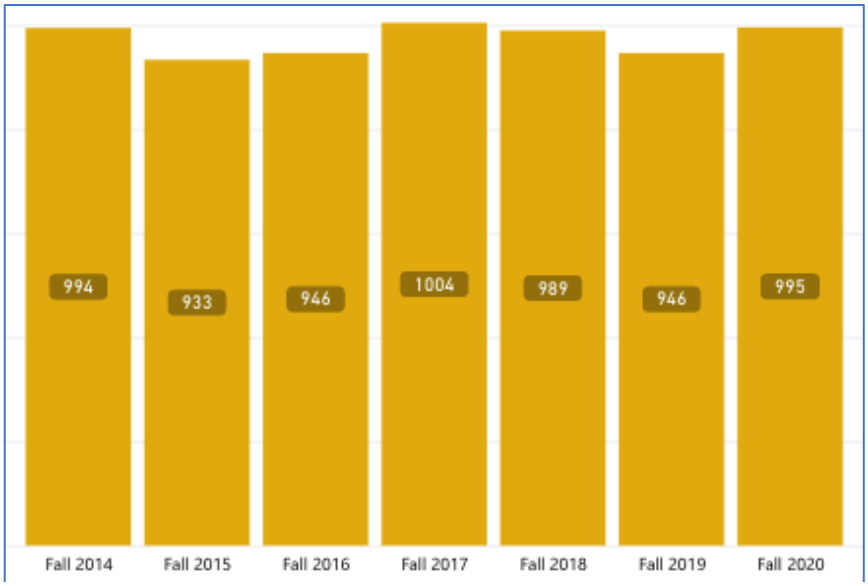


Figure 3.4. UTC Master's Program Enrollment

Table 3.5. Graduate Major Enrollment (Master's Program) by Gender and Ethnicity

Graduate Major Enrollment						
	2017-2018		2018-2019		2019-2020	
	Female	Male	Female	Male	Female	Male
African American		1		1	1	
American Indian						
Asian					1	
Hispanic	1				1	
Multiple Races	1	2		1		1
Native Hawaiian or Other Pacific Islander						
Unknown						
White	3	8	1	6	2	4
Total	**5**	**11**	**1**	**8**	**5**	**5**

Regarding the recently initiated Post-Baccalaureate Computational and Applied Statistics Certificate Program, one student has completed the certificate and a second student will soon do so. Enrollment in the Computational Science: Computational and Applied Mathematics PhD program since its beginning is shown in Figure 3.5. For comparison, in Fall 2020 there were 33 students (combined) in the three concentrations of the Computational Science PhD program. There were 328 PhD students at UTC, the majority of these in the College of Health, Education, and Professional Studies. All four of the students represented in Figure 3.5 are male, with three identifying as white and one Asian. One of those students graduated in summer 2020. Three students joined the program this year, and at least two more are expected in Fall 2021. Two of the latter five mentioned students are female. There is a strong pool of applicants for the master's program as well.

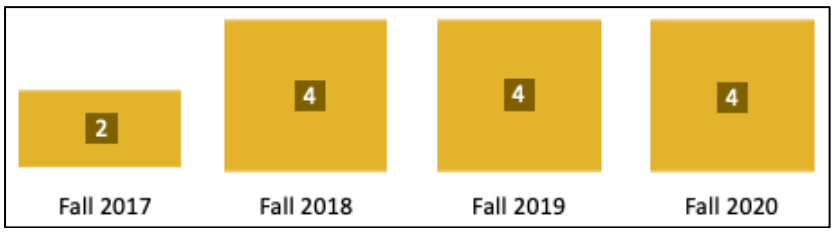


Figure 3.5. PhD Enrollment

3.2.2. Student Evaluation

Student evaluation of instruction data for graduate courses is combined with undergraduate courses in the tables presented in Section 3.1.2. As evidence of the high satisfaction among students with respect to graduate instruction, Table 3.6 displays results from student evaluations of math graduate courses, for the three instructor-related questions, in Fall 2018 and Fall 2019. The N value is 49 and the highest score possible (indicating a most favorable response) is 7.

The Math Department is developing plans to get more feedback from graduate students, including exit interviews and strengthened alumni relations. UTC is implementing the First Destination Survey with efforts to increase response rates. More data should be available in the near future.

Table 3.6. Student Ratings of Faculty in Graduate Courses Fall 18 and Fall 19

The instructor is willing to assist me with achieving the course learning outcomes.	6.7
The instructor provides constructive feedback on my coursework.	6.59
The instructor responds to my questions and emails within the time-frame stated in the syllabus.	6.74

3.2.3. Student Enrichment and Professional Development Opportunities

Most of the opportunities for student enrichment and professional development described in Sections 3.1.3 and 3.1.4 apply to both undergraduate and graduate students.

Graduate students who have completed 18 or more hours of graduate coursework in math may be given the opportunity to teach a freshman course, under the supervision of a faculty member. Three second-year master's students each taught two classes in Fall 2020 and are doing so again currently.

3.2.4. Graduate Student Recruitment

In addition to encouraging our own undergraduate students to apply to our program, the department has made a concerted effort to recruit graduate students by attending job fairs, contacting surrounding colleges and universities, and sending out flyers explaining the program to several local companies, as well as by our faculty advertising our program in colloquium talks and conference presentations.

Department faculty have an ongoing NSF Research Experience for Undergraduates (REU) program, which has attracted students to apply to our graduate program. Our faculty also participate in interdisciplinary REU programs lead by PI's in other departments.

Our faculty also work with undergraduate students from other departments, including Computer Science, Chemical Engineering, and Biology, creating a pathway to our master's program and the Computational and Applied Mathematics concentration in the Computational Science PhD program. We have also built a strong relationship with the SimCenter, which provides funding for some of our students and opportunities to attract students with strong computing backgrounds.

Faculty members are prioritizing efforts to attract underrepresented groups in STEM, including by engaging underrepresented groups in undergraduate research, something which we expect will be reflected in the long term in our master's program. Our NSF REU program has had strong minority participation. Other related programs in which our faculty members participate include the recently established URTOPS (Undergraduate Research Training Opportunity Program Scholars) program. For example, from this program two female African American students in Biology are working on mathematics projects with math faculty.

3.2.5. Duties of Graduate Students

The Department has an established set of expectations for students who obtain Graduate Assistantships. Namely, the students must work approximately 20 hours per week with a

possibility to be supported to work up to 29 hours per week. Research and instructional responsibilities are described below.

Research Duties: The student is expected to actively participate in research with their mentor. The research responsibility involves:

- Independent study of bibliography and scientific papers
- Demonstration of understanding of their study
- Regular meetings with their advisor (suggested frequency at least weakly or higher, as judged appropriate by advisor)
- Independent critical thinking
- Reliable handling of data
- Writing papers, giving presentations and posters

Teaching Duties: Typical teaching duties in one semester are:

- teach 5 to 6 one-hour recitations per week, plus a few hours tutoring in the Math Plaza
- students who have completed 18 hours of math graduate credits may be assigned to teach 2 Gen Ed classes in a semester, under the supervision of a faculty member

General information about graduate assistantships can be found on the Graduate School webpage at https://new.utc.edu/research/graduate-school/student-resources/graduate-assistantships#general.

3.2.6. Graduate Student Research

Our graduate students contribute significantly to the research mission of the department. Below is a sampling of projects/theses completed in the last few years and peer-reviewed publications, when applicable:

- Harsh Patel, Modeling Cholera Dynamics with Allee Effects, 2015, (Advisor Jin Wang)
- John Murphy, Vague convergence of spectral shift functions for periodic restrictions of one-dimensional *Schrödinger* operators, December 2016 (Advisor Roger Nichols). This work led to a publication in a peer reviewed scientific journal:
- Murphy and R. Nichols, Weak and vague convergence of spectral shift functions of one-dimensional Schrödinger operators with coupled boundary conditions, *Methods Funct. Anal. Topology* **23**, No. 4, 378–403 (2017).
- Chayu Yang, Impact of awareness programs on cholera dynamics: two modeling approaches, August 2017 (Advisor Jin Wang). This work led to the publications in peer-reviewed scientific journals:
- Yang, P. Lolika, S. Mushayabasa and J. Wang, Modeling the spatiotemporal variations in brucellosis transmission, Nonlinear Analysis: Real World Applications, vol. 38, pp. 49-67, 2017.
- Yang, X. Wang, D. Gao and J. Wang, Impact of awareness programs on cholera dynamics: Two modeling approaches, Bulletin of Mathematical Biology, vol. 79, pp. 2109-2131, 2017.
- C. Yang and J. Wang, On the intrinsic dynamics of bacteria in waterborne infections, Mathematical Biosciences, vol. 296, pp. 71-81, 2018.

- Philip Sofo, Krein's Identity and Trace Formulas for Half-Line Schrödinger Operators, May 2017, (Advisor Roger Nichols)
- Oluwakorede Ajumobi, On estimating the reliability in a multicomponent system based on progressively-censored data from Chen distribution, May 2019 (Advisor Sumith Gunasekera)
- Jeffrey Christopher, Induced path number for the complementary prism of a grid graph, May 2019 (Advisor Terry Walters)
- Lisa Nanni, Modeling zero-inflated and overdispersed count data: application to in-hospital mortality data, August 2019 (Advisor Lanni Gao)
- Daniel Plaisted, On a graph parameter related to vertex labeling and its application to minimum rank problems in graph theory, August 2019 (Advisor Francesco Barioli)
- Blake Smith, Robust optimization of linear optimization problems and an approximation approach to solve robust Knapsack Problem, May 2019 (Advisor Lakmali Weerasena)
- Conrad Ratchford, A Cholera Model Linking Between-Host, Within-Host and Environmental Disease Dynamics, 2018 (Advisor Jin Wang). This research lead to a publication in a peer-reviewed scientific journal:
- C. Ratchford and J. Wang, Modeling cholera dynamics at multiple scales: environmental evolution, between-host transmission, and within-host interaction, Mathematical Biosciences and Engineering, vol. 16(2), pp. 782-812, 2019.

3.2.7. Academic Support Services

During 2019-2020, the UTC Graduate Council developed a job description for department graduate program directors which includes their role in providing academic support for students. Specific duties in that write-up include

- [S]upporting the educational and professional success of its graduate students.
- Leading semester-by-semester reviews of graduate student progress

The position description also states that the graduate program director

- Ensures clear communication of degree requirements, milestones, expectations, and probation criteria in an annually updated handbook.
- Oversees program orientation of new graduate students and assists them in their transition to graduate student life.
- Ensures that program mentoring is functioning smoothly, regularly advises newly admitted students in arranging programs of study, and monitors their progress quarterly (or more often if warranted).
- Regularly monitors and updates, in partnership with program faculty, the progress of graduate students utilizing the advising software, approves student schedules, and ensures that students are aware of program and university requirements.
- Provides students with, at a minimum, annual communication informing them of their academic standing, e.g., face to face advising meetings and/or email updates.
- Ensures that any capstone experiences are properly conducted theses, dissertations,

internships, clinicals, and practica.

- Facilitates provision of academic and professional development support for all graduate students in the program

UTC's Graduate Student Association (GSA) offers programs geared toward opportunities for academic development of graduate students. GSA also organizes and sponsors social networking events that bring together graduate and professional students from across campus. All graduate students enrolled at UTC are automatically members of the GSA and are invited to attend events and meetings.

3.2.8. Internships

Alexis Jackson joined the Unum Scholars Program, while a junior undergraduate student, in January 2018. She worked as a Unum Scholar intern in the Short Term Disability department until June 2020 (and after completing one year of the M.S. program in Math at UTC), when she became a Unum Scholar intern in the Actuarial department. The department is planning to seek more internship opportunities for students at UNUM and other companies in the Chattanooga area, including BlueCross BlueShield of Tennessee, which is based in Chattanooga.

Part 4: Faculty

4.1 Overview

Faculty credentials are appropriate for the level at which they teach. In particular, SACSCOC guidelines are fully met. All tenured and tenure-track faculty within the department hold a doctorate, and all nontenure-track faculty members hold either a doctorate or a master's degree.

The official teaching load for university faculty is twenty-four semester hours per academic year, although exceptions may be made in consideration of alternate assignments. Due to the mathematics graduate program and research expectations for the tenure-track and tenured faculty, their teaching load is eighteen semester hours per academic year.

In the previous program review (February 2015), it was stated that the department was not regularly employing adjunct faculty. The number of adjunct faculty has risen since then from one in Fall 2014 to eight in Fall 2018 and Fall 2019. Figure 4.1 (from the UTC Institutional Dashboard) illustrates the relationship between student credit hours and type of instructor for math undergraduate courses during the past six years.

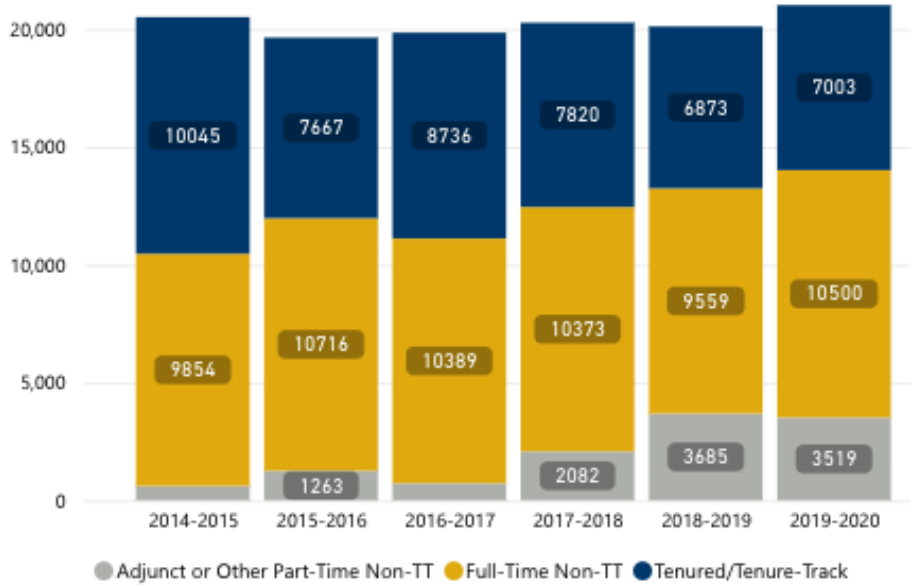


Figure 4.1. Student Credit Hours by Math Instructor Type

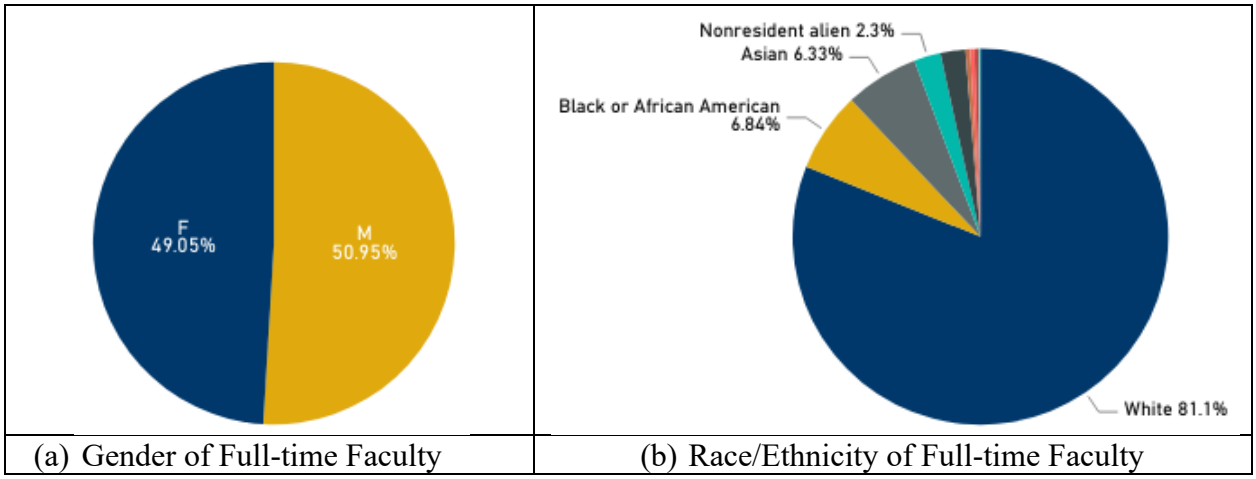
During this period there has been a net loss of 4 tenure-track or tenured faculty members. In Fall 2020, the instructor shortage was accommodated by:

- Seven adjunct faculty members teaching fifteen sections
- A visiting faculty member, hired through a Limited Duration Appointment, teaching 5 courses with one considered as an overload
- Four sections taught as overloads by fulltime faculty members

Table 4.1, provided by OPEIR, displays diversity data for department faculty, during the most recent 3 years. For comparison, university-wide numbers are in Figure 4.2. There is a clear need to improve diversity with respect to both gender and race/ethnicity in the department.

Table 4.1. Mathematics Faculty Diversity

Faculty*	2017-2018		2018-2019		2019-2020	
	Female	Male	Female	Male	Female	Male
African American	1	1	1	1	1	1
American Indian						
Asian	2	5	2	4	2	4
Hispanic						
Multiple Races						1
Native Hawaiian or Other Pacific Islander		1		1		1
Unknown						1
White	7	12	10	12	9	13
Total	**10**	**19**	**13**	**18**	**12**	**21**



(a) Gender of Full-time Faculty (b) Race/Ethnicity of Full-time Faculty

Figure 4.2 Current Diversity Data for UTC Faculty

4.2 Full-Time Faculty

A sampling of faculty curriculum vitae, representative of all faculty ranks, is on the Department SharePoint site at https://mocsutc0.sharepoint.com/:f:/s/mathematics/EpmvFm4heZRItPs4URDnnVUB2mGXEVTmiHIybvj7lTHZ5w?e=xi2euP in the folder "faculty_cv's".

4.2.1. Full-Time NTT Faculty

The Mathematics Department has a dedicated group of non-tenure-track faculty whose primary assignment is to teach, though several serve the university in roles such as coordinating a General Education course, leading summer bridge programs for new students, and chairing a department committee. The non-tenure-track faculty members in the 2020-2021 academic year are:

- Lecturers: Thandi Klingbeil. Matthew Villanueva
- Associate Lecturers: David Debter, John Gordon, Hadley Holcomb, Amanda Matthews

- Senior Lecturers: Tracy Hughes, Meg Kiessling, Angelique Ramnarine

4.2.2. Tenure-Track and Tenured Faculty

At the beginning of the review period, in the academic year 2014-2015, there were twenty tenure-track or tenured full-time faculty members at the department, specifically, twelve Full Professors, three Associate Professors, and five Assistant Professors. There were nine lecturers.

In the current (2020-2021) academic year, there are nine Full Professors, three Associate Professors, and three Assistant Professors, and one Chair of Excellence in Applied Mathematics, for a net loss of four tenure-track or tenured faculty members. Furthermore, one of the tenured faculty members in the 2014-2015 count is now working full time in the UTC Provost's Office. Because of visa restrictions imposed by the US Government in 2020, the hiring of an assistant professor for August 2020 was delayed. The arrival of this faculty member in summer 2021 will reduce the net loss to three. As of this writing, the Department has not been given permission to advertise for possible positions for 2021-2022. Three additional informational items worth noting in comparing Fall 2014 and Fall 2020 are:

- The number of math majors has increased from 80 to 101.
- The number of master's students has stayed the same at 13 (with some fluctuation during the period).
- The number of PhD students in the Computational and Applied Mathematics concentration of the Computational Science PhD program has gone from zero to four.

The tenure-track and tenured faculty members in the 2020-2021 academic year are:

- UNUM Chair of Excellence in Applied Mathematics: Jin Wang
- Professors: Boris Belinskiy, Aniekan Ebiefung, John Graef, Lingju Kong, Ossama Saleh, Terry Walters, Andrew Ledoan, John Matthews (Assistant Provost), Christopher Cox (Head)
- Associate Professors: Francesco Barioli, Roger Nichols, Lani Gao
- Assistant Professors: Lakmali Weerasena, Eleni Panagiotou, Ziwei Ma.

These faculty members are also members of the UTC *Graduate Faculty,* having applied for and been approved for teaching graduate courses and advising graduate students. The following list subdivides the current tenure-track and tenured faculty (all 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.

Applied Mathematics Concentration

- **Belinskiy, Boris**; PhD, St. Petersburg State University (Russia); Research interests: Applied Math, Differential Equation, Control Theory, Modelling. Journals: *Appl. Anal., Appl. Math. Optim., Discrete Contin. Dyn. Syst., Electron. J. Comput. Appl. Math., Electron. J. Differential Equations, Electron. J. Qual. Theory Differ. Equ., ESAIM Control Optim. Calc. Var., Int. J. Difference Equ., Inverse Problems, J. Appl. Probab., J. Differential Equations, J. Math. Anal. Appl., J. Phys. A, Math. Methods Appl. Sci., Math.*

Model. Nat. Phenom., Numer. Funct. Anal. Optim., Neural Parallel Sci. Comput., Quart. Appl. Math. Random Oper. Stoch. Equ., SIAM J. Control Optim., Stoch. Dyn., Tamkang J. Math., Wave Motion.

- **Cox, Christopher**; PhD, Carnegie Mellon University; Research interests: Numerical Methods for Partial Differential Equations, Computational Fluid Dynamics, Modeling of Filtration and Separation Processes, STEM Education. Journals: *Applied Numerical Mathematics*, *Comp. & Math. with Appls.*, *Electronic Transactions on Numerical Analysis, Filtration*, *Int. J. Control*, *International J. of Numerical Analysis and Modeling, J. Comp. Physics*, *J. of Applied Physics*, *J. of Applied Polymer Science*, *J. of Engineered Fibers and Fabrics*, *J. of Macromolecular Science: Part B-Physics*, *J. of Membrane Science*, *J. of Parallel and Distributed Computing*, *J. of the American Ceramic Society*, *Mathematical and Computer Modeling*, *Plastics, Rubber & Composites: Macromolecular Engineering*, *Separation and Purification Technology Separation Science and Technology*, *SIAM J. on Matrix Analysis and Applications*, *Water Resources Research*.
- **Graef, John**; PhD, Southern Illinois University at Carbondale; Research interests: Applied Math, Differential Equations, Difference Equations, Dynamical Systems, Biological Modeling. Journals: *Abh. Math. Sem. Univ. Hamburg, Abstr. Appl. Anal., Acta Sci. Math., Adv. Dyn. Syst. Appl., Ann. Differential Equations, Ann. Mat. Pura Appl. (4), Appl. Anal., Appl. Anal. Discrete Math., Appl. Math. Comput., Appl. Math. Lett., Arch. Math. (Brno), Atti Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. Natur. (8), Biol. Cybernet., Bull. Fac. Sci. Ibaraki Univ. Ser. A, Bull. Inst. Math. Acad. Sinica, C. R. Acad. Bulgare Sci., Canad. Math. Bull., Commu, Appl. Anal., Comm. Appl. Nonlinear Anal., Commun. Math. Anal., Commun. Pure Appl. Anal., Comput. Math. Appl., Czechoslovak Math. J., Differ. Equ. Appl., Differ. Equ. Dyn. Syst., Discrete Contin. Dyn. Syst., Dyn. Contin. Discrete Impuls. Syst. Ser. A Math. Anal., Dynam. Systems Appl., Electron. J. Differential Equations, Electron. J. Qual. Theory Differ. Equ., Fasc. Math., Fract. Calc. Appl. Anal., Fract. Differ. Calc., Funkcial. Ekvac., Hiroshima Math. J., Indian J. Math., Indian J. Pure Appl. Math., Int. Electron. J. Pure Appl. Math., Int. J. Appl. Math. Sci. Int. J. Difference Equ., Int. J. Differ. Equ. Appl., Int. J. Math. Math. Sci., Int. J. Pure Appl. Math., J. Appl. Anal. Comput., J. Appl. Math. Comput., J. Austral. Math. Soc. Ser. B, J. Differential Equations, J. Difference Equ. Appl., J. Math. Anal. Appl., Math. Biosci., Math. Bohem., Math. Comput. Modelling, Math. Mag., Math. Nachr., Math. Proc. Cambridge Philos. Soc., Math. Slovaca, Nelīnīīnī Koliv., Neural Parallel Sci. Comput., Nonlinear Anal., Nonlinear Anal. Real World Appl., Nonlinear Dyn. Syst. Theory, Nonlinear Stud., Nonlinear World, Opuscula Math., Pacific J. Math., Panamer. Math. J., Phys. Lett. B, Proc. Amer. Math. Soc., Proc. Edinb. Math. Soc., Proc. Japan Acad. Ser. A Math. Sci., Proc. London Math. Soc., Proc. Roy. Soc. Edinburgh Sect. A, Publ. Math. Debrecen, Rad. Mat., Rend. Accad. Sci. Fis. Mat. Napoli (4), Results Math., Rocky Mountain J. Math., Stoch. Anal. Appl., Topol. Methods Nonlinear Anal.*
- **Kong, Lingju**; PhD, Northern Illinois University; Research interests: Applied Math, Differential Equations, Dynamical Systems; Biomathematical Modeling. Journals: *Acta Sci. Math. (Szeged), Adv. Dyn. Syst. Appl., Appl. Anal., Appl. Anal. Discrete Math., Appl. Math. Comput., Appl. Math. Lett., Commun. Appl. Anal., Commun. Math. Anal.,*

Commun. Pure Appl. Anal., Comput. Math. Appl., Czechoslovak Math. J., Differ. Equ. Appl., Differ. Equ. Dyn. Syst., Discrete Contin. Dyn. Syst., Dyn. Contin. Discrete Impuls. Syst. Ser. A Math. Anal., Dynam. Systems Appl., Electron. J. Differential Equations, Electron. J. Qual. Theory Differ. Equ., Fract. Calc. Appl. Anal., Fract. Differ. Calc., Indian J. Math., J. Appl. Anal. Comput., J. Appl. Math. Comput., J. Difference Equ. Appl., J. Math. Anal. Appl., Math. Bohem., Math. Comput. Modelling, Math. Model. Anal., Math. Nachr., Math. Proc. Cambridge Philos. Soc., Nelīnīīnī Koliv., Nonlinear Anal., Nonlinear Dyn. Syst. Theory, Nonlinear Stud., Opuscula Math., Proc. Amer. Math. Soc., Proc. Edinb. Math. Soc., Results Math., Stoch. Anal. Appl., Topol. Methods Nonlinear Anal.

- **Matthews, John**; PhD, North Carolina State University; Research interests: Applied Math, Numerical Analysis, Granular Materials. Journals: *Discrete Math., Electron. J. Qual. Theory Differ. Equ., Inverse Problems, J. Comput. Phys., Tamkang J. Math.*
- **Nichols, Roger**; PhD, University of Alabama at Birmingham; Research interests: Applied Math, Spectral Theory, Operator Theory. Journals: *Ark. Mat., J. Anal. Math., J. Lond. Math. Soc. (2), J. Spectr. Theory, Math. Nachr., Methods Funct. Anal. Topology, Oper. Matrices, Opuscula Math.*
- **Wang, Jin**; PhD, Ohio State University; Research interests: Applied Math, Numerical Analysis; Mathematical Biology. Journals: *Appl. Anal., Appl. Math. Comput., Appl. Numer. Math., Can. Appl. Math. Q., Chaos Solitons Fractals, Commun. Comput. Phys., Discrete Contin. Dyn. Syst. Ser.Int. J. Biomath., Fluid Dynam. Res., Internat. J. Numer. Methods Fluids, J. Appl. Math. Comput., J. Biol. Dyn., J. Comput. Appl. Math., J. Comput. Phys., J. Univ. Sci. Technol. China, Math. Appl. (Wuhan), Math. Biosci., Math. Biosci. Eng., Methods Appl. Anal.*

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.*
- **Ziwei Ma**; PhD, New Mexico State University; Research interests: statistics and machine learning. Journals: *Journal of Intelligent Technologies and Applied Statistics, Springer Nature Switzerland, In Robustness in Econometrics, Springer, Cham, International Journal of Plasticity, Molecular BioSystems.*

Pre-professional Mathematics Concentration:

- **Barioli, Francesco**; PhD, University of Padua (Italy); Research interests: Matrix Theory; Graph Theory. Journals: *Ars Combin., Comm. Algebra, Electron. J. Linear Algebra., J.Combin. Math. Combin. Comput., J. Graph Theory, Linear Algebra Appl., Linear Multilinear Algebra, Rend. Sem. Mat. Univ. Padova.*
- **Ebiefung, Aniekan**; PhD, Clemson University; Research interests: Operation Research; Input-Output Analysis. Journals: *Ann. Oper. Res., Appl. Math. Comput., Appl. Math.*

Lett., J. Global Optim., J. Math. Anal. Appl., J. Math. Res., Linear Algebra Appl., Math. Programming, Optim. Methods Softw.

- **Ledoan, Andrew**; PhD, University of Illinois at Urbana-Champaign; Research interests: Number Theory. Journals: *Acta Math. Hungar., Comment. Math. Univ. St. Pauli, Funct. Approx. Comment. Math., Illinois J. Math., Integers, Int. J. Number Theory, Int. Math. Res. Not., J. Math. Anal. Appl., J. Number Theory, J. Theoret. Probab., Proc. Indian Acad. Sci. Math. Sci., Monatsh. Math., Ramanujan J., Rev. Roumaine Math. Pures Appl.*
- **Saleh, Ossama**; PhD, University of Nebraska-Lincoln; Research interests: Operations Research. Journals: *Acta Math. Sin. (Engl. Ser.), European J. Oper. Res., J. Combin. Math. Combin. Comput., J. Comb. Optim., J. Math. Anal. Appl., Linear Algebra Appl., Util. Math., SIAM J. Control Optim.*
- **Walters, Terry**; PhD, University of South Florida; Research interests: Differential Equations, Graph Theory. Journals: *Acta Math. Sin. (Engl. Ser.), ESAIM Control Optim. Calc. Var., J. Combin. Math. Combin. Comput., J. Comb. Optim., Util. Math., J. Math. Anal. Appl., Proc. Amer. Math. Soc., SIAM J. Math. Anal*
- **Lakmali Weerasena**; PhD, Clemson University; Research interests: Operation Research; Journals: *Journal of Global Optimization, Environmental Modeling & Assessment, Annals of Operations Research, Optimization Letters, Applied Mathematical Modelling, Optimization and Engineering.*
- **Eleni Panagiotou**; PhD, National Technical University of Athens (NTUA), Greece; Research interests: Topological methods. Journals: *J. Chem. Phys., Polymers, AMS Contemporary Mathematics Series, Springer Proceedings in Mathematics and Statistics, J. Phys. A: Math. Theory, Fluid Dyn. Res., Comp. Phys., Phys. Rev., Topological Fluid Dynamics II, A:Math. Theory.*

There is a healthy diversity in academic backgrounds among the graduate faculty. The research specialties in the Department fit well with the mentoring needs of our students. The official teaching load per faculty member is 24 semester hours over the course of an academic year. However, the teaching load for graduate faculty in our department is 18 hours per year. All of the graduate courses are taught by graduate faculty with a PhD in the appropriate discipline.

4.3 Scholarly Activities

Research productivity for the math faculty is very strong, especially considering that the master's program has been in existence only since 2009, the department's participation in the PhD program in Computational Science began in 2017, and also in light of the nine-hour per semester teaching load. The department's faculty research webpage (https://new.utc.edu/arts-and-sciences/mathematics/research/faculty-research) includes a listing of faculty research areas along with a record of research publications annually since 2005. The department has a travel fund that supports conference travel. This budget, combined with support provided by other sources on campus normally allows each faculty member who requests funding to present their research at least once per year at national meetings.

As illustrated by the colloquium series (https://new.utc.edu/arts-and-sciences/mathematics/special-events/colloquium) webpage, the department hosts a regular series

of research presentations on a variety of topics, including Zoom presentations from overseas during the pandemic.

Department faculty members have been very successful in obtaining grants from both external and internal sources to support their research efforts. Dollar amounts for external awards and proposals by math faculty during the past five years are listed in Table 4.2. This data comes from the UTC Office of Research and Sponsored Programs Annual Report. In comparison to other departments in the College of Arts and Sciences, the Math Department led in proposal dollars for each of the past four years, and in grant funding for the past two years.

Table 4.2. External funding attracted by MATH faculty from 2016-2020.

FISCAL YEAR	EXTERNAL AWARDS	EXTERNAL PROPOSALS
2016	$611,696	$419,609
2017	$131,880	$2,935,019
2018	$126,130	$1,567,660
2019	$324,274	$2,009,743
2020	$570,618	$2,427,314

There are several funding opportunities internal to UTC, including Faculty Development and Research Grants and SEARCH (Scholarship, Engagement, the Arts, Research, Creativity, and Humanities (SEARCH) Award) grants. A listing of internal grants secured by math faculty members is provided in Table 4.3, provided by OPEIR.

4.4 Professional Development Activities

Faculty members have a variety of on-campus opportunities for professional development, for example, offered by UTC's Walker Center for Teaching and Learning (the subject of Section 5.4).

The Walker Center facilitates a faculty grants program, described at https://new.utc.edu/academic-affairs/walker-center-for-teaching-and-learning/funding-opportunities/faculty-grants, that provides funding for full-time faculty, with proposals accepted during three rounds each year. As stated on the website:

> *Proposals are funded up to $1,500 for professional development activities and conference presentations, and up to $2,500 for research and creative activities. Proposals requiring international travel may be awarded up to $500 in additional funding.*

All new full-time faculty are required by Academic Affairs to participate in a semester-long pedagogy workshop during their first year. This workshop, for which a course release is given, is

Table 4.3. UC Foundation Support 2015-2020

Internal (UC Foundation) Support			
NAME OF AWARD/GRANT	DEPT. AWARDS	TOTAL AWARDS	DEPT. AWARDS AS % OF TOTAL AWARDS
SEARCH (previously Provost Student Research Award (joint faculty/student grants))[1] (AY15-16 through AY19-20)	2	133	1.50%
Faculty Development and Research Grants [1] (FY15-16 through FY19-20)	19	395	4.81%
Faculty Sabbaticals and Study Leaves[1] (AY15-16 through AY19-20)	1	38	2.63%
Faculty Summer Fellowships[2] (Sum15 - Sum16)	1	9	11.11%
HIP (High Impact Practice) (formerly QEP Grant Awards) (AY15-16 through AY19-20)	1	95	1.05%
QEP Faculty Awards (AY15-16 through AY19-20)	0	9	0.00%

[1]Unable to break apart undergraduate from graduate
[2] 2016 was last year for Faculty Summer Fellowships
AY - Academic Year (August through May)
FY - Fiscal Year (July through June)

run by the Walker Center. Here are some of the recent professional development activities involving math faculty.

- Several faculty members have completed or are currently enrolled in the Quality Matters online course certification process.
- Several faculty members took advantage of a variety of training opportunities, related to online course delivery, offered by the Walker Center when all UTC classes were converted to online format in the middle of the Spring 2020 semester.
- Some faculty members are participants in the Science and Math Conversations group, consisting of UTC STEM faculty who meet two or three times each semester to discuss pedagogical improvements. In the current academic year this group secured funding from the administration to have three external speakers provide webinars on active learning techniques for math and chemistry courses.
- A senior lecturer recently completed the Post-Baccalaureate Certificate in Computational and Applied Statistics.
- The Department Head participated in the AMS Chairs Workshop, January 2020, and in the TPSE (Transforming Post-Secondary Education) Math Chairs Forum (held by Zoom)

in May 2020.

The University also has a professional development leave (i.e. sabbatical) program. In 2020-2021, nine UTC faculty members are taking a one-semester sabbatical, and another is taking a sabbatical for both semesters. A math faculty member applied for and has been granted a one-semester sabbatical in 2021-2022.

4.5 Service Activities

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 a variety of service activities can be found in the sample curriculum vitae on the Department SharePoint site at https://mocsutc0.sharepoint.com/:f:/s/mathematics/EpmvFm4heZRItPs4URDnnVUB2mGXEVTmiHIybvj7lTHZ5w?e=xi2euP in the folder "faculty_cv's".

Mathematics faculty members often serve on College and University wide committees. For example, in 2018-19, two members of the Department (Barioli and Francesco) served on the UTC Faculty Senate and Lani Gao and Eleni Panagiotou were elected to the Senate in 2020. Dr. Gao served on UTC IT Governance Committee in 2018-2019. Lingju Kong is a member of the Graduate Council. In the past, faculty members have served on such major committees as the Faculty Development Grant Committee, the Faculty Research Committee, and Library Committee. In several cases graduate faculty members have served as chairpersons for these committees. In addition, several faculty members organized professional conferences (including those mentioned in Section 3.1.4). For example, in June 2020 John Graef and Lingju Kong were co-organizers of the virtual conference Recent Advances in Differential and Difference Equations and Their Applications, which included 20 presentations from 7 countries.

4.6 Evaluation of Faculty

All faculty are required to complete an annual Evaluation and Development by Objectives (EDO) report. This professional development report consists of two components: (1) Development by objectives, and (2) Annual evaluation. To complete the development by objectives portion of the EDO report, the faculty must clearly identify their objectives for the upcoming year within each of the following three standard evaluation categories:

- Instructional and advisement activities
- Research, scholarly, and creative activities
- Professional service activities

By completing the development by objectives portion of the EDO report, the department ensures that each faculty member has a professional development plan in place to delineate his or her role as a member of the department and the university.

The second component of the annual EDO process requires the faculty to complete an Individual Performance Report Form and conduct a self-assessment to review progress toward meeting their objectives from the previous year in the three standard evaluation categories. The full EDO

report is officially submitted to the department where it is then reviewed by the department head. The Individual Performance Report Form is used by the department head to gauge whether or not faculty are meeting the individual objectives they set. Upon evaluation of the full EDO report, the department head provides commentary under each of the three standard evaluation categories on both the annual evaluation and development by objectives portions.

Beginning with the 2021-2022 academic year, all UTC departments will use the Digital Measures system for faculty evaluations.

Each Fall the faculty are given the opportunity to complete the Faculty Rating of Administrators, providing feedback on administrators at all levels from department heads to the Chancellor.

Part 5: Learning Resources

5.1. Administrative Staff

At the center of the department's administrative support is Administrative Specialist Heather Heinlein. Ms. Heinlein's training (including an MBA degree) and skill set enable the department to operate with only one administrative assistant. The set of tasks in her job description would normally be assigned to more than one person. Ms. Heinlein oversees the department budget, maintains the website and all social media, and is the first point of contact for inquiries about degree programs and courses. She is also trained to set up course overrides in the Banner course management system. Ms. Heinlein is the departmental interface with facilities, IT and the Bookstore. She facilitates assignment of undergraduate teaching assistants, and trains and supervises student office assistants – a group normally consisting of two Work Study students and two others paid from department funds. Ms. Heinlein also maintains the department calendar and schedules special events whenever needed, along with handling department purchasing and inventory needs. Any growth in faculty or enrollment will justify additional administrative support.

5.2 Equipment and Facilities

Office Space

Departmental offices were moved to the third floor of Lupton Hall in Summer 2020. Figure 5.1 displays the layout of the entire third floor and Figure 5.2 shows the Math Department faculty and administrative offices. In the latter figure, offices for the department head and administrative specialist are at the lower left. The two offices labeled 'Admin Use' hold office supplies, a printer, mailboxes, and space for student workers. Two other offices are designated as a storage room and a library/visitor office. As shown in Figure 5.1, there are four classrooms and three computer labs on the third floor, shared by several departments. The department shares the breakroom, in the lower right-hand corner of the figure, with the other third floor occupants. As shown along the right side of Figure 5.1, there are 22 graduate student workstations. These are split between Math and English. The department-run Math Plaza, organized with roundtables, each with six workstations, is in the MacClellan Gym building. Office space for the Math Plaza Director and two supervisors is also included.

In addition to the aforementioned workstation areas provided for graduate students, students who are conducting research associated with the SimCenter may be given a desk in the Multi-Disciplinary Research Building.

Classrooms

The Math Department uses a variety of classrooms across the UTC campus. Many classes are held in the EMCS building. Table 5.1 lists EMCS classrooms used for math courses in Fall 2019, along with the room capacities. Most UTC classrooms have a multimedia teaching podium with a Pentium computer connected to the university network, laptop connectivity, document camera, recording and microphone capabilities, and a ceiling-mounted projector and screen.

Seating capacities for the Lupton Hall classrooms are flexible because the rooms are designed to have modifiable configurations, including those illustrated in Figure 5.1.

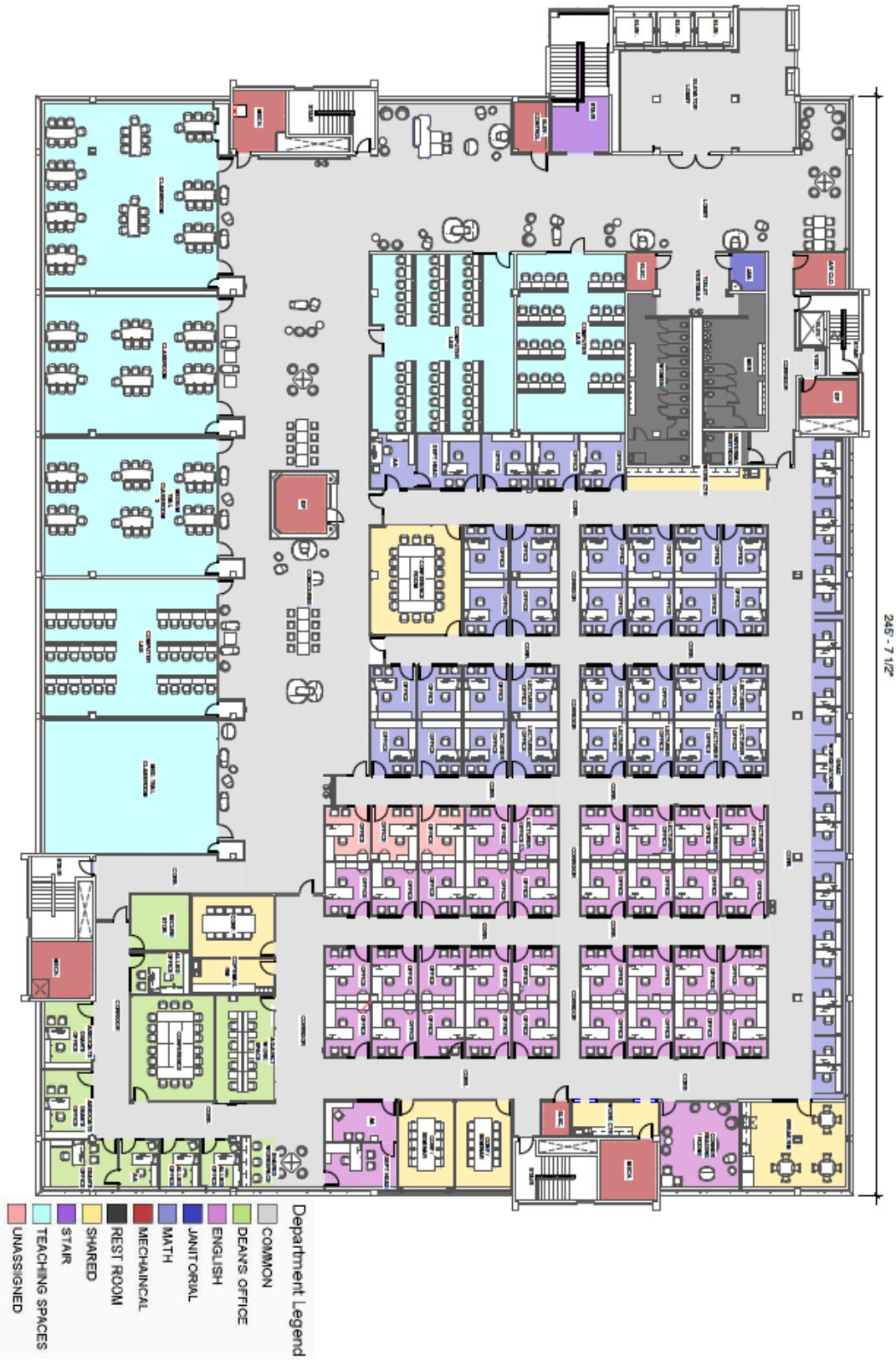


Figure 5.1. Lupton Hall Third Floor

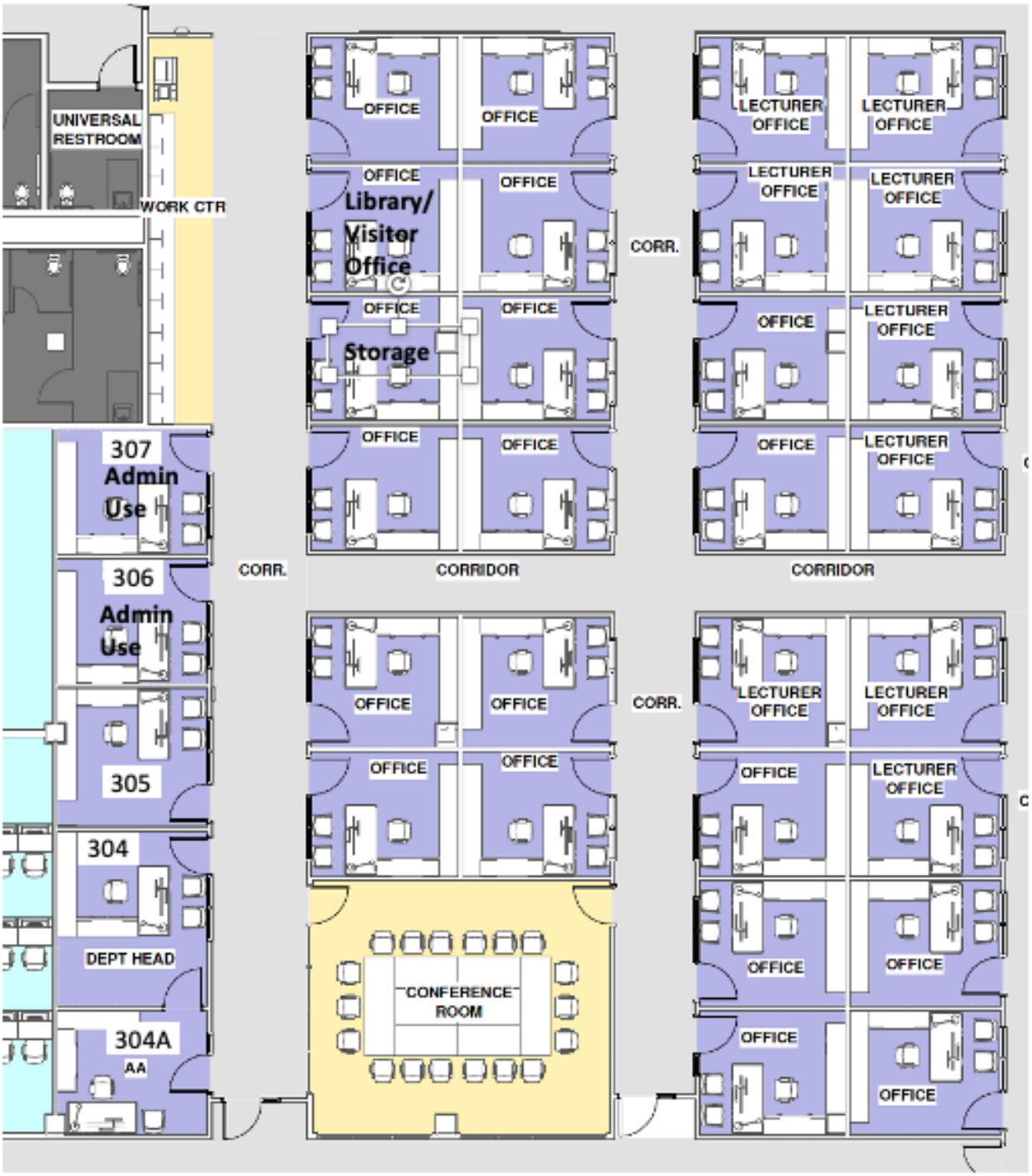


Figure 5.2. Math Department Offices

Computers and Other Technical Support

The availability of technology is sufficient for the needs of the department. All faculty have an office computer at a minimum. New faculty are provided with a computer as a part of the hiring package.

Table 5.1. EMCS Classrooms Used for Math Classes in Fall 2019

Location	Cap
EMCS 211, 216, 232, 240	30
EMCS 203, 219, 239	35
EMCS 218, 233, 238	40
EMCS 233	40
EMCS 201	100
EMCS 230	210

UTC has a computer refresh program which provides funds for the replacement of computers every four years, when qualifying faculty and staff receive a new, primary computer. The University contributes up to $1,200 towards a new device, peripherals, and accessories, with departments paying for any overages. More details about this program are at the website https://new.utc.edu/information-technology/services/computer-refresh-program.

The University provides technical support through a centralized staff of technicians who can service most computer problems. The University also has site licenses for necessary computer software such as Microsoft Office, MATLAB, SPSS, MAPLE and SAS. Software needed by mathematics faculty, but for which the University does not hold a site license, is purchased using other funds.

EPB, Chattanooga's publicly owned provider of electric power and next-generation fiber optic communications, formed a partnership with UTC in 2016 to provide 10 gigabit Internet connectivity throughout the entire campus. This facilitates internet connectivity on campus and through the broader Chattanooga community which is largely covered by a 1 gigabit fiber optic network.

The primary means for faculty to communicate outside of class with their students in their courses is through the Canvas learning management system. Canvas provides a uniform course content structure for all UTC students. Faculty typically provide syllabi, guidelines, objectives, assignments, and other course materials online. By default, only students enrolled in the class have access to course materials. Moreover, Canvas provides a means of emailing students - either individually or in groups - as well as a grade center so that students can track their own grades (for homework, tests, quizzes, etc.) as they are posted by the instructor.

Faculty and students whose research requires high performance computing are able to use facilities provided by the SimCenter, UTC's hub for HPC. Details are at https://new.utc.edu/research/simcenter/simcenter-facilities.

Other Equipment

The department owns a Risograph digital duplicator, a small photocopy machine, several small printers and a fax machine that are funded by the operating budget. Department personnel also have access to photocopy accounts through UTC's document service contractor that are used when necessary. Experience indicates that the best use of resources is normally with in-house equipment, so faculty are encouraged to use this equipment in most instances. Faculty are encouraged to post their syllabi and other written materials for classes on their Canvas sites to

avoid the expense of printing. This is reasonable as more and more students are comfortable with on-screen reading rather than using printed material.

5.3. Library Resources

A fact sheet summarizing Library services is in Appendix E.
A detailed description of library resources is in the file

Library_Support_Mathematics_FY2020_withpagenumbers.pdf

on SharePoint at
https://mocsutc0.sharepoint.com/:f:/s/mathematics/EpmvFm4heZRItPs4URDnnVUB2mGXEVTmiHIybvj7lTHZ5w?e=wypkZ7
In particular, a list of math-related journals that are available to UTC students, staff, and faculty is on pages 10-24 of the document.

5.3.1. Library General Information

The mission of the UTC Library is to support the teaching, learning, and research of UTC faculty and students through the development of collections and services to promote and enhance the university's curriculum and research endeavors. The UTC Library offers a comprehensive suite of materials, services, and programming to help the UTC community succeed. Students, faculty, and staff benefit from a number of critical resources, including:

- Books, journals, databases, and audio-visual materials available online and physical formats
- Technology, a vast array of equipment and support tools for use in the library and remotely
- Research, writing, communication, media production, and archival support
- Digital and physical spaces to pursue scholarship and research activities

The UTC Library employs 26 Librarians and 14 full-time staff members to support the students, staff, faculty, alumni, and campus community.

5.3.2. Databases, Serials, and Related Expenditures

As of June 30, 2020, the Library makes available **90,562** journal titles, including open access titles, through subscriptions to full-text resources, databases, journal packages, and individual journals. In support of the Mathematics Department, the Library has identified **2,033** related print and electronic journals, as well as **3,632** electronic proceedings.

Mathematics students and faculty have access to several large, multidisciplinary full-text journal packages and databases to support their scholarship. In addition, the Library spends **$22,688** on Mathematics-specific ongoing serial and database subscriptions (for example, MathSciNet). In total, the Library spends **$1,278,884** on all ongoing serial and database subscriptions.

As of June 30, 2020, the Library's collection consisted of **328,077** print monographs and **506,730** electronic books for a total of **834,807** titles. Of those, **41,667** bear the call numbers HA, GA, Q, and QA, which are related the study of Mathematics. The Library holds a collection of **21,105** physical audio/visual materials and **228,035** online streaming AV materials for a total of **249,140**. Of those, **77** titles are related to the study of Mathematics.

Each year, a portion of the Library's materials budget is spent to purchase books, audio-visual materials, and other one-time resources. The FY2020, the Library expenditure for one-time

resources for Mathematics was **$2,326** from a total amount of **$315,924** spent across all academic departments.

The UTC Library subscribes to journal content from the publishers listed in Table 5.2.

Table 5.2. Publishers of UTC Library Mathematics-Related Journal Subscriptions

ACM Digital Library	IEEE Xplore	ProQuest
American Mathematical Society	Institute of Physics	Purdue University Press
Cambridge University Press	JSTOR	SAGE
Duke University Press	Nature	SIAM Society for Industrial and Applied Mathematics
EBSCOhost	Oxford University Press	Springer Link
Elsevier ScienceDirect AutoLoad	Portico	SpringerLink – AutoHoldings
Galegroup	Print	Taylor and Francis Online
Hindawi	Project Euclid	Wiley Online Library

The UTC Library database subscriptions include those listed in Table 5.3 that support Mathematics.

Table 5.3. Sources of Mathematics-Related Databases available from UTC Library

MathSciNet	ProQuest Dissertations & Theses Global
ArXiv	Academic Video Online
ScienceDirect	ProQuest Academic Complete Ebook
ProQuest Central	Springer Ebooks
JSTOR	Statista
Web of Science	ScienceDirect/Elsevier Ebooks
Gale Academic OneFile	

5.3.3. Other UTC Library Services

Interlibrary Loan and Course Reserves

The Library offers interlibrary loan (ILL) and Document Delivery services at no cost to students and faculty who need to acquire materials that are not owned or accessible through the UTC Library. Patrons can submit and track progress of requests, receive email notification of materials that have arrived, and obtain articles electronically through the electronic ILL management system, ILLiad. The Library also participates in a nationwide program, Rapid ILL, that expedites article delivery to the patron. In FY2020, **3,572** ILL borrowing and document delivery requests were filled for the UTC community; of those, **57** were filled for Mathematics faculty and students.

Circulation of Physical Materials

The Library has generous circulation policies and allows semester-long borrowing of monographs for students and year-long borrowing for faculty members. In FY2020, physical monographs and audio-visual materials circulated **13,733** times, **218** of which were for Mathematics students and faculty. In addition, the Library circulates laptop computers, other tech

equipment (cameras, calculators, digital recorders, external hard drives, and more), and group study rooms to patrons. In FY2020, these resources circulated **54,148** times.

Research and Instructional Services

The Library boasts a state-of-the-art, well-used, and growing instruction program that combines traditional information literacy and research skills instruction sessions with skills-based workshops on topics ranging from preparing presentations to improving skills with Microsoft Office, Adobe, and statistical software.

The Library's Research and Instruction department develops and teaches both general and course-specific instructional sessions tailored to specific research needs or library resources. Partnering with UTC Faculty, the Instruction Team assists students who are seeking information and evaluation skills necessary to be effective 21st Century researchers. Instruction sessions are tailored specifically to the curriculum and include information literacy and research skills tied to assignment objectives. Workshops are open to any UTC student, faculty, or staff member and are developed and taught by skilled librarians and technology trainers. In FY2020, Instruction Librarians taught **436** (in-person + online) instruction sessions and workshops that reached **7,204** participants across all academic disciplines. Instruction Librarians also dedicate time to providing one-on-one individualized attention to students, faculty, and staff seeking research assistance in a particular area. In FY2020, Instruction Librarians participated in **303** individual research consultations.

Library Studio

The UTC Library Studio provides a creative space for the campus community to learn innovative technology and media creation. This well-used space provides access (in-person and from remote locations) to **24** workstations with specialized software including the Adobe Creative Suite, the AutoDesk Suite, Camtasia, and other digital design programs. In addition, the Studio provides cameras and other high-end production equipment as well as reservable spaces for students to use as they complete media projects. Last year, these resources circulated **7,975** times.

The Studio is staffed by expert Librarians and Staff who provide one-on-one consultations, small group and course-specific instruction, curriculum development, as well as a fully staffed service point to answer point-of-need questions. In FY2020, the Studio taught **217** classes (in-person + online) that reached **2,964** students across campus.

Writing and Communication Center

The Writing & Communication Center (WCC) supports writers of all backgrounds and proficiency levels with any kind of writing or communication project at any stage in the process. Peer consultants, faculty, and staff help writers brainstorm, organize ideas, develop or revise arguments, practice speeches, learn citation styles, become better self-editors, and more. In addition to in-person and online consultations, the WCC also offers workshops, a library of writers' resources, and a supportive environment for working independently.

In FY2020, the WCC conducted **1** individual consultation with a Math student related to a Math course, as well as **17** consultations for Math students for courses outside of their major. The WCC also taught **93** classes (in-person + online) reaching **1,807** students across campus.

Information Commons

The Information Commons provides students, faculty, staff, and community users with the tools and services needed to complete assignments and research. The Information Commons is open 103 hours each week and staff working at this service point fielded **3,780** research questions by phone, chat, e-mail, and in-person in FY2020.

Within the Information Commons patrons can get individualized research help at the Information Desk, complete research and assignments by utilizing one of 142 Windows and 36 Macintosh computers (in-person and from remote locations) loaded with a variety of software programs supporting all university disciplines, scan important documents, or simply print out an assignment. Comfortable open seating also makes the Information Commons a popular spot to complete work within the Library.

Departmental Liaisons

A Library Liaison program is in place where a librarian is assigned to each academic department to enhance communication and offer custom support. Librarians are matched with departments based on educational background, work experience, and subject expertise.

Typical library liaison activities involve attending departmental meetings, distributing information about new services or resources, organizing one-time purchase requests, teaching classes, maintaining the Mathematics Research Guide, creating course guides, meeting with students and faculty, and more. The current Library liaison for the Department of Mathematics is Wesley Smith.

5.3.4. Library Technology and Meeting Spaces

The UTC Library is a state-of-the-art facility that provides students, faculty, and staff with access to private and group study rooms, practice presentation rooms, conference meeting rooms, a theater classroom, and computer classrooms.

- Conference rooms are set up for hosting and attending online events; these rooms are equipped with overhead projection, podiums with Windows computers, HDMI cables for use with laptops, and white boards.
- Study rooms contain LCD monitors (HDMI and other cables are available to borrow) and whiteboards to aid in group assignments and quiet study.
- Computer classrooms contain desktop or laptop computers, presentation podiums, and built-in speakers.

Students, faculty, and staff can borrow Windows laptops, Chromebooks, high-end A/V equipment, scientific calculators, and a variety of cables, chargers, and other accessories. Multifunctional machines, which offer printing, copying, and scanning, are available throughout the Library. Additionally, the Library in coordination with the Disability Resource Center, offers a dedicated space for adaptive technology with the specialized resources (See the report). All computers in the Library (including circulating laptops) are loaded with a variety of software programs needed by students across the University.

5.4. The Walker Center for Teaching and Learning

The Walker Center's mission is to promote teaching excellence and innovation that cultivates student engagement, knowledge, and success. The Walker Center, located in the UTC Library, offers an inclusive service to help UTC faculty and students succeed in teaching and learning.

The Walker Center has ten full-time staff members and a team of Faculty Fellows, graduate assistants, and undergraduate student workers. The Center also has an advisory board of faculty and staff from across campus. Much of their work is aligned with UTC's Strategic Plan, including support of experiential learning – a high impact practice – and assisting faculty with accessible course content. The Center provides a variety of services related to teaching, learning, and academic technology integration.

- Orientations
- Faculty Support and Training
- Small-Group Instructional Diagnosis and Classroom Observation
- Learning Management System
- Quality Course Design and Curriculum Design Support (Quality Matters, Course Design Program, and Curriculum Design)
- Learning Technology Support (Zoom, Camtasia, Media site, Proctorial, YouTube/Canvas Studio)
- Accessibility
- Experiential Learning (Think Achieve)

(See https://www.utc.edu/walkercenter-teaching-learning/ for more information.)

5.5. Other Resources for Students

Counseling Center
https://new.utc.edu/enrollment-management-and-student-affairs/counseling-center

Mocs One Center (designed to provide a student-centered approach to three main areas within UTC's Enrollment Services division: Bursar, Financial Aid and Records)
https://new.utc.edu/enrollment-management-and-student-affairs/mocs-one-center

Financial Wellness Center (a campus-wide financial literacy program, funded by the Office of Financial Aid)
https://new.utc.edu/enrollment-management-and-student-affairs/financial-wellness-center

Center for Women and Gender Equity
https://new.utc.edu/enrollment-management-and-student-affairs/center-for-women-and-gender-equity

Scrappy's Cupboard (founded to address food insecurity of UTC students)
https://www.utc.edu/student-outreach/scrappys-cupboard/index.php

Office of Multicultural Affairs (committed to enhancing the academic, social, personal and professional development of all students through programming, support and activities)
https://www.utc.edu/multicultural-affairs/index.php

Center for Career and Leadership Development
https://new.utc.edu/enrollment-management-and-student-affairs/center-for-career-and-leadership-development

Part 6: Support

Unless otherwise noted, the data tables in this part were provided by UTC OPEIR. Figures with bar charts came from the UTC Institutional Dashboards.

6.1. Budget

6.1.1. Department Expenditures

Expenditures for the Department for the past five years are listed in Table 6.1. The Actual Expenditures (the first line in Table 6.1) have remained flat, especially comparing the first and last years. There is a substantial increase in the funding of adjunct instructors in recent years. The current salary budget and operating budget for the department are approximately $1.8 mil and $200,000, respectively. Expenditures for the College of Arts and Sciences and UTC are in Table 6.2 and 6.3. A comparison of the expenditures per Student Credit Hour in the three tables shows that the department cost per SCH is significantly lower – for example, in 2019-2020, the department figure is 71% of the CAS average cost per SCH and 53% of the UTC average. As an additional comparison, in the 2013-2018 English Department Review (available on the OPEIR website) the cost per SCH in 2017-2018 is $142.

Table 6.1. Math Department Expenditures

Expenditures					
	2015-16[1]	2016-17[1]	2017-18[1]	2018-19[1]	2019-20[1]
Actual Expenditures[2]	$2,602,410	$2,385,601	$2,467,297	$2,586,918	$2,600,214
Fall Adjunct Salaries[2]	$0	$5,867	$13,600	$14,400	$33,600
Spring Adjunct Salaries[2]	$0	$6,400	$12,800	$12,000	$2,400
FT Faculty FTE[2]	26.00	26.50	26.50	26.00	27.00
PT Faculty FTE	1.75	2.75	2.63	0.87	1.60
Total Major Enrollment	74	82	78	83	98
Degrees Awarded[3]	18	16	13	16	16
FT Faculty Fall SCH	9,910	10,571	10,003	8,747	9,751
FT Faculty Spring SCH	7,339	7,308	6,989	6,701	7,048
PT Faculty Fall SCH	987	397	1,230	2,429	1,944
PT Faculty Spring SCH	276	244	795	1,166	750
Fall SCH	10,897	10,968	11,233	11,176	11,695
Spring SCH	7,615	7,552	7,784	7,867	7,795
Total SCH	18,512	18,520	19,017	19,043	19,490
Expenditures per FT Faculty FTE	$100,093	$90,486	$94,102	$100,512	$97,638
Expenditures per Student Major	$35,168	$29,242	$31,970	$31,486	$26,900
Expenditures per SCH	$141	$129	$131	$137	$135

[1]FY data is July 1 - June 30

[2]data contains total department (graduate and undergraduate) results

[3]Calculated using preceding Summer, Fall and Spring terms

Table 6.2. College of Arts and Sciences Expenditures for Instruction per Student Credit Hour

Expenditures					
	2015-16[1]	2016-17[1]	2017-18[1]	2018-19[1]	2019-20[1]
Actual Expenditures[2]	$28,175,043	$29,307,238	$30,085,879	$29,934,519	$31,416,211
Fall Adjunct Salaries[2]	$424,155	$383,766	$499,604	$544,977	$605,786
Spring Adjunct Salaries[2]	$379,521	$343,997	$360,264	$403,610	$393,645
Fall SCH	90,872	91,383	92,191	92,402	92,887
Spring SCH	77,518	77,050	77,444	76,270	78,067
Total SCH	168,390	168,433	169,635	168,672	170,954
Expenditures per SCH	$172	$178	$182	$183	$190

[1]FY data is July 1 - June 30

[2]Data contains total department (graduate and undergraduate) results

Table 6.3. University Expenditures for Instruction per Student Credit Hour

Expenditures					
	2015-16[1]	2016-17[1]	2017-18[1]	2018-19[1]	2019-20[1]
Actual Expenditures[2]	$63,057,646	$67,057,473	$70,204,529	$72,378,729	$75,951,118
Fall Adjunct Salaries[2]	$1,759,537	$898,840	$1,061,491	$1,074,727	$1,168,778
Spring Adjunct Salaries[2]	$870,306	$882,020	$930,301	$966,283	$1,026,647
Fall SCH	146,000	148,069	151,798	153,142	154,997
Spring SCH	133,173	134,197	135,739	135,717	138,250
Total SCH	279,173	282,266	287,537	288,859	293,247
Expenditures per SCH	$235	$244	$251	$258	$266

[1]FY data is July 1 - June 30

[2]Data contains total department (graduate and undergraduate) results

6.1.2. Graduate Program Funding

Funding for the Graduate Program has been drastically reduced since the beginning of the Program in 2009. According to the previous M.S. program self-study, for the period Fall 2009-Fall 2014, the original plan called for a $12,000 yearly stipend per teaching assistant along with coverage of tuition and fees. In FY 2013, the University provided $152,000 for this purpose. That was reduced by $24,000 in FY 2014. In spite of further decreases in support, enrollment in the master's program increased through Fall 2016 (as shown in Figure 3.2 in Part 3), followed by a decrease in enrollment in subsequent years until enrollment rose in Fall 2020. In Fall 2019, the UTC Graduate School provided 3 assistantships each consisting of a $9,000 stipend for 9 months and an $8,450 tuition waiver. The Department supported an additional TA from its Math Fees account (corresponding to fees associated with some of the large-enrollment General Education courses).

In Fall 2020 the College allocated 1.5 assistantships to the department out of the funding provided by the Graduate School, and at this writing that is the planned allocation for FY 2022. In spite of those cutbacks, the Department found further funding last year so that an additional 6.5 units of full (nine-month) support were provided. The additional support came from the Foundation (applicable only to tuition), Math Fees and Online Fees. A stipend for three TA's was secured from funds normally used for adjunct faculty by assigning three second-year master's students to teach two freshman general education courses in the fall and spring semesters. In addition to 8 supported master's students, there were four self-funded students and two students in the Post-Baccalaureate Computational and Applied Statistics program.

It is hoped that funding similar to FY 2021 can be arranged for FY 2022. In the long run, as the graduate program experiences anticipated growth, a more sustainable and reliable means of support will be necessary.

6.2. Undergraduate Enrollment, Retention, Graduation and Placement

6.2.1. Enrollment

Tables 6.4 and 6.5 display the undergraduate enrollment in math courses during the past two academic years. There is an overall growth of 78 students from 2018-2019 to 2019-2020. College Algebra (MATH 1130) and Introductory Statistics (MATH 2100) each show significant growth in enrollment from one year to the next.

Table 6.4. Undergraduate Enrollment 1000-3000 courses

Course Enrollment* offered in Past Two Years								
COURSE INFORMATION			ACADEMIC YEAR 2018-2019			ACADEMIC YEAR 2019-2020		
NO.	TITLE	CREDIT HOURS	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING
1010	Math in the Modern World	3	48	352	153	41	342	155
1130	College Algebra	3	38	1013	266	33	1096	240
1710	Precalculus I	3		181	32		158	26
1720	Precalculus II	3		92	79		87	79
1730	Combined precalculus	4	20	77	41	11	103	50
1830	Calculus for Mgmt Life & Social Sci	3	83	470	506	74	488	519
1950	Calc with Analytic Geometry I	4	30	186	146	22	183	129
1960	Calc with Analytic Geometry II	4	14	109	115	17	104	137
2030	Discrete Math for Computer Science	3	7	39	54		58	52
2100	Introductory Statistics	3	86	568	560	88	626	590
2150	Math for Elem & Mid Sch Tch I	3		74	49		68	40
2160	Math for Elem & Mid Sch Tch II	3		34	66		38	51
2200	Elementary Linear Algebra	3	21	134	146	14	131	147
2300	Math Models, Functions and App	3		4				13
2450	Intro to Different and Diff Equations	3	32	90	86		106	73
2560	Cal with Analytic Geometry III	4	14	44	65	31	41	52
3000	Intro to Logic and Proof	3		25	23		26	31
3100	Applied Statistics	3			26		16	
3310	Introduction to Mathem AS	3						29
3510	Intro to Analysis I	3		26			17	
3820	Communicating Mathematics	3			14			10
	Total		393	3518	2427	331	3688	2423

Table 6.5. Undergraduate Enrollment 4000 courses

Course Enrollment* offered in Past Two Years								
COURSE INFORMATION			ACADEMIC YEAR 2018-2019			ACADEMIC YEAR 2019-2020		
NO.	TITLE	CREDIT HOURS	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING
4010	Basic Concepts of Geometry	3			9			
4050	Intro to Point Set Topology	3		4				
4130	Intro to Probability and Statistics	3		15			12	
4140	Mathematicsl Statistics	3			10			8
4160	Appllied Statistical Methods	3						9
4170	Nonparametric Statistics	3			2			
4200	Linear Algebra & Matrix Theory	3		20			25	
4250	Modern Alegra I	3		5			5	
4270	Elementary Number Theory	3						8
4300	Mathematics of Interest	3					6	
4310	Operations Research I	3		7				
4320	Operations Research II	3			2			
4350	Mathematics of Finance	3			8			10
4450	Ordinary Diff Equations	3		5				
4460	Partial Differential Equations	3			12			11
4510	Intro to Analysis II	3			7			2
4570	Complex Analysis	3					4	
4600	Numerical Analysis I	3			21			
4700	Techniques of Applied Math	3		7				
4720	Introduction to Graph Theory	3					5	
4750	Research Seminar	1	1					
4995R	Departmental Thesis	3					2	2
4997R	Research	9						1
	Asymptotic Analysis	3					1	
	Advanced Matrix Theory	3						1
	Analysis of Variance	3		5				
	Calculus of Variations	3					2	
4999/	Functional Analysis	3						2
4999R	Intro to Biostatistics	3					1	
	Numerical Analysis I	3		4			2	
	Vector Analysis	3			2			
	Real Analysis	3		1			1	
	Stat Comp & Programming	3					1	
	Total		1	73	73	0	67	54

6.2.2. Retention and Graduation

Figures 6.1, 6.2, and 6.3 contain undergraduate retention and graduation data for Math majors, College of Arts and Sciences majors, and all UTC majors, respectively. The 'Not retained' values for Math majors compare favorably to values for CAS and UTC except for the final year.

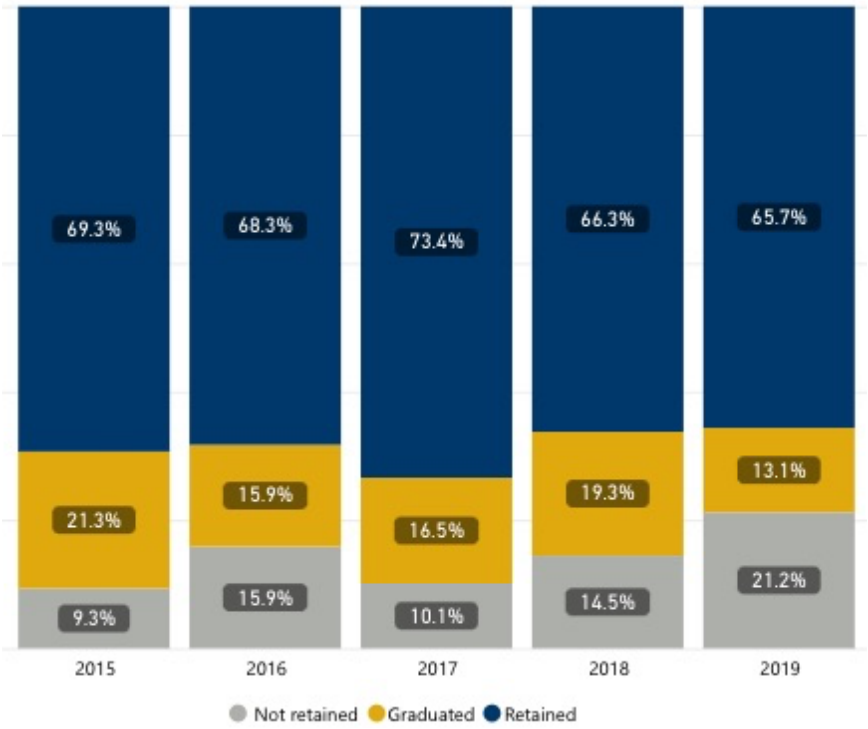


Figure 6.1. Math Major Retention and Graduation Data

The 'Retained' numbers for Math majors compare favorably to the CAS and UTC values across all years. Hopefully the 2019 'Not retained' value for Math is a one-time occurrence. This will be monitored and addressed going forward.

6.2.3. Placement

Employment and placement data for math majors, along with results for the College and UTC for comparison, are listed in Tables 6.6 and 6.7. This data corresponds to the years 2017-2018 and 2018-2019. The sample size for math majors is relatively small (e.g. N=10 for the 'Primary Status after Graduation' question over two years). The results in Table 6.6 indicate that math majors (albeit relatively few) have good success at finding employment. Data in Table 6.7 suggest that math majors are getting experiential learning and internship opportunities, though there is room for growth in the numbers.

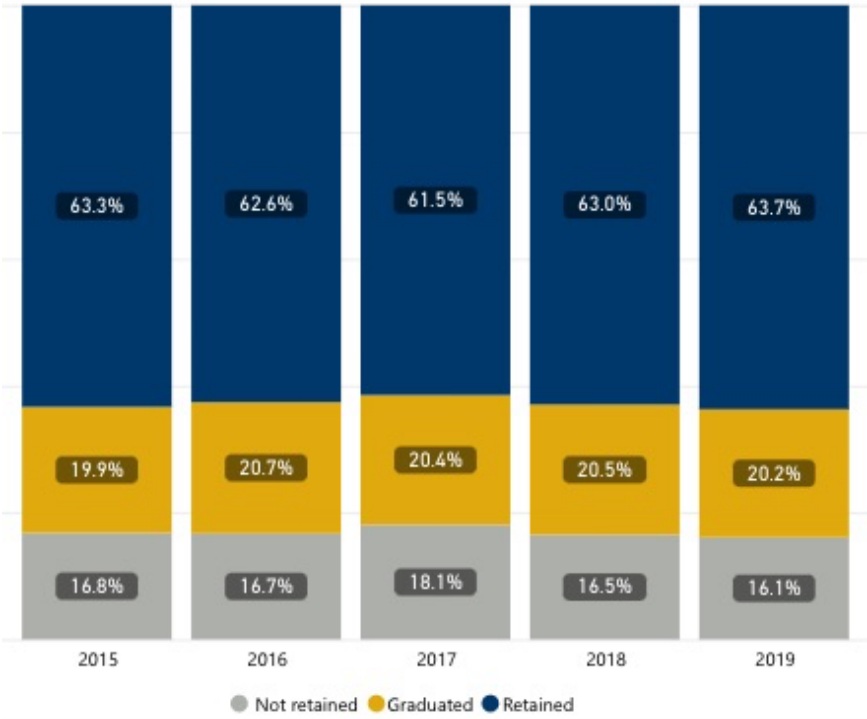


Figure 6.2. College of Arts and Sciences Majors Retention and Graduation Data

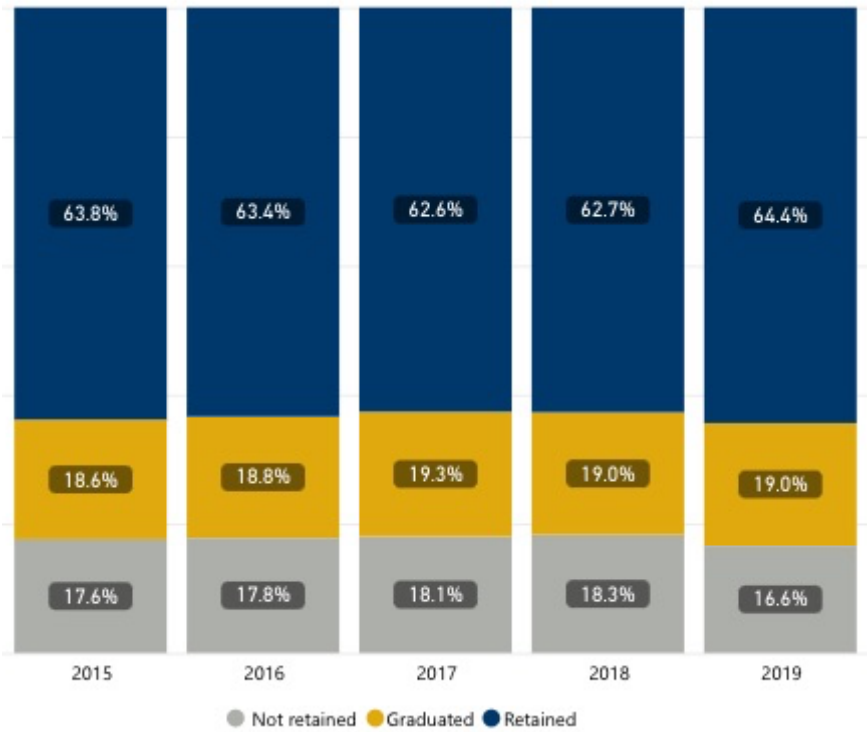


Figure 6.3. University Retention and Graduation Data

Table 6.6. Undergraduate Employment and Placement Part 1

Employment and Placement												
	University results for all Bachelor's degrees				College results for all Bachelor's degrees				Department/Program results			
Primary Status after Graduation	Summer 2017-Spring 2018 (N)	%	Summer 2018-Spring 2019 (N)	%	Summer 2017-Spring 2018 (N)	%	Summer 2018-Spring 2019 (N)	%	Summer 2017-Spring 2018 (N)	%	Summer 2018-Spring 2019 (N)	%
Employed full time	354	67.9	163	72.1	37	48.7	37	52.9	4	80.0	3	60.0
Employed part time	35	6.7	7	3.1	8	10.5	5	7.1	1	20.0	0	0.0
Pursuing another degree	50	9.6	24	10.6	10	13.2	13	18.6	0	0.0	1	20.0
Seeking employment	57	10.9	26	11.5	10	13.2	11	15.7	0	0.0	1	20.0
	521		226		76		70		5		5	
Relevance of job to degree	Summer 2017-Spring 2018 (N)	%	Summer 2018-Spring 2019 (N)	%	Summer 2017-Spring 2018 (N)	%	Summer 2018-Spring 2019 (N)	%	Summer 2017-Spring 2018 (N)	%	Summer 2018-Spring 2019 (N)	%
Yes, my position is directly related to my degree program	185	60.7	47	43.1	12	33.3	13	32.5	2	40.0	3	100.0
Yes, my position is somewhat related to my degree program	71	23.3	38	34.9	12	33.3	14	35.0	1	20.0	0	0.0
No, my degree program has little relevance to my current position.	32	10.5	13	11.9	8	22.2	6	15.0	2	40.0	0	0.0
	305		109		36		40		5		3	

N=The number of respondents during the Academic Year (Summer, Fall, Spring)
If N is less than 5 then the two years are combined

6.3. Graduate Enrollment, Retention, Graduation and Placement

6.3.1. Enrollment

Tables 6.8 and 6.9 provide enrollments in math graduate courses during the past two years, fall and spring semesters. The majority of these courses are offered as split 4000/5000 courses. The enrollment in graduate sections grew from 63 in the FY 19 to 87 in FY 20. There were no 5000 courses offered in the 2018 and 2019 Summers. In Summer 2020, the course Linear Algebra and Matrix Theory was offered as a mixed undergraduate/graduate class, MATH 4200 (11 students) and MATH 5210 (2 students).

The enrollment in graduate courses continues to grow. In FY 2021, the fall and spring semester graduate course enrollments total 114 students, with 7 sections offered as separate sections and 10 offered joint with undergraduate sections.

Table 6.7. Undergraduate Employment and Placement Part 2

Employment and Placement												
	University results for all Bachelor's degrees				College results for all Bachelor's degrees				Department/Program results			
Did you complete an internship	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**
Yes	234	92.9	98	58.7	29	93.5	32	51.6	3	100.0	2	40.0
No	18	7.1	69	41.3	2	6.5	30	48.4	0	0.0	3	60.0
	252		167		31		62		3		5	
Did your internship lead to your current job	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**
Yes	85	90.4	38	47.5	5	62.5	12	40.0	0	0.0	1	50.0
No	9	9.6	42	52.5	3	37.5	18	60.0	0	0.0	1	50.0
	94		80		8		30		0		2	
Experiential Learning graduates participated in	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**	**Summer 2017-Spring 2018 (N)**	**%**	**Summer 2018-Spring 2019 (N)**	**%**
Formal research project	46	14.6	29	21.6	23	46.0	17	34.7	2	66.7	2	66.7
Internship	255	81.2	98	73.1	31	62.0	32	65.3	3	100.0	2	66.7
Practicum	41	13.1	24	17.9	10	20.0	12	24.5	0	0.0	1	33.3
Other	22	7.0	17	12.7	2	4.0	5	10.2	1	33.3	0	0.0

N=The number of respondents during the Academic Year (Summer, Fall, Spring)
If N is less than 5 then the two years are combined

6.3.2. Retention, Graduation and Placement

The retention and graduation data that is displayed in Figure 6.1 for undergraduate students is not available for graduate students. Department records provide the following information about students whose graduate research was mentioned in Chapter 3.

- Hersh Patel is an assistant professor at Chattanooga State Community College.
- John Murphy is an actuarial analyst at BlueCross BlueShield of Tennessee.
- Chayu Yang went on to receive a PhD from UTC in 2020, and he is currently a visiting assistant professor of mathematics at the University of Florida.
- Philip Sofo was hired as adjunct faculty at UTC for a semester.
- Jeffrey Christopher is on the faculty at the STEM School Chattanooga, one of the Hamilton County magnet schools.
- Conrad Ratchford is in the UTC Math PhD program.
- Blake Smith is a PhD student at Clemson University, South Carolina.

- Lisa Nanni and Daniel Plaisted have both recently taught as adjunct faculty for the department.

Table 6.8. Enrollment in 5000 Graduate Courses Offered in the Past Two Years. Parentheses Indicate Undergraduate Enrollment in 4000/5000 Courses.

COURSE INFORMATION			ACADEMIC YEAR 2018-2019		ACADEMIC YEAR 2019-2020	
NO.	TITLE	CREDIT HOURS	FALL	SPRING	FALL	SPRING
5050	Intro to Point Set Topology	3	3 (4)			
5130	Intro to Probability & Stats	3	4 (15)		7 (12)	
5131	Stat Computation & Programming	3	7		5 (1)	
5140	Mathematical Statistics	3		2 (10)		1 (8)
5150	Intro to Biostatistics	3			2 (1)	
5160	Applied Statistical Methods	3				7 (9)
5170	Nonparametric Statistics	3		1 (2)		
5180	Analysis of Variance	3	4 (5)			
5210	Linear Algebra & Matrix Theory	3	6 (20)		5 (25)	
5220	Advanced Matrix Theory	3				3 (1)
5310	Operations Research (Linear)	3	2 (7)			
5320	Operations Research (Nonlinear)	3		2 (2)		
5450	Ordinary Diff Equations	3	3 (5)			
5460	Partial Differential Equations	3		2 (12)		
5500	Intro to Analysis II	3		3 (7)		5 (2)
5530	Calculus of Variations	3			7 (2)	
5560	Real Analysis	3	2 (1)		3 (1)	
5570	Complex Analysis	3		4		
5590	Functional Analysis	3				4
5600	Numerical Analysis I	3	13 (4)		20 (2)	
5610	Numerical Analysis II	3		4		14
5620	Num Sol of Part Diff Eq I	3				4
5910R	Vector Analysis	3		1 (2)		
	Total Graduate Enrollment		44	19	49	38

Table 6.9. Enrollment in 5000 Independent Study/Thesis and 7000 Courses

COURSE INFORMATION			ACADEMIC YEAR 2018-2019			ACADEMIC YEAR 2019-2020		
NO.	TITLE	CREDIT HOURS	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING
5997R	Individual Studies Matrix Analysis	9			1			
5999R	Thesis	2				1		
		3			4	1		
		6	1	4				
7160	Computational Statistics	3			5			
7560	Asymptotic Analysis	3					2	
7640	Numerical Linear Algebra	3			6			
7950R	Doctoral Research	3		1	1		1	
		6				1		
		9	1	2	3	1	2	2
7997R	Individual Studies	3		1	1			
		9			1			
7999R	Doctoral Dissertation	3			1	1		1
		6				2		
		12	1	1	1		2	1

6.4. Responsiveness

The Department is committed to educating students in a manner that best prepares them for success in meeting an assortment of challenges that require advanced mathematical problem-solving skills. Examples of developments, since the last review, aimed at achieving that goal are:

- The introduction of the course MATH 4350, Mathematics of Finance, in 2017, to help students prepare for careers in the financial math and actuarial science fields. Two insurance companies with headquarters in Chattanooga (UNUM and BlueCross BlueShield of Tennessee) hire our graduates.
- Department faculty are collaborating on interdisciplinary STEM proposals with partners from other departments on campus along with Hamilton County Schools (the district in the greater Chattanooga area) and other institutions of higher learning.
- During the review period, the National Science Foundation has funded two Research Experience for Undergraduates proposals in the department, resulting in advanced training for students from across the country who often are motivated by their REU participation to pursue graduate studies.
- In Spring 2020, the ACT-Residual exam offered on campus at UTC was put on hold and the department was asked to provide a replacement for the Math ACT-R. An online placement exam was developed and continues to be used to help determine readiness for

MATH 1130. The department is currently developing placement exams for precalculus and calculus, based on a recognized need for those courses.

6.5. Alignment with Institutional Policies

The department works closely with departments and programs across the UTC campus to ensure that department policies are consistent with those at the College and University level. Recent examples of this cooperation are:

- Department bylaws are being updated, with the new version meeting all the criteria prescribed by the College of Arts and Sciences and UTC Academic Affairs.
- The Department requires that master's students and students in the Computational and Applied Mathematics concentration of the Computational Science PhD program adhere to all institutional policies regarding admission and management of graduate student progress toward graduation.

Appendices

Appendix A. Summary Recommendations from Previous Review

A.1. Undergraduate Program

Overall, what are your impressions of the program?

The undergraduate program is a very strong program with faculty with excellent credentials. They do face a number of challenges. Among them:

1. The loss of the remedial program due to external decisions required them to make significant changes in the way that they teach lower level courses.

2. The ramifications of the Tennessee Promise program may cause further disruption in the curriculum and in the budget that will be available.

3. The department is undergoing a significant transition. There have been a number of retirements in recent years and there may be many more in the next few years.

4. Although it seems to be improving there was some indication that the perception of the department within the university is generally somewhat negative.

5. There may be some disagreement within the department about the relative importance of teaching versus research.

6. The morale among the faculty may be low. Part of this may result from the meager salary increases and the unfilled positions that have taken place over the last few years.

7. There is a plan to move the STEM center out of the college to the College of Education. One of the strengths of the STEM concentration is that the education of the students is tailored to the discipline that they will be teaching. If this move results in a generic education in pedagogy teaching it could seriously weaken the program.

What goals would you suggest the program set for the next five years? Please list goals in order of priority (i.e., the most important goal first, followed by the second most important goal, etc.)

1. Continue the progress that has already been made toward improving the department's image within the university. Some of this may be a matter of correcting misperceptions, but these perceptions, whether accurate or not, should be taken seriously by the entire department. It should be noted that it is not unusual for a mathematics department to have a reputation for having unnecessarily high standards in its courses. Most mathematics departments realize that, in the long run, it benefits nobody to give a student who is not prepared for the next level a passing grade. However, it is important to provide evidence that the department is making efforts to enable all students to reach their potential in their mathematics classes.

2. Take a serious look at the teaching of College Algebra and of all lower-level courses. Experiment with some alternative methods of teaching in some sections of these courses that might improve the success rate. If these experiments are successful and can be documented as being successful, make the case for more resources to implement these methods in all the sections.

3. Explore additional ways to encourage, support, and reward successful teaching, particularly among the new faculty. For example, there is an existing program that offers release time to

faculty to concentrate on their research. Consider a similar program that would offer release time to faculty who would like to develop an innovative approach to teaching. Encourage any new faculty to apply for a Project Next fellowship.

4. Make a strong case that the STEM center should remain in the college and that, in general, those who are training to be mathematics teachers are best served when taught by faculty who understand mathematics.

5. In cooperation with the administration develop a replacement plan for new equipment that will allow the department to plan for the future.

6. Investigate ways to adequately support existing faculty and to fill current and future unfilled lines with highly qualified faculty.

7. Seek ways to get additional support to relieve existing support staff.

How can the program work to achieve these goals over the next five years?

Some of the goals mentioned above can be done with existing resources. There may be a possibility of external funding to help, at least in the early stages. However, it is likely that, at some point, there will need to be additional resources. If a strong case can be made that these additional resources will result in increased retention rates among students, then the administration should view these additional resources as a wise investment of scarce dollars that will pay off in the future.

A.2. Graduate Program

Overall, what are your impressions of the program?

It is a solid nascent graduate program that is poised for growth. The challenges involve strengthening the recruitment program and finding adequate funding for the teaching assistantships. It should be noted that an increase in the number and quality of teachings assistants would benefit not only the graduate program, but the undergraduate program as well, since teaching assistants provide an important resource for the teaching of undergraduates.

An additional challenge results from the overall budgetary situation that has resulted in meager increases in salary and unfilled positions. This puts a strain on the morale of the department.

What goals would you suggest the program set for the next five years? Please list goals in order of priority (i.e., the most important goal first, followed by the second most important goal, etc.)

1. Determine how to take advantage of the expected increase in demand for qualified community college mathematics teachers that should result from recent changes in state law.

2. Consider whether or not the department wants to pursue the development of an online graduate program.

3. Fill existing and future vacant positions with highly qualified and well-rounded faculty.

4. Find a way to reward existing faculty with salary increases and additional support.

5. Monitor the existing curriculum and identify any improvements that should be made based on the experience of the early years of the program.

How can the program work to achieve these goals over the next five years?

Goals 1 and 2 can at least be started with minor increases in resources. If it is determined that the department does wish to pursue an online graduate program then there may be additional equipment needs and it will be necessary to support those faculty who are willing to do the necessary course development, preferably with course releases. This might also involve other forms of faculty development such as travel to workshops.

Goals 3 and 4 will definitely require additional resources but they should be important priorities for the institution.

Goal 5 is something that may already be taking place, but will require no additional resources

Appendix B. Clear Path Undergraduate Curriculum Descriptions

B.1. Actuarial Science Concentration

CLEAR PATH for ADVISING – 2016-2017

Mathematics: Actuarial Science, B.S.

Please see the Courses section of this catalog for complete course descriptions.

First Year – 31-32 Hours			
• Meet with Academic Advisor two times each semester.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH 1950 (Mathematics)	4	MATH 1960	4
CPSC 1100	4	MATH 2200	3
ENGL 1010 or 1011	3-4	ENGL 1020 or HIST 2100	3
FAH: Historical Understanding	3	FAH: Thought, Values and Beliefs	3
Elective	1	FAH: Literature	3
	15-16		16
Second Year – 32 Hours			
• Using MyMocsDegree, create course plan for your remaining degree requirements.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH 2450	3	MATH 2560	4
ECON 1010 (Behavioral Social and Sciences)	3	MATH 3000	3
ACC 2010	3	ECON 1020 (Behavioral and Social Sciences)	3
FAH: Visual and Performing Arts	3	ACC 2020	3
Natural Science with Lab	4	Natural Science without Lab	3
	16		16
Third Year – 30 Hours			
• Participate in study abroad, leadership opportunities, service learning, civic engagement, internships, research projects, and other learning opportunities.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH 4130	3	MATH 4140 (Statistics)	3
MATH 3510	3	FIN 3370	3
MATH 3820	3	ECON 3250	3
MATH 4200	3	THSP 1090 (or THSP 2090)	3
ECON 3240	3	Elective (ECON 4600)	3
	15		15
Fourth Year – 26-27 Hours			
• Complete your Graduation application with the Records Office.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH 4600	3	MATH 4160 or 4310 or 4320	3
FIN 3020	3	MATH Elective (3000-4000 Level)*	3
MATH Elective (3000-4000 Level)*	3	MATH Elective (3000-4000 Level)*	3
Non-Western Culture	3	Elective	3
Elective	2	Elective	0-1
	14		12-13

*Math 4160, 4510 and 4300 are strongly recommended Math Electives if not taken as a required course. MATH 3100 will not satisfy the requirement.

Completed:			
Graduation Requirements:	**Hrs**	**Degree Requirements:**	**Hrs**
120 Total Hours		28-29 General Education Hours	
39 Upper Division (3000-4000) Hours		82 Program (Major) Hours	
30 Hours at UTC		Minor *(Not Required)*	
60 Hours at 4-year Institution		8-9 Elective Hours	
		Foreign Language *(Not Required)*	

B.2. General Mathematics Concentration

CLEAR PATH for ADVISING – 2016-2017

Mathematics: General Mathematics, B.S.

Please see the Courses section of this catalog for complete course descriptions

First Year – 30-31 Hours			
• Meet with Academic Advisor two times each semester.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH 1950 (Mathematics)	4	MATH 1960	4
CPSC 1100	4	MATH 2200	3
ENGL 1010 or 1011	3-4	ENGL 1020 or HIST 2100	3
FAH: Historical Understanding	3	FAH: Thought, Values and Beliefs	3
Elective	1	FAH: Literature	3
	15-16		16
Second Year – 32 Hours			
• Using MyMocsDegree, create course plan for your remaining degree requirements.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH 2450	3	MATH 2560	4
Natural Science with Lab	4	MATH 3000	3
FAH: Visual and Performing Arts	3	Natural Science without Lab	3
Behavioral and Social Sciences	3	Behavioral and Social Sciences	3
Approved Elective or Minor Course	3	Approved Elective or Minor Course	3
	16		16
Third Year – 30 Hours			
• Participate in study abroad, leadership opportunities, service learning, civic engagement, internships, research projects, and other learning opportunities.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH 3100 or 4130 (Statistics)*	3	MATH Elective or 4140 (Statistics)*	3
MATH 3250 or 4200	3	MATH Elective (3000-4000 Level)	3
MATH 3510	3	THSP 1090 (or THSP 2090)	3
MATH 3820	3	Approved Elective or Minor Course (3000-4000 Level)	3
Approved Elective or Minor Course	3	Elective	3
	15		15
Fourth Year – 27-28 Hours			
• Complete your Graduation application with the Records Office.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
MATH Elective (3000-4000 Level)	3	MATH Elective (3000-4000 Level)	3
Approved Elective or Minor Course (3000-4000 Level)	3	Approved Elective or Minor Course (3000-4000 Level)	3
Non-Western Culture	3	Elective (3000-4000 Level)	3
Elective (3000-4000 Level) (MATH 4510)	3	Elective	3
Elective	3	Elective	0-1
	15		12-13

*Must take either a) MATH 3100 and a MATH Elective or b) MATH 4130 and 4140. Either MATH 3100 or 4140 will fulfill the General Education Statistics requirement.

Completed:			
Graduation Requirements:	**Hrs**	**Degree Requirements:**	**Hrs**
120 Total Hours		34-35 General Education Hours	
39 Upper Division (3000-4000) Hours		52 Program (Major) Hours	
30 Hours at UTC		0-18 Minor Hours	
60 Hours at 4-year Institution		16-34 Elective Hours	
		Foreign Language *(Not Required)*	

B.3. STEM Education Concentration

CLEAR PATH for ADVISING – 2016-2017

Mathematics: STEM Education, B.S.

Please see the Courses section of this catalog for complete course descriptions.

First Year – 29-30 Hours			
• Meet with Academic Advisor two times each semester.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
STEM 1030	2	MATH 1960	4
MATH 1950 (Mathematics)	4	MATH 2200	3
CPSC 1100	4	PSY 1010 (Behavioral Social Sciences)	3
ENGL 1010 or 1011	3-4	ENGL 1020 or HIST 2100	3
		FAH: Literature	3
	13-14		16
Second Year – 33 Hours			
• Using MyMocsDegree, create course plan for your remaining degree requirements.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
STEM 2010	3	STEM 2020	3
MATH 2300	3	MATH 2560	4
MATH 2450	3	MATH 3000	3
PHYS 2300/2300L (Natural Science)	4	PHYS 2310/2310L (Natural Science)	4
FAH: Visual and Performing Arts	3	Behavioral and Social Sciences	3
	16		17
Third Year – 30 Hours			
• Participate in study abroad, leadership opportunities, service learning, civic engagement, internships, research projects, and other learning opportunities.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
STEM 3010 (FAH: Thought, Values and Beliefs)	3	STEM 3020	3
MATH 3250 or MATH 4200	3	MATH 4010	3
MATH 3100 or MATH 4130 (Statistics)*	3	MATH Elective or MATH 4140 (Statistics)*	3
Elective	3	Non-Western Culture	3
Elective	3	Elective	3
	15		15
Fourth Year – 27-28 Hours			
• Complete your Graduation application with the Records Office.			
Fall Semester:	**Hrs**	*Spring Semester:*	**Hrs**
STEM 4010	3	STEM 4020	6
MATH 3510	3	MATH Elective (3000-4000 Level)	3
EDUC 4170 or CPSC 1000	3	Elective	3
MATH Elective (3000-4000 Level)	3	Elective	0-1
FAH: Historical Understanding	3		
	15		12-13

*Must take either a) MATH 3100 and a MATH Elective or b) MATH 4130 and 4140. Either MATH 3100 or 4140 will fulfill the General Education Statistics requirement.

Completed:			
Graduation Requirements:	**Hrs**	**Degree Requirements:**	**Hrs**
120 Total Hours		General Education Hours	
39 Upper Division (3000-4000) Hours		Program (Major) Hours	
30 Hours at UTC		Minor	
60 Hours at 4-year Institution		Elective Hours	
		Foreign Language	

Appendix C. Course Descriptions

C.1. Undergraduate Courses

MATH 1010 - Mathematics in Our Modern World

(3) Credit Hours

Introduction to the nature and techniques of mathematics for non-technical majors through applications of mathematics to the solution of historical and modern problems. Includes such topics as mathematics of finance, laws of growth, graph theory and management science, mathematics of social choice and voting schemes, probability, and basic combinatorics. Laboratory/studio course fee will be assessed.

MATH 1130 - College Algebra

(3) Credit Hours

Designed primarily for students majoring in business, the life sciences, or the social sciences who intend to take MATH 1830. Includes topics such as polynomial, rational, radical, exponential, and logarithmic functions and their graphs, factoring, solving linear inequalities, solving linear, quadratic, exponential, and logarithmic equations, slope and equations of lines, difference quotient, systems of equations, exponential growth and decay, and mathematics of finance. Mathematical models are taken from business, biology, and the social sciences. Prerequisites: MATH 1006 with a minimum grade of C or a score of 19 or higher on the ACT Math or successful completion of the Step Ahead Math program or department head approval. Credit not allowed in MATH 1130 after completion of MATH 1830 or MATH 1710 or any other mathematics course for which these are prerequisites. Credit not allowed in both MATH 1130 and MATH 1710. Laboratory/studio course fee will be assessed.

MATH 1710 - Precalculus I

(3) Credit Hours

Designed primarily for students majoring in mathematics, the physical sciences, and engineering who intend to take MATH 1720 and MATH 1950. Includes topics such as solving polynomial equations and inequalities, complex numbers, the fundamental theorem of algebra, rational functions, graphing techniques, functions, exponential functions, and logarithmic functions. Mathematical models will be taken primarily from the fields of engineering, biology, and the natural sciences. Prerequisites: MATH 1006 with minimum grade of C or a score of 19 or higher on the ACT Math or successful completion of Step Ahead Math program, or department head approval. Credit not allowed in MATH 1710 after MATH 1830, MATH 1730, MATH 1720, or MATH 1950 with a minimum grade of C. Credit not allowed in both MATH 1130 and MATH 1710. Laboratory/studio course fee will be assessed.

MATH 1720 - Precalculus II

(3) Credit Hours

Designed primarily for students majoring in mathematics, the physical sciences, or engineering who intend to take MATH 1950. Includes topics such as trigonometric identities, trigonometric equations, complex numbers, conic sections, sequences, and other selected topics. Prerequisites: MATH 1710 with minimum grade of C or a score of 26 or higher on the ACT Math or department head approval. Credit will not be allowed in Mathematics 1720 after completion of MATH 1950 with a minimum grade of C. Credit is not allowed in both MATH 1720 and MATH 1730.

MATH 1730 - Combined Precalculus
(4) Credit Hours
This precalculus course is designed primarily for students majoring in Mathematics, the physical sciences, and Engineering who intend to take the calculus course MATH 1950. It combines topics from precalculus I and precalculus II into a one-semester course. Topics include complex numbers; the Fundamental Theorem of Algebra; rational, exponential, logarithmic, and trigonometric functions; solving trigonometric identities and equations; conic sections; and other selected topics. Every semester. Prerequisites: MATH 1130 with a minimum grade of C or Math ACT 24 or above (Math SAT 560 or above), or department head approval. Credit not allowed in MATH 1730 after MATH 1720 or MATH 1910 or MATH 1950 with a minimum grade of C.

MATH 1830 - Calculus for Management, Life, and Social Sciences
(3) Credit Hours
Introduction to calculus: limits, differentiation of functions, optimization, marginal analysis, integration, the Fundamental Theorem of Calculus, applications of integration. Every semester. Prerequisites: MATH 1130 or MATH 1710 with minimum grade C or Math ACT 26 or above or department head approval. Credit not allowed in MATH 1830 after completion of MATH 1910 with a minimum grade of C.

MATH 1920 - Calculus II
(3) Credit Hours
Additional topics in the calculus of functions of one real variable. Applications of integration, techniques of integration, infinite series, and convergence tests. Every semester. Prerequisites: MATH 1950 with a minimum grade of C and department head approval.

MATH 1950 - Calculus with Analytic Geometry I
(4) Credit Hours
The calculus of functions of one real variable. Precise definitions of limits, derivatives, and integrals including Riemann sums; applications of these concepts and the Fundamental Theorem of Calculus. Every semester. Prerequisites: MATH 1720 or MATH 1730 with a minimum grade of C or Math ACT 28 or above, or department head approval.

MATH 1960 - Calculus with Analytic Geometry II
(4) Credit Hours
Additional topics in the calculus of functions of one real variable. Applications of integration, techniques of integration, infinite series, and convergence tests, polar coordinates and conics. Every semester. Prerequisites: MATH 1950 with a minimum grade of C or department head approval.

MATH 1999r - Special Projects
(1-9) Credit Hours
Individual or group projects. Maximum credit 4 hours. On demand. Prerequisites: department head approval.

MATH 2030 - Discrete Mathematics for Computer Science
(3) Credit Hours
Designed primarily for students majoring in computer information systems. topics will include logic, introduction to mathematical induction, sets, relations, counting methods, graph theory and trees. Prerequisites: MATH 1830 or MATH 1910 and MATH 1911 or MATH 1950 with minimum grades of C; CPSC 1100 or department head approval. Credit not allowed in this course after completion of MATH 3030 or MATH 4720 with a minimum grade of C.

MATH 2100 - Introductory Statistics
(3) Credit Hours
An introductory course suitable for students in a variety of disciplines. This course will teach students to interpret, develop, and use statistical and probabilistic models of real-world phenomena; develop the concepts of uncertainty, probability, and statistical significance; and will indicate how these concepts arose and how they aid our understanding of the universe. Students will learn how to solve practical problems using statistical vocabulary, notation, and appropriate technology. Students who have not recently taken a mathematics course or who have a MATH ACT score of less than 19 are strongly advised to take USTU 1050r: Foundations of Mathematics before enrolling in this course.

MATH 2150 - Mathematics for Elementary and Middle School Teachers I
(3) Credit Hours
This is the first course in a two-semester sequence designed for elementary, middle school, and special education majors. The purpose is to develop a thorough understanding of the mathematics taught in the schools. Topics include the arithmetic properties and operations for the natural numbers, whole numbers, integers, rational and irrational number systems; elementary number theory including prime and composite numbers, factors and divisibility criteria, the fundamental theorem of arithmetic, greatest common divisors and least common multiples; place values, percentages, decimals, and other numeration systems. Prerequisites: MATH 1006 or USTU 1050r with minimum grade of C or Math ACT 19 or above or department head approval.

MATH 2160 - Mathematics for Elementary and Middle School Teachers II
(3) Credit Hours
This is the second course in a two-semester sequence designed for elementary, middle school, and special education majors. The purpose is the continuation of the study of mathematical topics from MATH 2150 with an emphasis on algebraic notation, sets and functions, basic geometric concepts of measurement, length, area, perimeter, surface area, volume, and the Pythagorean Theorem. Some elementary probability and statistics, including some educational statistics, will be included. This course will meet General Education Mathematics requirement, but not General Education Statistics requirement. Every semester and summers. Prerequisites: MATH 2150 with a minimum grade of C and completion of the Foundations of Mathematics tutorial (USTU 1050r), or Math ACT 26 or above; or department head approval.

MATH 2200 - Elementary Linear Algebra
(3) Credit Hours
Systems of linear equations, matrix algebra, determinants, geometric vectors, vector spaces, linear transformations, eigenvalues and eigenvectors, inner product spaces. Every semester. Prerequisites: MATH 1910 and MATH 1911 or MATH 1950 or MATH 2030 with minimum grades of C or department head approval.

MATH 2300 - Mathematical Models, Functions and Applications
(3) Credit Hours
Lab-based activities designed to strengthen and expand knowledge of topics in secondary mathematics, focusing on topics from precalculus and elementary calculus. Explorations will involve the use of multiple representations, transformations, data analysis techniques and interconnections among geometry, probability and algebra. Most labs will include significant use of various technologies. The use of quantitative approaches and building relationships between discrete and continuous reasoning will be recurrent themes. Every semester. Prerequisites: University, STEM, and major department grade point averages of at least 2.5; STEM 1020 and MATH 1920 or MATH 1960 and MATH 2200 with minimum grades of C, or STEM Education Co-Director approval. Admissions to the STEM Education program.

MATH 2450 - Introduction to Differential and Difference Equations
(3) Credit Hours
First order and second order linear differential and difference equations, systems of equations and transform methods. Every semester. Prerequisites: MATH 1920 or MATH 1960 with a minimum grade of C or department head approval. Pre or Corequisites: MATH 2200 with a minimum grade of C or department head approval. Standard letter grade.

MATH 2550 - Multivariable Calculus
(3) Credit Hours
Lines, curves, and surfaces; partial derivatives, gradients, divergence and curl; multiple integrals and vector analysis. Every semester. Prerequisites: MATH 2200 and either MATH 1920 or MATH 1960, all with minimum grades of C, and department head approval. Credit not allowed in both MATH 2550 and MATH 2560. Standard letter grade.

MATH 2551 - Multivariable Calculus Laboratory
(1) Credit Hours
Calculator and computer treatment of problems and topics in MATH 2550 using graphical, numerical, and symbolic methods. Spring semester. Laboratory 2 hours. Pre or Corequisites: MATH 2550 or MATH 2560, or department head approval. Laboratory/studio course fee will be assessed. Standard letter grade.

MATH 2560 - Calculus with Analytic Geometry III
(4) Credit Hours
Lines, curves, and surfaces, partial derivatives, gradients, divergence and curl; multiple integrals and vector analysis including Green's, Stokes', and Gauss' Theorems. Every semester. Prerequisites: MATH 2200 and either MATH 1920 or MATH 1960, all with minimum

grades of C, or department head approval. Credit not allowed in both MATH 2550 and MATH 2560. Standard letter grade.

MATH 2999R - Group Studies
(1-9) Credit Hours
On demand. Prerequisites: Department head approval. Department may have additional prerequisite requirements.

MATH 3000 - Introduction to Logic and Proof
(3) Credit Hours
Introductory concepts of sets, functions, equivalence relations, ordering relations, logic, methods of proof, and axiomatic theories with topics from combinatorics, graph theory, or abstract algebra. This course is a prerequisite for MATH 3250, MATH 3500, MATH 4720, MATH 4270, MATH 4200, MATH 4050, MATH 4000 and MATH 4010. Mathematics majors should enroll in it at the end of the sophomore year or beginning of the junior year. Fall and spring semesters. Prerequisites: MATH 1920 or MATH 1960 with a minimum grade of C or department head approval. Standard letter grade.

MATH 3030 - Discrete Structures
(3) Credit Hours
Concepts and techniques of several areas of discrete mathematics with emphasis on areas often applied to computer science. Topics will include formal logic, induction, recursion, algorithms, counting methods, languages and grammars, and finite state machines. Fall and spring semesters. Prerequisites: MATH 1920 or MATH 1960 and CPSC 1100 with minimum grades of C or department head approval. Standard letter grade.

MATH 3100 - Applied Statistics
(3) Credit Hours
Introduction to probability and statistical methods with applications to various disciplines. A study of some basic statistical distributions, sampling, testing of hypotheses, and estimation problems. Fall and spring semesters. Prerequisites: MATH 1920 or MATH 1960 with a minimum grade of C or department head approval. Credit not allowed in both MATH 3100 and MATH 4130 and MATH 4140. Standard letter grade.

MATH 3250 - Introduction to Modern Algebra
(3) Credit Hours
Groups, rings, fields, and other selected topics. Prerequisites: MATH 2200 and MATH 3000 with minimum grades of C or department head approval. Credit not allowed in both MATH 3250 and MATH 4250.

MATH 3310 - Introduction to Mathematical Programming
(3) Credit Hours
Examines the basic concepts and applications of mathematical programming. Topics include formulation of mathematical models, linear programming, the simplex algorithm, duality, sensitivity analysis, transportation problems and assignment problems. Prerequisites: MATH 2200 or department head approval.

MATH 3510 - Introduction to Analysis I
(3) Credit Hours
Theoretical investigation of real sequences, functions, limits, and continuity. Prerequisites: MATH 2450, MATH 2550 or MATH 2560, and MATH 3000, all with minimum grades of C, or department head approval. Standard letter grade.

MATH 3820 - Communicating Mathematics
(3) Credit Hours
Introduction to the techniques and tools of written and oral communication in mathematics. Prerequisites: MATH 3000 or department head approval.

MATH 3999r - Group Studies
(1-9) Credit Hours
On demand. Prerequisites: department head approval. Department may have additional prerequisite requirements.

MATH 4000 - 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. Historical overview of the evolution of the discipline through comparative examination of specific theories and results. Prerequisites: MATH 3000 with a minimum grade of C or department head approval.

MATH 4010 - 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. Prerequisites: MATH 3000 with a minimum grade of C or department head approval.

MATH 4050 - Introduction to Point Set Topology
(3) Credit Hours
Introductory set theory, topologies and topological spaces, continuous mappings, compactness, connectedness, separation axioms and metric spaces. Prerequisites: MATH 3000 with a minimum grade of C or department head approval.

MATH 4130 - 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. Prerequisites: MATH 2550 or MATH 2560 with a minimum grade of C or department head approval.

MATH 4140 - Mathematical Statistics
(3) Credit Hours
A continuation of MATH 4130 with an introduction to the Central Limit Theorem, statistical inference, probability distributions of functions of random variables. Prerequisites: MATH 4130 with a minimum grade of C or department head approval.

MATH 4160 - 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. Prerequisites: MATH 3100 or MATH 4130 or ENCE 2220 with a minimum grade of C, or department head approval.

MATH 4170 - 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: MATH 3100 or MATH 4130 or ENCE 2220 with a minimum grade of C or department head approval.

MATH 4200 - Linear Algebra and Matrix Theory
(3) Credit Hours
Vector spaces, linear transformations, eigenvalue and similarity transformations, orthogonal and unitary transformations, normal matrices, Jordan form. Prerequisites: MATH 2200, MATH 3000 with a minimum grades of C or department head approval.

MATH 4250 - Modern Algebra I
(3) Credit Hours
Groups, subgroups, quotient groups, homomorphisms, simple groups, solvable groups, group actions, Sylow theorems and the fundamental theorem of finitely generated abelian groups. Prerequisites: MATH 2200 and MATH 3000 with minimum grades of C or department head approval. Credit not allowed in both MATH 3250 and MATH 4250.

MATH 4260 - 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. Prerequisites: MATH 4250 with a minimum grade of C or department head approval.

MATH 4270 - 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. Prerequisites: MATH 3000 with a minimum grade of C or department head approval.

MATH 4280 - Analytic Number Theory
(3) Credit Hours
Arithmetic functions, the distribution of primes, Dirichlet series, Euler products, the Riemann zeta-function, the prime number theorem, and Dirichlet's theorem on primes in arithmetic progressions. Prerequisites: MATH 4570 and either MATH 4250 or MATH 4270, all with minimum grades of C, or department head approval.

MATH 4300 - 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. Recommended for students planning to take actuarial exams. Prerequisites: MATH 1920 or MATH 1960 with a minimum grade of C or department head approval. Standard letter grade.

MATH 4310 - Operations Research (Linear)
(3) Credit Hours
Introduction to linear programming, duality, transportation and assignment problems, and integer programming. Prerequisites: MATH 2200 and MATH 3000 with a minimum grades of C or department head approval.

MATH 4320 - Operations Research (Non-Linear)
(3) Credit Hours
Network flows, Markov chains and applications, queuing theory and applications, inventory theory, decision theory and games. Prerequisites: MATH 4310 and either MATH 3100 or MATH 4130 with minimum grades of C or department head approval.

MATH 4350 - Mathematics of Finance
(3) Credit Hours
Mathematical aspects of finance; theory of pricing derivatives of financial instruments; options in Black-Scholes model; portfolio optimization; capital asset pricing model. Offered alternate spring semesters. Prerequisites: MATH 3100 or MATH 4130 with a minimum grade of C, or department head approval.

MATH 4450 - Ordinary Differential Equations
(3) Credit Hours
Systems of differential equations; existence and uniqueness theorems; linear systems; phase plane analysis; stability theory; applications. Prerequisites: MATH 2450 and MATH 2550 or MATH 2560, all with minimum grades of C, or department head approval. Standard letter grade.

MATH 4460 - 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. On demand. Prerequisites: MATH 2450 and MATH 2550 or MATH 2560, all with minimum grades of C, or department head approval. Standard letter grade.

MATH 4510 - Introduction to Analysis II
(3) Credit Hours
Rigorous development of the derivative, the definite integral, sequences and series of functions, and improper integrals. Prerequisites: MATH 3510 with a minimum grade of C or department head approval.

MATH 4550 - Applied Analysis
(3) Credit Hours
Vector analysis through Stokes' Theorem and the Divergence Theorem. Topics in advanced calculus including implicit functions, Jacobians, interchange of limit processes, and uniform convergence of series of functions. Prerequisites: MATH 2450 and MATH 2550 or MATH 2560, all with minimum grades of C, or department head approval. Standard letter grade.

MATH 4570 - 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; contour integration. Prerequisites: MATH 2450 and MATH 2550 or MATH 2560, all with minimum grades of C, or department head approval. Standard letter grade.

MATH 4600 - 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 and MATH 2450 with minimum grades of C, and CPSC 1020 or CPSC 1100, or department head approval.

MATH 4610 - 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. Prerequisites: MATH 4600 with a minimum grade of C or department head approval.

MATH 4700 - 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. Prerequisites: MATH 2450 and MATH 2550 or MATH 2560, all with minimum grades of C, or department head approval. Standard letter grade.

MATH 4720 - Introduction to Graph Theory
(3) Credit Hours
An overview of graph theory and its applications including trees, planar graphs and graphical invariants such as domination, coloring, and matchings. Prerequisites: MATH 3000 with a minimum grade of C or department head approval.

MATH 4750 - Research Seminar
(1) Credit Hours
Investigation of special topics in mathematics using the directed research technique. On demand. Prerequisites: department head approval. Graded satisfactory/no credit.

MATH 4995r - Departmental Thesis
(1-3) Credit Hours
Requires University Honors approval. Department may have additional prerequisite requirements. Student must submit an Individual Studies/Research Contract to the Registrar's Office at the time of registration. Every semester.

MATH 4997r - Research
(1-9) Credit Hours
Student must submit an Individual Studies/Research Contract to the Registrar's Office at the time of registration. Every semester. Prerequisites: department head approval. Department may have additional prerequisite requirements.

MATH 4998r - Individual Studies
(1-9) Credit Hours
Student must submit an Individual Studies/Research Contract to the Registrar's Office at the time of registration. Every semester. Prerequisites: department head approval. Department may have additional prerequisite requirements.

MATH 4999r - Group Studies
(1-9) Credit Hours
On demand. Prerequisites: department head approval. Department may have additional prerequisite requirements.

C.2. Graduate Courses

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. Prerequisites: department head approval.

MATH 5010r - Advanced Special Topics
(3) Credit Hours
Concentration in selected fields of study. Prerequisites: approval of instructor.

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. Prerequisites: 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, Central Limit Theorem

MATH 5131 - Statistical Computation and Programming
(3) Credit Hours
Data structure, data input and output, write maintainable code and functions, data analyses and simulation. Prerequisite: Department Head approval. Prerequisites: department head approval. Corequisites: MATH 5130 or department head approval.

MATH 5140 - Mathematical Statistics
(3) Credit Hours
A continuation of MATH 5130. The Central Limit Theorem revisited, statistical inference, probability distributions of functions of random variables. Prerequisites: MATH 5130 with a minimum grade of C or department head approval.

MATH 5150 - Introduction to Biostatistics
(3) Credit Hours
Descriptive statistics, parametric and non-parametric inferential statistics, power and size analysis, ROC curve analysis, Bayes theorem, survival curve analysis, relative risks, and odds ratio. Prerequisites: MATH 5130 with a minimum grade of C or department head approval.

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. Prerequisites: MATH 5130 with a minimum grade of C or 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: MATH 5130 or department head approval. Standard letter grade.

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). Prerequisites: MATH 5130 and MATH 5210 with minimum grades of C or department head approval.

MATH 5190 - Design of Experiments
(3) Credit Hours
A study of methods for the design and analysis of experiments. Randomization, blocking, replication, and cofounding. Complete and incomplete block designs, Fractional factorial experiments. Prerequisites: MATH 5180 with a minimum grade of C or department head approval.

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. Standard letter grade.

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. Prerequisites: MATH 5210 or department head approval. Standard letter grade.

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 321 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. Prerequisites: MATH 5250 or department head approval. Standard letter grade.

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 quadric reciprocity. Background in logic and proof at the level of UTC Math 3000 required. Standard letter grade.

MATH 5280 - Analytic Number Theory
(3) Credit Hours
Arithmetic functions, the distribution of primes, Dirichlet series, Euler products, the Riemann zeta-function, the prime number theorem, and Dirichlet's theorem on primes in arithmetic progressions. Prerequisites: MATH 5570 and either MATH 5250 or MATH 5270, or 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. Standard letter grade.

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. Standard letter grade.

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. Standard letter grade.

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. Prerequisites: MATH 5310 or MATH 5320 with minimum grade of C or department head approval.

MATH 5350 - Mathematics of Finance
(3) Credit Hours
Mathematical aspects of finance; theory of pricing derivatives of financial instruments; options in Black-Scholes model; portfolio optimization; capital asset pricing model. Prerequisites: MATH 5130 or department head approval.

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. Prerequisites: 4550 with minimum grade of C or department head approval.

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. Prerequisites: MATH 5470 or department head approval.

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. Prerequisites: department head approval.

MATH 5530 - Calculus of Variations
(3) Credit Hours
History of the calculus of variations; minimization of functionals; Euler-Lagrange equations; necessary conditions of optimality; sufficient conditions; Sturm-Liouville problem; applications to geometry; direct methods.

MATH 5560 - Real Analysis
(3) Credit Hours
Lebesgue measure on the real line, integration and differentiation of real-valued functions of a real variable, and the classical Banach spaces. Prerequisites: MATH 5500 with a minimum grade of C or department head approval.

MATH 5570 - Complex Analysis
(3) Credit Hours
Topics include analytic functions, complex integration, Cauchy's theorem, residue theorem, argument principle, conformal mappings, Riemann mapping theorem, Picard's theorem, analytic continuation, and Riemann surfaces. Prerequisites: MATH 5500 or department head approval.

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 department head approval.

MATH 5590 - Functional Analysis
(3) Credit Hours
Banach and Hilbert spaces; Riesz representation, Hahn—Banach, closed graph, and open mapping theorems; uniform boundedness principle; bounded linear operators; compact operators. Prerequisites: MATH 5500 with a minimum grade of C or department head approval.

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. Prerequisites: Math 5600 or department head approval.

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. Prerequisites: 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. Prerequisites: 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. Prerequisites: department head approval. Standard letter grade.

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. Prerequisites: department head approval. Standard letter grade.

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. Prerequisites: approval of student's Graduate Program Committee and the Mathematics Graduate Coordinating Committee.

MATH 5910r - 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. Prerequisites: 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 5997r - 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. Prerequisites: approval of instructor and department head.

MATH 5998r - 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. Prerequisites: approval of department head.

MATH 5999r - 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. Prerequisites: approval of department head.

MATH 7160 - Computational Statistics
(3) Credit Hours
Topics include factor analysis, Monte Carlo simulations, Markov chains, bootstrapping, data mining, and other computationally intensive methods. Prerequisites: MATH 5130 or department head approval.

MATH 7180 - Probability Theory
(3) Credit Hours
Mathematical foundations of probability and stochastic processes, probability measures, random variables, distribution functions, convergence theory, the Central Limit Theorem, conditional expectation, and martingale theory. Prerequisites: MATH 5130 and MATH 5560, or department head approval.

MATH 7290 - Algebraic Number Theory
(3) Credit Hours
Further development of the theory of fields covering topics from valuation theory, ideal theory, algebraic number fields, ramification, function fields, and local class field theory. Prerequisites: MATH 5260 or department head approval.

MATH 7460 - Mathematical Biology
(3) Credit Hours
Topics include population dynamics, differential equation and dynamical system theory applied to biological sciences, mathematical methods in ecology, epidemiology, and cell biology. Prerequisites: MATH 5450 or department head approval.

MATH 7560 - Asymptotic Analysis
(3) Credit Hours
Topics include Laplace and saddle point methods, Abelian and Tauberian theorems, asymptotic analysis of integrals and differential equations, special functions, Sturm-Liouville theory, and perturbation theory. Prerequisites: MATH 5470 or MATH 5570, or department head approval.

MATH 7580 - Discrepancy Theory
(3) Credit Hours
Classic results in number theory, Fourier analysis and combinatorial and geometric discrepancy, and the relations between them. Prerequisites: MATH 5130 and MATH 5500, or department head approval.

MATH 7590 - Spectral Theory
(3) Credit Hours
The spectral theory of unbounded self-adjoint operators, including the spectral theorem; form methods and the KLMN theorem; one-particle and atomic Schrodinger operators. Prerequisites: MATH 5560 and MATH 5590, or department head approval.

MATH 7640 - Numerical Linear Algebra
(3) Credit Hours
Topics include linear systems, matrix computations, direct methods, iterative methods, Krylov subspace methods, sparse matrices. Prerequisites: MATH 5210 and MATH 5600, or department head approval.

MATH 7910r - Special Topics in Computational and Applied Mathematics
(3) Credit Hours
Selected advanced topics and problems of current interest. May be repeated in the same or separated semesters. Prerequisites: approval of instructor and department head.

MATH 7930 - Graduate Seminar
(3) Credit Hours
Seminar on topics of current interest in computational and applied mathematics. Students present seminars and discussion on various topics. Prerequisites: approval of instructor and department head.

MATH 7950r - Doctoral Research
(1-9) Credit Hours
Graduate research, primarily for advanced doctoral students participating in research projects other than their dissertation work. May be repeated. Prerequisites: department head approval

MATH 7997r - Individual Studies
(1-12) Credit Hours
Individual studies in computational and applied mathematics. May be repeated in the same or separate semesters. Prerequisites: approval of instructor and department head.

MATH 7999r - Doctoral Dissertation
(1-12) Credit Hours
Graduate research for students working on their doctoral dissertation. May be repeated.
Prerequisites: department head approval

Appendix D. Master's Degree Requirements and Sample Course Schedules

D.1. Applied Mathematics

- One of the following six-hour sequences:

  a) Numerical Analysis I and II

  - MATH 5600 - Numerical Analysis I
  - MATH 5610 - Numerical Analysis II

  b) 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

  c) 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

  d) Differential Equations

  - MATH 5450 - Ordinary Differential Equations
  - MATH 5460 - Partial Differential Equations

- Plus six additional hours chosen from

  - MATH 5350 – Mathematics of Finance;
  - MATH 5530 – Calculus of Variations;
  - MATH 5560 – Real Analysis;
  - MATH 5590 – Functional Analysis.
  - 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)

D.2. 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 5131 - Statistical Computation and Programming
  - MATH 5320 - Operations Research (Nonlinear)
  - MATH 5330 - Optimization
  - MATH 5170 - Nonparametric Statistics;
  - 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)

D.3. 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):
  a) Graph Theory and Number Theory
     - MATH 5720 - Graph Theory
     - MATH 5270 - Number Theory
  b) Linear Algebra and Matrix Theory
     - MATH 5210 - Linear Algebra and Matrix Theory
     - MATH 5220 - Advanced Matrix Theory
  c) Modern Algebra
     - MATH 5250 - Modern Algebra I
     - MATH 5260 - Modern Algebra II
  d) Differential Equations
     - MATH 5450 - Ordinary Differential Equations
     - MATH 5460 - Partial Differential Equations
  e) Operation Research
     - MATH 5310 - Operations Research (Linear)
       and one of
     - MATH 5320 - Operations Research (Non-Linear)
     - MATH 5330 – Optimization (Operation Research III)
  f) Analysis
     - MATH 5560 – Real Analysis;
     - MATH 5590 – Functional Analysis.
- 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.4. 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)

Appendix E. Library Fact Sheet

University Library Facts:

- 180,000 square feet
- 5 floors
- New facility opened in January 2015
- The LEED-certified library is accommodates a variety of new strategic campus partnerships and is the premier location for student academic needs outside of the classroom. New and expanded partnerships represented in the new building include: Art Department, Center for Advisement and Student Success, Copy Services, Information Technology Division, Disability Resources Center, Southern Writers, Walker Center for Teaching and Learning, and Writing and Communication Center. Designed with a robust technological infrastructure and themes of transparency, collaboration, and flexibility, student access and success has always been at the center of building design and utilization.
- 37 study rooms (29 small, 7 medium, 1 large)
- 2 practice presentation rooms
- 24 hour student study space, opened Sunday to Thursday
- 4 lounges (2 quiet, computer and graduate student)
- Starbucks
- Information Commons (research assistance and 175+ computers)
- Studio 305: advanced media studio and creator space
- 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 material browsing area (think more Barnes and Noble)
- Media viewing room
- Expanded special collections storage with unique climate controls
- New auditorium housing 2 lecture halls of ~225 seats each adjacent to the new library.