Fitchburg State University

Mathematics Department

Self-Study Report

for the

Program Review – 2017

Approved by the Mathematics Department

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1. Department Overview

1.1 History of the Department

While mathematics courses had been taught at Fitchburg Teachers College since its founding in 1894-1895, it was during the 1950s and 1960s that the Massachusetts Legislature transformed the teacher colleges into comprehensive colleges, offering not only the several professional degrees, but also a full complement of liberal arts majors. Thus, by 1970 Fitchburg State College offered a B.S. and B.A. in Mathematics as well as a B.S. Ed. in Secondary Education in Mathematics and enrolled over twenty majors per year. In summer 2010 the Massachusetts Legislature granted university status to most of the four-year state colleges. And in October 2010 our college officially became Fitchburg State University. Today at Fitchburg State University students in the mathematics program can pursue a Bachelor of Science in Mathematics, a Bachelor of Arts in Mathematics or a minor in mathematics. The Department also offers an Applied Mathematics concentration, a Secondary Education concentration and a mathematics minor designed specifically for the early childhood and elementary education students.

The Mathematics Department is organized under the *Agreement between the MSCA and the BHE (the Massachusetts State College Association and the Board of Higher Education)* which mandates the election of a chair every three years and two departmental standing committees, the Curriculum Committee and the Peer Evaluation Committee. The Department currently has four additional standing committees for which the departmental faculty members volunteer. These are the Assessment Committee, Elizabeth Haskins High School Mathematics Contest Committee, Seminar/Math Circles Committee and Hospitality Committee. In recent academic years, this list has also included a Search Committee. Other ad hoc committees have been formed as needed. Examples of these are the Mathematics Readiness Program Committee, a Calculus Text Selection Committee, Precalculus redesign committee, and this year's Self Study Steering Committee. The Department Chair along with the department secretary and the departmental committees take care of the business of the Department. The Department meets as a whole once a month. Since all faculty offices are in close proximity, faculty can and do communicate regarding day-to-day concerns and often can quickly resolve the minor issues that arise, through informal face-to-face communications and/or email.

During the last thirty-five years, the Department of Mathematics has functioned both as a "service" department and a department with a viable undergraduate mathematics major program. An M.A.T. program in mathematics thrived during the late 1970s, was discontinued, and was reactivated in 1999 for another period of five years. Again, it has been suspended for lack of interested students. In 2017, the M.A.T program was officially discontinued. Although the Department had either eleven or twelve faculty members for many years, during the period from approximately 2000 to 2010 it was staffed by nine or ten full-time members often with one of these members having a one-year temporary position. For academic year 2016-2017 the department has eleven tenure-track full time faculty members, and one developmental mathematics coordinator, a status it has been trying to achieve for several years. Each semester there is also need for several adjunct faculty members and the department has been fortunate to have a few excellent and dedicated long-time adjunct faculty members. See the Faculty Data section for more information.

In 2007, the Mathematics Department established a chapter of Pi Mu Epsilon, the national honorary mathematics society. Several current students, faculty members and alumni have been inducted as members. Additionally, the Department has an active mathematics club which sponsors various annual activities including speakers, problem solving sessions and social gatherings. In recent years, many of our students have given presentations at conferences hosted by regional and national mathematical organizations. Our faculty members are professionally active in national and regional mathematics associations, in research, in the university and local communities, and in fostering student involvement in the mathematics community.

College policies and general governance of our academic workplace are determined by contract provisions and by proposals for change passed by the contractually established All University Committee (AUC) and approved by the President of the University. Faculty and librarian members of the AUC are annually elected by their colleagues to serve in this post. Administrators and students also serve on this committee. The Department traditionally has had at least one member on the AUC. One current member of the Mathematics Department is serving as Chair of the AUC and another member of the Mathematics Department currently (2016-2017) is serving on the AUC. Two of the standing subcommittees of the AUC, the Curriculum Committee and the Academic Policy Committee also have traditionally had Mathematics Department faculty representation. Our Department members have also participated in nearly every campus-wide curriculum and accreditation effort and in various other campus-wide committee work or other initiatives. It was principally through the efforts of one of the newer members of the Mathematics Department that the University's Undergraduate Research Conference, now an annual program, was established in academic year 2009-2010. Two members of the Department served on NEASC college-wide subcommittees preparing for the University's upcoming visit and evaluation by the NEASC accreditation team. One faculty member served as co-chair of the NEASC Academic Program and Faculty subcommittee and another served on the Technology subcommittee.

The defining characteristic of the Department and the major remains its devotion to its students and to high academic standards within service courses and major courses. The 2008 Academic Plan for the Mathematics Department, prepared at the request of the Office of Academic Affairs, expresses the Department's mission in the following way:

"The mission of the Department of Mathematics is to foster our students' self-reliance in mathematics, to produce graduates who can bring together the theory and practice of mathematics, and to create in graduates strengthened ability for critical and logical thinking."

Previous formal Program Reviews of the mathematics program at Fitchburg State were conducted in Spring 1983, Spring 2002, Spring 2006, and Spring 2012. In Spring 1983, Dr. Thomas Kearns of Northern Kentucky University conducted an on-site review. In Spring 2002, Dr. C. Edward Sandifer of Western Connecticut State University conducted a paper review. In Spring 2006, Dr. Ockle Johnson of Keene State University in Keene, New Hampshire conducted an on-site review. In Spring 2012, Dr. David L. Abrahamson of Rhode Island College conducted on-site review. His report, together with the Department's response are in Appendix G. A brief synopsis of departmental activities since 2012 associated with the

Department's formal Action Plan and/or given impetus as the Department reflected on Dr. Abrahamson's 's report recommendations follows.

1.2 Major Recommendations for Improvement

Dr. Abrahamson's report of May 2012 contained five recommendations for improvement in the program. Each of these will be listed below together with the Department's action or response to that recommendation.

Recommendation 1: *The Department should review the calculus sequence in the major and determine whether they think it is feasible to change to a three-course sequence instead of a four-course sequence.* (Note that this recommendation does not say that they must change the sequence, merely that they give careful consideration and decide if a change is possible given their goals and objectives.)

Department Response: Indeed, the Department has completely followed this recommendation and has reorganized the calculus sequence into three semesters of four credits each and addressed the many complications, both individual and systematic, resulting from this change. At this writing the calculus sequence in the new format is fully established and all subsequent issues from the change have been dealt with.

Recommendation 2: *The Department should review what mathematics courses are taken by each of its majors over a period of time and determine whether it might be appropriate to list more courses as required in the major.* (As above, this is not to say that a change must be made, just that the Department should review the possibility of delineating it more clearly.)

Department Response: The Department regularly considers this issue in its curriculum deliberations. One specific change in this regard was the requiring of MATH 2500, Introduction to Mathematical Thought, as part of the applied mathematics track. Previously this course was an option in the applied track (required in the general track) and it was determined that requiring a proofs-based course for students in the applied track was beneficial and necessary. Considerations of requirements for various advanced courses in all tracks continue but at this time no other changes of this type have been made.

Recommendation 3: *The Department should continue to expand its cooperation with the Placement Testing Center and Mathematics Center.*

Department Response: This cooperation has continued in general and in at least four specific instances. First, there was collaboration with the Tutor Center, in which the Mathematics Center is housed, in the hiring of designated Precalculus tutors, linked to specific sections, as part of the redesign of MATH 1300, Precalculus, into a four-credit course. Secondly, the creation of "Supplemental Instruction" for MATH 1700, Applied Statistics, was accomplished with considerable assistance from and consultation with these centers. Thirdly, these centers were involved in the Department's work with a pilot involving the use of HS GPA to determine placement into some mathematics courses. Fourthly, one member of the Department served on the search committee for hiring a new Director of Peer Services and other mathematics faculty members and mathematics majors participated in the interview process.

Recommendation 4: *The Department and the University should strive to reach common ground on staffing* *issues and to strengthen the Department in the field of mathematics education.*

Department Response: In the years since the last review the Department has hired five new tenure-track professors including one, Dr. Nermin Bayazit, who is a specialist in mathematics education. This marks the first time since 1995 that the education component of the Department has been under the direction of an individual with a full background in mathematics education.

Recommendation 5: *The Department should continue its development and implementation of the Outcomes Assessment Plan.*

Department Response: The Department's continuing work on assessment is available under section 3.5 of this review, Outcomes Assessment Plan.

1.3 Best Practices for Mathematics Departments

The Mathematical Association of America's Committee on the Undergraduate Program in Mathematics (CUPM) has been studying the curriculum of undergraduate mathematics majors in the U.S. since 1953. The CUPM reports are considered to be a primary source for "best practices" in the teaching and design of undergraduate mathematics programs and courses in this country. The most recent reports were 2004 and 2015. There were six recommendations made in *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004* (available at www.maa.org/cupm/), which will be examined in the following sections. In addition, there was a recommendation for Pre-service K-6 and middle school teachers that will be addressed in section 3.7. It is worth noting that the Department's assessment committee is currently looking into incorporating goals from the 2015 guide into the department's outcomes assessment plan.

1.3.1 Recommendation 1

Mathematical science departments should

1. *Understand the strengths, weaknesses, career plans, fields of study, and aspirations of the students enrolled in mathematics courses;*
2. *Determine the extent to which the goals of courses and programs offered are aligned with the needs of students as well as the extent to which these goals are achieved;*
3. *Continually strengthen courses and programs to better align with student needs, and assess the effectiveness of such efforts.*

The members of the Mathematics Department have good contact with alumni and many in the Department have been cited by current students as being very approachable. There is a constant stream of current students seeking help from their professors and using the computers in the Mathematics Department area of E301. The newly renovated offices, especially the facilities for adjunct faculty, have supported this. The small number of advisees per faculty member allows for good personal contact between advisor and advisees. Some of our incoming mathematics majors are not really prepared for, or committed to, a mathematics major. Therefore, an important part of advising has been to help students find their best choice of major. It is also not unusual for informal conferences to develop between an instructor and an advisor concerning a particular student. If a certain mathematics major needs a collective “push” to achieve excellence, the department collaborates to help the student. So, there is a good departmental knowledge of strengths, weaknesses, career plans, fields of study, and aspirations of the students enrolled in mathematics courses. As described in the Mathematics Department Academic Plan:

> “We stay abreast of the needs of our students as a whole as well as of individual students and their goals. Whether our students’ goals are to teach, attend graduate school, get a job in a mathematics field after graduation, or use mathematics as a foundation for logical thinking to step into another career path, our goal is to support our students in their endeavors. This involves not only providing these students with the knowledge they need to succeed in their specific goals, but also fostering a sense of belonging on campus and to the mathematics community as a whole.” See Appendix F for the entire Mathematics Department Academic Plan.

The Assessment Committee of the department has been busy creating rubrics for assessing various portions of the Outcomes Assessment plan. The assessment process has started for some objectives. In addition, the process has brought the department to adopt “best practices” guidelines for student homework assignments, proofs and lab reports. In terms of curriculum, the Mathematics Department continually re-assesses the two-year plan of offerings of upper-level mathematics courses to meet the needs of current mathematics majors. The current scheduling plan can be found in Appendix D. Even with this rotating schedule, it is difficult to keep upper level electives running, due to low enrollment. The Department continues to lobby for these electives to run so that students can get the courses they need to graduate. The new Applied Mathematics concentration was implemented as a result of studying interests of majors and the job market. It offers an interdisciplinary option for the students and helps prepare them for a career in industry.

The Department is also very dedicated to its non-major curriculum and the students it serves. The new MATH 2100 Technical Calculus was invented in response to the need of architecture students, who were failing Calculus I. The new mathematics requirements for K-6 education majors was the result of studying recommendations for best practices in pre-service teacher education (see section 3.7 below), new requirements by the Commonwealth of Massachusetts and in-depth conferences with members of the Fitchburg State Education Department and outside constituents affiliated with the local public schools. There have also been recent discussions of what might be done for education students who fail the Arithmetic Accuplacer but pass the Algebra Accuplacer. This discussion was the direct outgrowth of the sabbatical work of one member of the department. In addition, there have been several revisions of the core curriculum for these courses for education majors.

For more details on curriculum and assessment, see the Curriculum section.

1.3.2 Recommendation 2

Every course should incorporate activities that will help all students progress in developing analytical, critical reasoning, problem-solving, and communication skills and acquiring mathematical habits of mind. More specifically, these activities should be designed to advance and measure students' progress in learning to

- *State problems carefully, modify problems when necessary to make them tractable, articulate assumptions, appreciate the value of precise definition, reason logically to conclusions, and interpret results intelligently;*
- *Approach problem solving with a willingness to try multiple approaches, persist in the face of difficulties, assess the correctness of solutions, explore examples, pose questions, and devise and test conjectures;*
- *Read mathematics with understanding and communicate mathematical ideas with clarity and coherence through writing and speaking.*

As can be seen by a perusal of the Mathematics Department Outcomes Assessment Plan (see Appendix F), the above is covered in the primary goals of the Mathematics Department. In particular, two goals of the plan are:

Goal 2: Each undergraduate mathematics major, upon graduation from Fitchburg State University, should be able to apply mathematics to a broad spectrum of complex problems and issues by formulating and solving problems.

Goal 3: Each undergraduate mathematics major, upon graduation from Fitchburg State University, should be able to read, write, listen, and speak mathematically, as well as to be able to read and understand technically-based materials and to contribute effectively to group efforts.

While particular methods of teaching cannot be legislated due to issues of academic freedom, the philosophy of all members of the department support these goals. In particular, the department did specify that the Informal Geometry course be taught using the discovery method and that the Informal Number Theory and Informal Mathematical Modeling courses be taught using an interactive, group work approach as much as possible as well as stressing multiple representations and approaches to problems. These are the required courses for K-6 pre-service teachers. Approaches used by members of the department include quizzes based on reading assignments, precise writing stressed in proofs and lab reports, oral presentations in the mathematics seminar and other upper level courses, and group projects.

1.3.3 Recommendation 3

Every course should strive to

- *Present key ideas and concepts from a variety of perspectives;*
- *Employ a broad range of examples and applications to motivate and illustrate the material;*
- *Promote awareness of connections to other subjects (both in and out of the mathematical sciences) and strengthen each student's ability to apply course material to these subjects;*
- *Introduce contemporary topics from the mathematical sciences and their applications, and enhance student perceptions of the vitality and importance of mathematics in the modern world.*

Again, issues of academic freedom forbid legislating certain approaches to teaching courses. However, the Outcomes Assessment Plan and the Academic Plan of the Mathematics Department support these recommendations. They are reflected in the general philosophy of all members of the department, which affects how each professor teaches his/her courses.

The recent establishment of a Scientific Computing and Visualization course introduces some contemporary mathematics into the mathematics major. Our mathematics seminar course often involves contemporary topics including graph theory with applications to computer science and other fields. Some professors who teach Number Theory include some crypto-analysis. Some professors who teach Linear Algebra include applications to computer graphics. Some professors who teach the Informal Geometry course include fractals as a topic. In addition, students undertaking independent study sometimes choose more contemporary topics, such as cryptography.

The Applied Mathematics concentration requires a minor in another field and a capstone project, which definitely involves applications of mathematics to other fields. The new Liberal Arts and Sciences (LAS) requirements encourage a minor in another field by giving an option that involves a cluster of courses in a single discipline outside the student's major. This helps encourage more mathematics majors to minor in computer science, business, biology, chemistry or some other field.

1.3.4 Recommendation 4

Mathematical sciences departments should encourage and support faculty collaboration with colleagues from other departments to modify and develop mathematics courses, create joint or cooperative majors, devise undergraduate research projects, and possibly team-teach courses or units within courses.

The Mathematics Department has had extensive collaboration with the Education Department over a period of years to establish the three required mathematics courses for K-6 pre-service teachers. These discussions have been ongoing, with revisions in the core syllabi of the courses as a result. Discussion with the Industrial Technology Department led to the creation of the Technical Calculus course for architecture majors. The creation of the Applied Mathematics track involved discussion with the various science departments. Members of the department have engaged several undergraduates in research projects which have led to many student presentations with some potential for future publication. Another member of the department received a grant to support a Math Circle at the Fitchburg Arts Academy, a local middle school, and has since involved students in assisting with this project.

In terms of team teaching, 3 members of the mathematics department and 1 member of the education department team taught a hybrid graduate level mathematics education course to in service teachers since the last program review. This course ran 3 times.

1.3.5 Recommendation 5

At every level of the curriculum, some courses should incorporate activities that will help all students progress in learning to use technology

- *Appropriately and effectively as a tool for solving problems;*

- *As an aid to understanding mathematical ideas.*

Virtually all members of the Mathematics Department incorporate the use of technology in their courses, where appropriate. Fitchburg State supports the use of Excel, PowerPoint, Maple, Matlab and Minitab. Before changing to a 3-course calculus sequence, labs using Maple were a required part of Calculus I and II. With the conversion to the 3-course calculus sequence came the development of a separate 3 credit Symbolic Computational Mathematics course, giving the students even more experience with the use of CAS. Linear Algebra is often taught with computer assignments using Matlab or Maple. Most professors of Applied Statistics give class assignments using MyStatLab, R, Googledocs, Excel and/or TI calculators. Some Precalculus and Functions courses have graphing calculator assignments or Excel assignments. Excel and other programs have been used in Finite Mathematics. Technology assignments are regularly used in applied mathematics courses, Operations Research, Probability and Statistics and other upper level courses. Last but not least, we have recently included a required data project assignment in our basic mathematics II non-stem track since most of these students will go on to take applied statistics.

Many members of the department use MyMathLab for online assignments in lower-level mathematics courses and others use WebWork and Hawkes Learning System.

1.3.6 Recommendation 6

Mathematical science departments and institutional administrators should encourage, support and reward faculty efforts to improve the efficacy of teaching and strengthen curricula.

During the evaluation process, members of the Peer Evaluation Committee and the department chair regularly recognize the work of members of the department in the area of improving the efficacy of teaching and the strengthening of curricula. Recently Academic Affairs has instituted grants that can be used for assessment or curriculum development. Some of the newer members of the department have been successful in obtaining these grants. There has been recent targeted support for faculty to attend education based conferences including those centered around STEM education and inquiry based learning.

The Department and University have purchased wireless tablets and iPads for use in the classroom and in online courses. Several of the Mathematics Department faculty members have made use of these in their teaching. Apple TV has also been installed in several classrooms and is a useful instructional tool. One issues is there is no longer a laptop requirement for students so classes requiring such technology run into issues with students not being prepared. This needs to be addressed since several of our mathematics classes require regular use of a computer in class.

1.3.7 Recommendation for Pre-service Elementary and Middle School Teachers

Mathematical sciences departments should create programs of study for pre-service elementary and middle school teachers that help students develop

- *A solid knowledge—at a level above the highest grade certified—of the following mathematical topics: number and operations, algebra and functions, geometry and measurement, data analysis and statistics and probability;*

- *Mathematical thinking and communication skills, including knowledge of a broad range of explanations and examples, good logical and quantitative reasoning skills, and facility in separating and reconnecting the component parts of concepts and method;*
- *An understanding of and experience with the uses of mathematics in a variety of areas;*
- *The knowledge, confidence, and motivation to pursue career-long professional mathematics growth.*

The current mathematics requirements for K-6 pre-service teachers more than meet these requirements. Fitchburg State has a very strong requirement of three rigorous, in-depth mathematics content courses required of all Early Childhood, Special Education and Elementary majors which cover all the topics outlined above with the exception of probability and statistics. A serious problem is keeping this requirement in the face of pressure from outside sources to accept the transfer of credit from community colleges with "mile wide and inch deep" courses. However, the department has worked on getting local community colleges to align their pre-service courses with ours and has been successful in doing so with many feeder institutions.

Middle School mathematics pre-service teachers at Fitchburg State have to be mathematics majors and receive dual certification in Middle School and Secondary Mathematics. So the requirement for them also is far greater than the minimum recommended in the CUPM report.

At its August meeting in 2014, the Board of Governors of the MAA approved the Cognitive and Content Recommendations shown below in italics and also reaffirmed the principles of the *CUPM Curriculum Guide 2004.*

1.4 Cognitive Goals

Every mathematical sciences major should be designed to help students acquire "mathematical habits of mind." Students should develop the ability and inclination to use precise language, reason carefully, solve problems effectively, and use mathematics to advance arguments and increase understanding. These cognitive goals are not achieved in a single assignment or course; they must be approached within the context of each student's mathematical maturation throughout his or her undergraduate years. A well-constructed curriculum supports students in learning concepts, acquiring skills, and achieving cognitive goals. In the following paragraphs, we describe several cognitive goals in more detail.

1.4.1 Cognitive Recommendation 1:

Students should develop effective thinking and communication skills.

Major programs should include activities designed to promote students' progress in learning to

- state problems carefully, articulate assumptions, understand the importance of precise definition, and reason logically to conclusions;
- identify and model essential features of a complex situation, modify models as necessary for tractability, and draw useful conclusions
- deduce general principles from particular instances;
- use and compare analytical, visual, and numerical perspectives in exploring mathematics;

- assess the correctness of solutions, create and explore examples, carry out mathematical experiments, and devise and test conjectures;
- recognize and make mathematically rigorous arguments;
- read mathematics with understanding;

communicate mathematical ideas clearly and coherently both verbally and in writing to

- audiences of varying mathematical sophistication;
- approach mathematical problems with curiosity and creativity and persist in the face of difficulties;
- work creatively and self-sufficiently with mathematics.

At Fitchburg State University Mathematics major students learn the skills in clear thinking and communication through the different course requirements. For instances, in MATH 2500 (Introduction to Math Thought, students learn exact definitions, proof of theorems, and logical conclusions. In MATH 4450 (Mathematical Modeling) state problem carefully, make assumptions, identify and model features of a complex situation, modify models as necessary for traceability, and draw useful conclusions.

1.4.2 Cognitive Recommendation 2

Students should learn to link applications and theory.

Mathematics students should encounter a range of contemporary applications that motivate and illustrate the ideas they are studying, become aware of connections to other areas (both in and out of the mathematical sciences), and learn to apply mathematical ideas to problems in those areas. Students should come to see mathematical theory as useful and enlightening in both pure and applied contexts.

This recommendation is met by the courses in the Applied Mathematics concentration, many of which are taken by other math majors as well. The mathematics seminar course also often exposes students to contemporary applied mathematics (e.g. graph theory and applications)

Cognitive Recommendation 3:

Students should learn to use technological tools.

Mathematical sciences major programs should teach students to use technology effectively, both as a tool for solving problems and as an aid to exploring mathematical ideas. Use of technology should occur with increasing sophistication throughout a major curriculum.

Although many courses required for mathematics major use technology (as previously explained), the new course MATH2550 (Symbolic Computational Mathematics) introduces students to a computer algebra system (CAS), a crucial technological tool solve problems from Precalculus to calculus and other courses.

1.4.3 Cognitive Recommendation 4

Students should develop mathematical independence and experience open-ended inquiry.

A mathematical sciences major should be structured to move students beyond the carefully choreographed mathematical experiences of the classroom. A major curriculum should gradually prepare students to pursue open-ended questions and to speak and write about mathematics with increasing depth and sophistication.

With the exception of the Applied Mathematics concentration students are required to take MATH 3900 (Mathematics Seminar) which provides students the opportunity to work on one or more topics outside the core curriculum areas. Student are required to write and present on a topic in depth. For students in the applied concentration, MATH 3500(Methods of Applied Mathematics) fosters students' learning of techniques for performing research.

1.5 Departmental Initiatives and Significant Changes in the Past Five

Several of the changes listed in this section are also detailed in Section 1.2 and other sections of this self - study. In particular, certain curricular and staffing changes directly address some of Dr. Abrahamson's recommendations in his 2012 review. Listed below are some of the significant changes in the Department completed since the 2012 Program Review.

1.1.1 Staffing Changes

Five (out of a total of 11 tenure track positions in the Department) tenure track hires have occurred since 2012. Four of these were "replacement" hires for departing faculty members and one position was "new." Dr. Catherine Buell began working in the Department in academic year 2014/2015, Dr. Jenna Reis and Dr. Nermin Bayazit began in academic year 2015/2016, and Dr. Benjamin Levy and Dr. Sarah Wright arrived in this academic year 2016/2017. It should be pointed out that Dr. Bayazit is a specialist in mathematics education and that now, for the first time in 20 years, the education component of the Department is under an individual with a full background in mathematics education.

There were also three significant personnel changes in the Department since 2012. Dr. Mary Ann Barbato was promoted to Full Professor, Dr. Peter Staab was granted tenure, and Dr. Jennifer Berg was granted tenure and promoted to the rank of Associate Professor.

1.5.1 Curriculum Changes

Several significant curriculum changes have occurred in the last five years. First, the calculus sequence was changed from a four semester three credit format to a three semester four credit format. The calculus computer labs previously associated with Calculus I and Calculus II as a fourth credit in the "old" Calculus I and Calculus II were discontinued and replaced by a new three credit course, MATH 2550, Symbolic

Computational Mathematics, which is required in all major tracks. Secondly, MATH 1300, Precalculus, was changed from three credits to four credits and a modular approach is being developed and used. Thirdly, in the applied track, MATH 3900, Mathematics Seminar, was eliminated as a required course and MATH 2500, was added as a required course. The reasoning behind these changes was twofold. Majors in the applied track already are required to take a senior seminar course. Also, it was determined that majors in this track should be required to take a "proofs based" course. Fourthly, a new advanced course in scientific computation and visualization has been offered under "topics" and is being prepared for introduction into the formal course structure. Fifthly, several core syllabi were reviewed and changed, including MATH 1700, Applied Statistics, MATH 1500, Informal Number Theory, and MATH 1600, Informal Mathematical Modeling. Finally, the MAT program in the Department was formally dropped as it has been inactive and suspended for over 10 years. Discussions are ongoing with other departments with respect to creation of a revised or new master's program in STEM Education.

1.5.2 Supplemental Instruction

Applied Statistics, MATH 1700, has the highest enrollment of all Departmental service courses. A fourth meeting hour of "supplemental instruction" has been added for this course and the results are being studied as this system relates to the "D,F,W" rates for the course (see sections 4 and 5 for more details).

1.5.3 Mathematics Readiness Program

This program is seriously affected by state and Department of Education policies and initiatives. Many changes are ongoing as policies change. The Department made its own significant change with the creation of tracks in Basic Mathematics II. One track is more or less for STEM majors, namely those whose next course will be MATH 1250, Introduction to Functions, or MATH 1300, Precalculus. The other track is mostly for non STEM majors or those who will move on to other college level mathematics courses depending on their major. A modular approach is also being used in Basic Mathematics with in class tutors to help facilitate student progress (see section 4 for more details).

1.6 Centrality of Department Programs to the Mission and Vision of the University

The mission statement of Fitchburg State University reads:

Fitchburg State University is committed to excellence in teaching and learning and blends liberal arts and sciences and professional programs within a small college environment. Our comprehensive public university prepares students to lead, serve, and succeed by fostering lifelong learning and civic and global responsibility. A Fitchburg State education extends beyond our classrooms to include residential, professional, and co-curricular opportunities. As a community resource, we provide leadership and support for the economic, environmental, social, and cultural needs of North Central Massachusetts and the Commonwealth.

The core values of the University as given on its website are *accessibility, affordability community, enrichment, and excellence.*

The mission of the Department of Mathematics is to foster our students' self-reliance in mathematics, to produce graduates who can bring together the theory and practice of mathematics, and to create in graduates strengthened ability for critical and logical thinking.

The Mathematics Department advances the mission of the University by providing to Fitchburg State students the best possible programs it can deliver for all of the department's constituencies – the mathematics major program (including concentration options in applied mathematics and secondary education), the post-baccalaureate program leading to initial licensure as a secondary education teacher of mathematics, the traditional mathematics minor, the mathematics minor designed for the early childhood, elementary, and special education students, the mathematics service courses for students in disciplines which require particular quantitative knowledge and skills, the mathematics courses which satisfy graduation requirements of the Liberal Arts and Science Program, and the developmental mathematics program designed for students needing further preparation for college level mathematics.

The Mathematics Department supports the mission of the College in several ways:

a) The Department has offered a traditional mathematics major, which has compared favorably with majors at other liberal arts and comprehensive colleges. In addition to the calculus computer labs, the department initiated a Mathematics Seminar for mathematics majors in which students demonstrate writing and speaking skills in the study of problem solving and research on one or more topics outside the usual curriculum. Writing has become a part of many mathematics courses.

b) The mathematics offerings for the professional majors are considerable and have been continually re-evaluated. A list of service courses offered for particular majors can be found in the CURRICULUM section under *Mathematics Requirements for Other Majors*.

c) The Mathematics Department consistently attempts to keep an appropriate focus on mathematics content through the offerings of courses that are appropriate and up-to-date for the many different major programs it serves, and for its own mathematics majors.

d) The Elizabeth Haskins Mathematics Contest for area high school students has been an annual event for thirty years. Approximately 500-600 students have come to this event each year to compete for prizes, listen to talks on a variety of mathematical topics, and visit the campus.

e) The Math Circle program initiated during the period of the previous review continues in cooperation with the Fitchburg Arts Academy middle school on campus.

f) One member of the Department was awarded a grant from the National Endowment for the Humanities for a program in collaboration with a member of the Computer Science Department and undergraduate student research.

g) A program of "Supplemental Instruction" was developed and initiated to assist instruction in MATH 1700, Applied Statistics, the most populated service course offered by the Department. This program continues to evolve and be evaluated in formal and informal ways to assess its value for the many students and programs served by this course.

1.7 Program Structure

The Mathematics Department serves all students at the University. Mathematics majors receive a comprehensive foundation in abstract or applied mathematics as preparation for graduate studies or for a professional career. Minors in mathematics receive the mathematical foundation needed for advanced work in their major field. The Department also provides all students with courses for their major or with courses to fulfill the requirements of the Liberal Arts and Sciences Program.

Mathematics students may pursue:

- A concentration in a 'traditional' Mathematics program (analysis, algebra, geometry, number theory, and selected 'applied' fields).
- A concentration in Applied Mathematics (operations research, mathematical modeling, numerical analysis, graph theory, probability and statistics).
- Initial licensure as a high school mathematics teacher (a mathematics major program which includes geometry, number theory, probability and statistics, pedagogy, and practicum in a secondary school setting).
- **One of two minor programs in mathematics (one of these is a general program and one is designed for the Early Childhood, Elementary, and Special Education majors).**

The Bachelor of Science or Bachelor of Arts in Mathematics 'traditional' major program is comprised of 46 credit hours of course work. Twenty-five (25) of those required credit hours are for specified mathematics courses, three (3) are for a required course in computer science, three (3) are for a required speech course and for the remaining fifteen (15) credit hours, students may choose any five courses from among the 3000 and 4000 level mathematics electives offered, at least three of the electives chosen must be at the 4000 level. All upper level mathematics electives are 3-credit hour courses.

The Bachelor of Science in Applied Mathematics is comprised of 43 credit hours of course work in mathematics, 3 credit hours for a required speech course, and 3 credit hours for a required computer science course. Requirements mirror those of the 'traditional' program described above with twenty-one (21) of the required credit hours identical to those of that program. Nine (9) additional credit hours for mathematics courses are specified with a choice of 12-credit hours (or four courses) in mathematics electives. At least three of these elective courses must be at or above the 3000 level. In addition, the program requires eight (8) credit hours in General (or Calculus Based) Physics I and II and also requires a minor in biology, chemistry, computer science, economics, geography/earth science, psychology, or another major approved by the department. The program is designed to provide students with a strong mathematical background and an emphasis in a second field in which the student can integrate his/her mathematical knowledge.

The Bachelor of Science in Mathematics with Initial Teacher Licensure program is structured similarly to the 'traditional' mathematics major program described above with both an exception to the number of 'free' electives and with an add-on of course work designed to introduce students to theories and practices in secondary education. The mathematics portion of this program has two additional 'required' mathematics courses (Math 3000 Geometry and Math 4200 Probability and Statistics I). Hence the 'free' upper level mathematics electives are reduced in number to three (3), at least two (2) of which must be at the 4000 level. Four (4) additional 3-credit hour courses in educational theory and practice, including a special course in methods of teaching secondary school mathematics are required. In addition, two 150-

hour practicums in a secondary school are required. Students who successfully complete this program are awarded the Initial Teacher Licensure as a high school mathematics teacher in the state of Massachusetts. This program also has NCATE certification.

The post-baccalaureate secondary education program is designed to provide the student who has already earned a Bachelor's degree an avenue to acquire the Massachusetts' Initial Teacher Licensure as a secondary education mathematics teacher. The program requirements mirror those of the corresponding program for undergraduate students.

The 'traditional' minor in mathematics is composed of twenty-three (23) semester hours of mathematics courses, consisting of eight (8) credit hours in calculus, three (3) in either Linear or Abstract Algebra, and twelve (12) credit hours of mathematics electives. The electives must satisfy particular requirements with respect to course level and type of course. The level of mathematical attainment in this mathematics minor program is approximately equal to one half that in the mathematics major program.

The mathematics minor for Early Childhood, Elementary, or Special Education majors is a 23-24 credit hour program which includes seven 3 or 4-credit hour courses in mathematics. It is designed to integrate the three mathematics course requirements for all education majors into a program that gives the student a basic understanding of those concepts in higher mathematics that have special relevance to the mathematics taught in the elementary classroom.

1.8 Interdisciplinary Programs

The Applied Mathematics concentration is an interdisciplinary program in that requires the student to have a minor in a discipline that uses mathematics, and has a program requirement that the student complete a mathematically-related research project on a topic from the minor field of study. Ideally this project will be directed by both a supporting faculty member from the department in which the minor is offered and a faculty member from the Mathematics Department.

The three-mathematics course requirement for Early Childhood, Elementary, and Special Education majors, while not a formal interdisciplinary program, is a program in which the Mathematics and Education Departments expect to have continued collaboration.

2. THE FACULTY

The full-time mathematics faculty members of the department have varied backgrounds and academic interests. We currently have 12 members of the full-time faculty, including 1 faculty member on a one-year temporary position. Of the 12 faculty members, 8 are women and 4 are men. One of the faculty members is a person of color and the background of the faculty represents a broad geographic distribution of the U.S. and world. Since the last review, we added five (5) members to our faculty, which has brought new ideas and interests to the department. The research interests of the faculty include mathematics education, graph theory, mathematical knowledge for teaching, advanced mathematical thinking (particularly proof), teacher education, field experiences, co-teaching, representation theory and combinatorics, , assessment, algebraic group theory, symmetric spaces, lie groups and lie algebras, summability theory, mathematical biology, infectious disease modeling, population modeling, distribution modeling, statistical modeling, undergraduate education, linear algebra, numerical analysis, orthogonal polynomials, image processing, fluid mechanics, dynamical systems, numerical analysis, partial differential equations, mathematical pedagogy, combinatorial matrix theory, matrix completion problems, history of mathematics, differential equation, and analysis. Many of the faculty members regularly attend national mathematics conferences with some having recently given presentations at these conferences, and are involved in various other professional development activities. There is a strong focus across the faculty on undergraduates, with a faculty supervised math-club, faculty guided research and general close contact with mathematics majors and alumni. Other activities of the faculty include heading the Massachusetts Eta Chapter of Pi Mu Epsilon, running a math circle at a local middle school, and extensive committee work for Fitchburg State University. More details are categorized in the sections below and can be found in Appendix B, which includes a complete list of the faculty members and their vitae. which includes a complete list of the faculty members and their vitae.

The Department also employs several part-time faculty members each semester and has been fortunate to have a few excellent and dedicated long-time adjuncts. The adjunct faculty members teach most of our developmental mathematics course sections as well as some 1000-level course sections each semester. The developmental courses are module-based courses where students work at their own pace. Each developmental course has an instructor and a professional in-class tutor. For non-developmental courses, the instructors have full responsibilities, although some course coordination has recently been established for Applied Statistics and Introduction to Functions. Many adjuncts give useful input on the courses they teach as well as departmental policies. The resumes of our current adjuncts are included in Appendix B.2.

2.1 Faculty Teaching Activities

Faculty full-time teaching responsibility consists of 12 credits per semester. Approximately three-quarters of the sections taught in each semester are devoted to service courses. Hence, each faculty member typically gets one mathematics major course and three service courses to teach in any given semester.

Because the courses in our Calculus sequence are each four credits and the seminar courses are one-credit courses, several of our faculty routinely carry overloads and hence are compensated at a later time with a course reduction.

The Mathematics faculty members are generous in doing independent/directed studies with students. Directed studies are occasionally offered if a student misses a course when it was offered, but still needs it for graduation. Several faculty have offered independent studies for students who are interested in mathematics research. These activities are indicative of the support and encouragement departmental faculty extend to our students. These extras are especially notable because this work yields very little compensation. (For a 3-credit directed or independent study course a faculty member is compensated at the rate of ¼ -credit per student.) Recent independent and directed studies include: Probability and Statistics, Tropical Algebra, Senior Seminar in Applied Mathematics, Complex Analysis, Operations Research, Ordinary Differential Equations, Mathematics Seminar, Abstract Algebra 2, Topology, and Introduction to Mathematical Thought,

In response to comments from the external reviewer in our last self-study, in AY 2015 the department voted to change the calculus sequence to a three three-credit sequence and added a three-credit course on mathematical software. (See Section 3 on curriculum for more details.) Several of our courses are offered as online classes through Graduate and Continuing Education Most of the online classes are taught by adjuncts, but one of our tenured faculty members regularly teaches Precalculus online in the summer.

2.2 Faculty Research, Outreach and Professional Activities

Our faculty members are very active outside of teaching. Since the last review, our faculty members have collectively given numerous presentations at local, regional, national and international conferences. Many have also attended professional development workshops, participated in grant activities and organized mathematics activities with the local public schools.

The department has hired five new faculty members in the department in the past three years. These faculty members have hit the ground running. One faculty member was awarded $1900 worth of grants and awards from various entities at Fitchburg State University in the spring of her first year of teaching here. This same faculty member has given four presentations in her first 1.5 years at Fitchburg State University.

Another faculty member has been awarded almost $60,500 worth of grants, including a $40,000 grant from the National Endowment for the Humanities for Scientific Workflows, *Image Analysis, and Visual Stylometry in the Digital Analysis of Art*, and $15,000 from the Associated College of the South for a *Math and Social Justice Workshop* at Rollins College. Another faculty member was awarded a $40,000 grant from the Massachusetts Department of Higher Education State University STEM Retention and Completion Program and a three-year grant from the Department of Higher Education Performance Incentive Grant for over $418,000 for the three years to revamp our Developmental Mathematics program. With the help of the mathematics department, Fitchburg State University was also awarded a grant to run a Massachusetts Licensure Academy course for in-service teachers on Content and Pedagogy. The course was co-taught by three members of the mathematics department and one member of the education department for 3 semesters and was coordinated by a member of our department. Grant funds for the three semesters exceeded $113,400.

Five of our faculty members have been Project NeXt fellows, two of which were awarded Project Next Fellowships this year. Among all of our faculty members, we have at least 8 publications in the past 5 years while employed at Fitchburg State University. In addition, we collectively have 3 accepted papers, 6 works in the submission stage, and 12 publications in progress. These publications include articles, books, and book reviews, among other publications.

The department is also very focused on service to the university community, the community surrounding the university, the state, and the nation at large. Each year the department discusses who will sign up for each all-campus committee, ensuring wide representation among the committees. Through this process, we have representation on the main governance committees on campus that oversee curriculum and policy changes and collective bargaining issues as well as several other committees on the campus at large. Similarly, we typically have good representation on our departmental committees, including the Departmental Curriculum Committee, Assessment Committee, Seminar Committee, Hospitality Committee, Peer Evaluation Committee, and Contest Committee, as well as several other "as needed" committees, such as the hiring committee and the calculus textbook committee. In addition, department members regularly serve on both departmental and campus-wide tenure and promotion committees as well as volunteer to serve on search committees for administrative hires. The Mathematics Department has regularly had members participate in university-wide accreditation efforts, in particular drafting 10- and five-year self-study reports for NEASC accreditation.

Service to the community includes enrichment activities for K-12 students in the area. Statewide contributions include involvement in PARCC (Partnership for Assessment of Readiness for College and Careers), Massachusetts Transfer Pathways, STEM education collaboration and the Union Bargaining Committee. Nationally, faculty have been involved in judging poster sessions, editing and reviewing journal articles, organizing and participating in research groups, collaborating on creating modules for K-12 classrooms, PARCC revisions and standard setting. One faculty member is involved in research internationally, including mathematical modeling of Ebola outbreaks in Africa.

In addition, members of our department are integrally involved in assessment at the departmental, institution-wide, and state-wide level, and we are constantly seeking opportunities to improve assessment and teaching and learning. Members of the department are constantly evaluating their teaching and communicate with one another about their changes, what is working, and what they would like to further improve on. One of the venues for this discussion are our Departmental Discussions on Teaching (Math DOTs), which are held 2 times per year.

We have a vibrant constantly changing department. We are open to new ideas and are committed to improving our teaching and curriculum. Each new influx of faculty has infused new ideas and energy into the department and has given all of us the opportunity to evolve.

3. CURRICULUM

3.1 Program Objectives

The mission of the Department of Mathematics is to foster our students' self-reliance in mathematics, to produce graduates who can bring together the theory and practice of mathematics, and to create in graduates a strengthened ability for critical and logical thinking.

The Mathematics Department advances this mission by providing to Fitchburg State University students the best possible programs it can deliver for:

- The mathematics major program
- The mathematics major leading to initial licensure as a secondary education teacher of mathematics
- The mathematics major with a concentration in Applied Mathematics
- The post-baccalaureate program for initial licensure as a secondary education teacher of mathematics
- The mathematics minor program
- The mathematics minor program for Early Childhood, Elementary and Special Education students.
- The mathematics service courses for students in disciplines which require particular quantitative knowledge and skills
- The mathematics courses which satisfy graduation requirements of the Liberal Arts and Science Program
- The developmental mathematics program designed for students needing further preparation for college level mathematics

While each of these components has a somewhat different purpose and objectives, the all- encompassing goal of the Department of Mathematics is to provide Fitchburg State students with the best possible teaching and learning environment, to ensure the academic integrity and academic quality of all mathematics programs and individual courses, and to actively encourage the academic growth and success of all students. The Department of Mathematics serves all students at the University. Mathematics majors receive a comprehensive foundation in abstract and applied mathematics as preparation for a professional career or for further study. Minors in mathematics receive the mathematical foundation needed for advanced work in their major fields. Other students receive instruction in the quantitative theory and skills appropriate for their chosen disciplines. The hope is that all students also receive an appreciation of mathematics as an intellectual endeavor.

The Bachelor of Science or the Bachelor of Arts in Mathematics major program is designed to provide the student with a comprehensive foundation in abstract and applied mathematics and an appreciation of mathematics as an intellectual endeavor. The program is designed to provide the mathematics majors with maximum career flexibility including options for graduate study or for careers in areas such as technology, statistics, engineering, law, business, finance, actuarial science and operations research.

The Bachelor of Science or Bachelor of Arts in Mathematics with Initial Teacher Licensure program is designed to provide mathematics majors with an opportunity to teach mathematics at the secondary school level, grades 8 – 12. Students who successfully complete the program are awarded the Initial Teacher Licensure as a high school mathematics teacher in the state of Massachusetts.

The Bachelor of Science or Bachelor of Arts in Mathematics with Applied Mathematics Concentration program is designed to provide mathematics majors with an opportunity to integrate mathematics into another field of study. Students who complete this program will have a strong mathematical background as well as an emphasis in a second field.

The Bachelor of Science in Middle School Education Mathematics Initial Teacher Licensure program is designed to provide mathematics majors with an opportunity to teach mathematics at the middle school level, grades 5 – 8. Students who successfully complete the program are awarded the Initial Teacher Licensure as a middle school mathematics teacher in the state of Massachusetts.

The post-baccalaureate secondary education program is designed to provide the student who has already earned a Bachelor's degree an avenue to acquire the Massachusetts' Initial Teacher Licensure as a secondary education mathematics teacher. The program requirements mirror those of the corresponding program for undergraduate students.

The minor in mathematics is designed to provide the student with a firm mathematical foundation needed to successfully pursue the study of higher level mathematics or to provide a solid mathematical basis for advancing in the study of another quantitative or scientific discipline. The level of mathematical attainment in the minor program is approximately equal to one half that in the mathematics major program.

The mathematics minor for Early Childhood, Elementary and Special Education Students is designed to provide Early Childhood, Elementary and Special Education students who are interested and strong in mathematics, with an opportunity to study further mathematics that is appropriate for their future teaching career. Students who complete this program will have the opportunity to become mathematics specialists in elementary school.

Courses and programs to serve other disciplines are designed to provide students with the particular mathematical understandings and skills required in those other disciplines. Periodic consultation with faculty of the partner disciplines aims to ensure that these students are equipped with the requisite mathematical skills for their programs of study.

Courses to fulfill core Liberal Arts and Sciences requirements are designed to provide students with an understanding of mathematics as an academic discipline which can be used to solve a wide variety of problems encountered in many diverse areas. These courses also aim to enhance the problem solving and analytical skills of the students and expose them to college level mathematics. These courses are intended to address the following student learning outcome form the Liberal Arts and Sciences program:

> "Students will think critically and synthesize ideas within and across disciplines. They will fuse experience, training and research into considered judgment, then working individually or with others, form problem-solving strategies and evaluate their effectiveness. Among these strategies, students will analyze and interpret data as a means to evaluate arguments and make informed choices."

The developmental mathematics program is designed to give students the basic numerical and algebraic skills needed for the successful study of college level mathematics courses or other college level courses which require quantitative or mathematical skills. Our so called “Mathematics Readiness Requirement”, is a prerequisite for many introductory level mathematics courses and is detailed in section 3.6. We have been piloting alternate forms of mathematics placement and remediation which is also explained in section 3.6

Our *Master of Arts Program in Teaching Mathematics* which ran from 1999 until 2004 will be removed from our program this academic year due to several years of inactivity. Corresponding courses will remain on the books and the Mathematics Department will continue to collaborate with other departments on the potential creation of a Master of Arts in STEM Education in an attempt to streamline our math and science education graduate and post baccalaureate programs as well as serve the current population of in service teachers.

3.2 Description of the Curricula

3.2.1 The Bachelor of Science or the Bachelor of Arts in Mathematics

Required Courses in Mathematics

Course Number	Course Name	3.2.1.1 Credit hours
MATH 2300	Calculus I	4
Math 2400	Calculus II	4
Math 2500	Introduction to Math Thought	3
Math 2550	Symbolic Computational Mathematics	3
Math 2600	Linear Algebra	3
Math 3550	Multivariate Calculus	4
Math 3900	Mathematics Seminar	1
Math 4300	Abstract Algebra (fulfills FSU junior-senior writing requirement)	3

The student must also complete 15 additional credits of advanced mathematics (3000 or 4000 level, 9cr. of which must be at the 4000 level)

Required Courses in other Departments

Course Number	Course Name	Credit Hours
SPCH 1000 OR SPCH 1100	Introduction to Speech Communication **OR** Argumentation and Debate (fulfills Fitchburg State speaking and listening requirement*)	3
CSC 1500	Computer Science I (fulfills Fitchburg State computer literacy requirement*)	3

Note: Students pursuing a Bachelor of Arts degree as opposed to a Bachelor of Science degree are also required to obtain proficiency of a foreign language at the intermediate level. This can be done by completing appropriate coursework and/or by attaining a sufficiently high score on the CLEP exam.

*Every major program at Fitchburg State must fulfill these requirements. The details of how to satisfy these requirements for each major is left up to the individual departments.

See Appendix D for the suggested Four Year **Plan** of Study for the mathematics major program.

3.2.2 The Bachelor's in Mathematics with Initial Teacher Licensure, Grades 8 – 12

Required Courses in Mathematics

Course Number	Course Name	Credit Hours
MATH 2300	Calculus I	4
MATH 2400	Calculus II	4
MATH 2500	Introduction to Mathematical Thought	3
MATH 2550	Symbolic Computational Mathematics	3
MATH 2600	Linear Algebra	3
MATH 3000	Geometry	3
MATH 3350	Multivariate Calculus	4
MATH 3900	Mathematics Seminar	1
MATH 4200	Probability and Statistics I	3
MATH 4300	Abstract Algebra (fulfills Fitchburg State junior-senior writing requirement)	3

The student must also complete 9 additional credits of advanced mathematics (3000 or 4000 level, 6cr. of which must be at the 4000 level)

Required Courses in other Departments

Course Number	Course Name	Credit Hours
SPCH 1000 OR SPCH 1100	Introduction to Speech Communication **OR** Argumentation and Debate (fulfills Fitchburg State speaking and listening requirement*)	3
CSC 1500	Computer Science I (fulfills Fitchburg State computer literacy requirement*)	3

Required Courses for Initial Licensure in Secondary Education Mathematics

Course Number	Course Name	Credit Hours
MATH 2860	Introduction to Secondary School Teaching 3cr.	3
EDUC 3122	Sheltered English Immersion (SEI) 3cr.	3

SPED 3800	Secondary Programs for Adolescents (14-22) with Disabilities 3cr.	3
ENGL 4700	Teaching Reading and Writing Across the Content Area 3cr.	3
MATH 4850	Methods and Materials in Secondary Mathematics 3cr.	3
MATH 4012	Practicum Seminar 3cr. (co-requisite for practicum)	3
MATH 4860	Mathematics Practicum in Secondary School I (150 hrs.) 4.5cr.	4.5
MATH 4870	Mathematics Practicum in Secondary School II (150 hrs.) 4.5cr.	4.5

See Appendix D for the suggested Four Year Plan of Study for the mathematics major program with initial teacher licensure, grades 8-12.

3.2.3 Bachelor's of Science in Mathematics with Concentration in Applied Mathematics

Required Mathematics Courses

Course Number	**Course Name**	**Credit Hours**
MATH 1850	Freshman Seminar in Applied Mathematics	1
MATH 2300	Calculus I	4
MATH 2400	Calculus II	4
MATH 2500	Introduction to Mathematical Thought	3
MATH 2550	Symbolic Computational Mathematics	3
MATH 2600	Linear Algebra	3
MATH 3350	Multivariate Calculus	4
MATH 3500	Methods in Applied Mathematics	3
MATH 3550	Ordinary Differential Equations	3
MATH 4400 or MATH 4450	Operations Research **OR** Mathematical Modeling	3
MATH 4600	Senior Seminar in Applied Mathematics (fulfills the Fitchburg State junior-senior writing requirement)	3

The student must also complete 3 additional courses (at least two of which must be at the 3000 level or higher) selected from the following:

Course Number	**Course Name**	**Credit Hours**
MATH 1900	Discrete Mathematics	3
MATH 3150	Elementary Number Theory	3
MATH 4200	Probability and Statistics I	3
MATH 4250	Probability and Statistics II	3
MATH 4300	Abstract Algebra	3
MATH 4350	Complex Analysis	3
MATH 4400 **or** MATH 4450	Operations Research **or** Mathematical Modeling	3
MATH 4500	Numerical Analysis	3

Required Courses in other Departments

PHYS 2600 or PHYS 2300	Calculus Based Physics I **OR** General Physics I	4
PHYS 2700 or PHYS 2400	Calculus Based Physics II or General Physics II	4
SPCH 1000 OR SPCH 1100	Introduction to Speech Communication **OR** Argumentation and Debate (fulfills speaking and listening requirement)	3
CSC 1500	Computer Science I (fulfills the Fitchburg State computer literacy requirement)	3

Required Minor in another Department

A core aspect of the applied math program is knowledge of another field. The student must also minor in one of the following areas: Computer Science, Psychological Science, Biology, Chemistry, Economics, Earth Systems Science, Geographic Science & Technology or a minor approved by the Mathematics Department. Note: Many of the courses in the minor can be counted toward the Liberal Arts and Science (LA&S) courses.

See Appendix D for the suggested Four Year Plan of Study for the mathematics major program with concentration in applied mathematics.

3.2.4 The Bachelor's in Mathematics with Initial Teacher Licensure, Grades 5 – 8

The requirements for this program are as follows:

Required Courses in Mathematics

Course Number	Course Name	Credit Hours
MATH 2300	Calculus I	4
MATH 2400	Calculus II	4
MATH 2500	Introduction to Mathematical Thought	3
MATH 2550	Symbolic Computational Mathematics	3
MATH 2600	Linear Algebra	3
MATH 3000	Geometry	3
MATH 3200	History of Mathematics	3
MATH 3350	Multivariate Calculus	4
MATH 3900	Mathematics Seminar	1
MATH 4300	Abstract Algebra	3

The student must also complete 9 additional credits of advanced mathematics at the 4000 level.

Required Courses in other Departments

Course Number	Course Name	Credit Hours
SPCH 1000 OR SPCH 1100	Introduction to Speech Communication OR Argumentation and Debate (fulfills Fitchburg State speaking and listening requirement*)	3
CSC 1500	Computer Science I (fulfills Fitchburg State computer literacy requirement*)	3

Required Courses for Middle School Education

Course Number	Course Name	Credit Hours
EDUC 2300	Foundations of Inclusive Education	3
EDUC 3070	Middle School Concept	3
EDUC 3026	Teaching Math in the Middle School	3
EDUC 3122	Sheltered English Immersion (SEI).	3
EDUC 3300	Curriculum, Instruction, and Assessment in the Middle School	3
EDUC 4550	Collaboration: Co-Teaching, Building Communities, and Working with Families	3
SPED 2210	Understanding Diversity and Disability	3
SPED 3720	Classroom Management and Behavior Support	3
SPED 3800	Secondary Programs for Adolescents (14-22) with Disabilities	3
ENGL 4700	Teaching Reading and Writing Across the Content Area	3
EDUC 3740	Onsite Immersion Field Experience	3
EDUC 4885	Practicum in Middle School Education I .	6
EDUC 4886	Practicum in Middle School Education II	6

See Appendix D for the suggested Four Year Plan of Study for the middle school mathematics program with initial teacher licensure, grades 5-8.

3.2.5 Post-Baccalaureate Program in Mathematics Education, Grades 8-12

Course Number	Course Name	Credit Hours
SEED 7015 **OR** MATH 2860	Intro. to Strategies for Effective Teaching in the Academic Discipline **OR** Introduction to Secondary School Teaching	3
SPED 7709 **OR**	The High School Environment-Challenges in Educating Students with Disabilities **OR**	3

SPED 3800	Secondary Programs for Adolescents (14-22) with Disabilities	
ENGL 8076 **OR** ENGL 4700	Creating Literacy Experience: Building Reading and Writing into the Content **OR** Teaching Reading and Writing Across the Content Area	3
MATH 8000 **OR** MATH 4850	Advanced Methods of Teaching at the Secondary Level **OR** Methods and Materials in Secondary Mathematics	
MATH 8090 **OR** MATH 4860 **AND** MATH 4870	Practicum **OR** Mathematics Practicum in Secondary School I (150 hrs.) **AND** Mathematics Practicum in Secondary School II (150 hrs.)	

Students who enroll in this program must meet the following criteria:

- A bachelor's degree with a cumulative GPA of 2.8 or higher
- Successful completion of the Communication and Literacy Skills Sub-test of the Massachusetts Test for Educator Licensure (MTEL).

Once accepted, students will undergo a transcript review by the undergraduate advisor, as designated by the department, and a plan of study will be developed that addresses both the education requirements and the mathematical requirements needed to complete the program. Students will complete all requirements of the major and license as identified in the undergraduate program. Once a student has completed all requirements for professional and content-specific courses, the student will be eligible for endorsement for the initial licensure in secondary mathematics through Fitchburg State University. Note that in order to enroll in the Practicum courses the students will have had to pass the Mathematics (content) MTEL.

3.2.6 Requirements for the Minor in Mathematics

A minor in Mathematics is comprised of 23 semester hours of mathematics coursework as follows:

Course Number	**Course Name**	**Credit Hours**
MATH 2300	Calculus I	4
MATH 2400	Calculus II	4
MATH 2600 OR MATH 4300	Introduction to Mathematical Thought **OR** Abstract Algebra	3

The students must also complete at least 12 additional credits in mathematics, at least 3 of which must be at the 3000 level or above and at least one of which must be at the 4000 level or above.

The majority of students earning a minor in mathematics are either Computer Science majors or Middle School Education majors who have chosen interdisciplinary studies as their second major with a concentration in mathematics.

3.2.7 Requirements for the Mathematics Minor for Early Childhood, Elementary and Special Education Students

This minor is comprised of 21-23 credit hours as follows:

Course Name	Course Name	Credit Hours
Math 1300	Precalculus	4
Math 1500	Informal Number Theory	3
Math 2000	Informal Geometry	3
Math 2300	Calculus	4
Math 1900 OR Math 2500	Discrete Mathematics OR Introduction to Mathematical Thought	3

Plus 2 of the following courses:

Course Number	Course Name	Credit Hours
MATH 1700	Applied Statistics (if this is taken, MATH 1900 may not be taken)	3
MATH 2400	Calculus II	4
MATH 2600	Linear Algebra	3
MATH 3000	Geometry	3
MATH 3150	Elementary Number Theory	3
Any 3000 or 4000 level 3-credit mathematics course except MATH 4850, 4860 and 4870		3

Middle School Education students pursing the Mathematics/Science Track must complete a minor in mathematics in addition to the other requirements of their program.

3.2.8 Mathematics Department Courses

Below is a list of all departmental courses. Most of the upper level mathematics electives are offered on a two-year rotating schedule. See Appendix D.2 for the Mathematics Course Scheduling Plan.

Course Name	Course Name	Credit Hours
Math 0100	Basic Mathematics I (does not count toward graduation)	3
Math 0200	Basic Mathematics II (does not count toward graduation)	3
Math 1200	Finite Mathematics	3
Math 1250	Introduction to Functions	3
Math 1300	Precalculus	4
Math 1500	Informal Number Theory	3

Math 1600	Informal Mathematical Modeling	3
Math 1700	Applied Statistics	3
Math 1800	Business Statistics	3
Math 1850	Freshman Seminar in Applied Mathematics	3
Math 1900	Discrete Mathematics	3
Math 2000	Informal Geometry	3
Math 2100	Technical Calculus	3
Math 2200	Business Calculus	3
Math 2300	Calculus I	4
Math 2400	Calculus II	4
Math 2500	Introduction to Mathematical Thought	3
Math 2550	Symbolic Computational Mathematics	3
Math 2600	Linear Algebra	3
Math 2680	Introduction to Secondary School Teaching	3
Math 3000	Geometry	3
Math 3150	Elementary Number Theory	3
Math 3200	History of Mathematics	3
Math 3350	Multivariate Calculus	4
Math 3500	Methods of Applied Mathematics	3
Math 3550	Ordinary Differential Equations	3
Math 3900	Mathematics Seminar	1
Math 4000	Real Variable Theory	3
Math 4012	Practicum Seminar	3
Math 4050	Topology	3
Math 4150	Advanced Multivariate Calculus	3
Math 4200	Probability and Statistics I	3
Math 4250	Probability and Statistics II	3
Math 4300	Abstract Algebra	3
Math 4350	Complex Analysis	3
Math 4400	Operations Research	3
Math 4450	Mathematical Modeling	3
Math 4500	Numerical Analysis	3
Math 4600	Senior Seminar in Applied Mathematics	3
Math 4860	Special Methods in Teaching Mathematics	3
Math 4900	Independent Study	1,2 or 3
Math 4901	Independent Study	1,2 or 3
Math 4975	Directed Study	1-6

The following courses are new since our last program review in 2012: Math 2550, Math 3350, Math 4012.

The following courses were omitted since our last program review in 2012: Applied Statistics II, Calculus III, Calculus IV.

In addition, we have offered the following so called “topics courses” which are defined as experimental courses and may be scheduled for up to two semesters prior to being submitted to governance for formal approval as regular course offerings.

- MATH 3001: Scientific Computing and Visualization (cross listed with CSC 3003)
- HON 1700: Honors Applied Statistics (offered for the first time in spring 2017)

HON 1700 is being piloted to fulfill the math requirement for honors students who also need to take applied statics as part of their major requirements. This will prevent these students from having to take an extra mathematics course. The expectation is that this will go through governance in 2017.

3.2.9 Mathematics Requirements for Other Majors

All students, regardless of major, must complete at least one college level mathematics course to satisfy the Liberal Arts & Sciences Program Requirement. Some majors specify which particular mathematics course or courses its students must take.

Specific mathematics courses required by various major programs are outlined below.

Major	**Mathematics Course(s)**
Biology	Two courses at or above the level of Math 1300 Precalculus (Math 1300, Math 1700 and/or Math 2300 recommended and in some cases required depending on the concentration).
Business Administration	• Math 1250 – Introduction to Functions (if needed) • Math 1800 – Business Statistics • Math 2200 – Business Calculus
Chemistry (new since last review)	• Math 1300: Precalculus • Math 2300: Calculus I • Math 2400: Calculus II
Communications Media	Math 2000 recommended
Computer Information Systems	• Math 1250: Introduction to Functions (if needed) • Math/CSC 1900: Discrete Mathematics • Math 2200: Business Calculus
Computer Science	• Math 1300: Precalculus (if needed) • Math 1800: Business Statistics • Math/CSC 1900: Discrete Mathematics • Math 2300: Calculus I • Math 2400: Calculus II • Math 2600: Linear Algebra • Math elective at 3000-level or above
Criminal Justice	Math 1700: Applied Mathematics
Economics	• Math 1250: Introduction to Functions (if needed) • Math 1800: Business Statistics • Math 2200: Business Calculus
Early Childhood, Elementary and Special Education	• Math 1500: Informal Number Theory • Math 1600: Informal Mathematical Modeling

	• Math 2000: Informal Geometry
Earth Systems Science	Two courses at or above the level of Math 1300: Precalculus
Exercise & Sports Science	• Math 1250 recommended for Fitness Management students • Math1700 recommended for Clinical Exercise Physiology students
Geographic Science and Technology	One course at or above the level of Math 1300: Precalculus
Honors Program	• Math/CSC 1900: Discrete Math **OR** • HON 1700: Honors Applied Statistics **OR** • a math course at the level of Math 2300: Calculus I
Industrial Technology	• Math 1300: Precalculus • Math 2100: Technical Calculus (architecture students only)
Nursing	• Math 1700: Applied Statistics
Political Science	• Math 1700: Applied Statistics
Psychological Science	• Math 1700: Applied Statistics
Sociology	• Math 1700: Applied Statistics
All other majors	• One college-level mathematics courses

The Mathematics Department has prepared a “Guide to Mathematics Courses” that it sends to all faculty advisors prior to each registration period to help ensure that students are directed to the most appropriate mathematics courses for their program and their level of preparation. See Appendix D.

3.3 Relationships of Courses and Curriculum to Objectives and Mission

3.3.1 Department Mission Statement

The mission of the Department of Mathematics is to foster our students' self-reliance in mathematics and a strengthened ability for critical and logical thinking and to produce graduates who can bring together the theory and practice of mathematics.

The sections below detail how our curriculum is related to our Departmental Mission.

3.3.2 Goals for the Mathematics Major

It is expected that each undergraduate mathematics major, upon graduation from Fitchburg State University, should:

- possess an understanding of the breadth of the mathematical sciences and their deep interconnecting principles.
- be able to apply mathematics to a broad spectrum of complex problems and issues by formulating and solving problems.
- be able to read, write, listen, and speak mathematically, as well as to be able to read and understand technically-based materials and to contribute effectively to group efforts.

- have an understanding of the appropriate uses of technology in mathematics.
- be adequately prepared for a mathematically-oriented career.

These are the Goals for the Mathematics Major as stated in the Department's Outcomes Assessment Plan. The relationship of these goals to the courses and curriculum is included below.

The inclusion of the calculus sequence, Calculus I, II, and Multivariate Calculus in the program is standard practice among institutions of higher learning. The ideas and techniques of calculus are used in most applied mathematics courses and in advanced level courses in analysis. Our calculus sequence is essentially a sequence of 3 four-credit courses recently switched from a 4-course sequence with an embedded lab component. This change was made in part to align with other 4-year state institutions, addressing a point made in previous program reviews. Along with this change came the creation of a required separate 3-credit lab course titled *Symbolic Computational Mathematics* designed to sustain and expand student exposure to mathematics technology in our curriculum. This was in response to alumni feedback during our last program review stating that more experience with technology would benefit our graduates. Currently, MAPLE is the principal software used in this course. Excellence, precision and completeness in expository mathematical writing are stressed on the lab reports. This portion of the curriculum teaches students to read and write mathematically, interact and learn from others in the classroom lab, use a computer algebra system as an exploratory and problem-solving tool, and formulate and solve problems. See Appendix E for samples of students' completed lab assignments.

The *Introduction to Mathematical Thought* course introduces students at an early stage to both rigorous treatment of mathematics and certain basic mathematical ideas that occur in many branches of mathematics. This course is designed to teach the fundamental strategies and styles used in mathematical proofs. Assignments demanding precise and clear writing of proofs are the norm for this course. So, students learn: to have a better understanding of the breadth of the mathematical sciences and their deep interconnecting principles, to be able to apply mathematics to a broad spectrum of complex problems and issues by formulating and solving problems, to think logically, to be able to read, write, listen and speak mathematically, and to emulate a professional mathematician's approach to proving theorems. Many students work together outside of class but are required to write up their solutions individually. See Appendix E for student work samples.

The *Linear Algebra* course includes an introduction to solutions of linear equations in n-dimensional space. Besides being an applied course, Linear Algebra provides a first introduction to abstract mathematical systems through the study of vector spaces. The students learn that the techniques used in real space can be extended to more abstract solutions. MAPLE and Mathematica software are used by the instructors of this course to illustrate concepts and give computer lab assignments, expanding their experience with mathematical technology

The *Abstract Algebra* course is included in the core curriculum in recognition of the subject's foundational relationship to all modern mathematics. Concepts introduced in this course are shared with all branches of mathematics and help students to see similarity in diversity and perceive an underlying global theme in mathematics. This course meets the Fitchburg State junior/senior level LA&S writing requirement for the major in mathematics. Assignments demanding precise and clear writing of proofs are the norm for this course. So students learn: to emulate a professional mathematician's approach to the abstract thinking processes involved in proving theorems and the precision required in expressing these proofs in formal written form, to have a better understanding of the breadth of the mathematical sciences and their deep interconnecting principles, to apply mathematics to a broad spectrum of complex problems and issues by formulating and solving problems, and to be able to read, write, listen and speak mathematically. See Appendix E for student work samples.

The *Mathematics Seminar* course exposes students to research and encourages them to read mathematical journals at the undergraduate level. Topics not ordinarily covered in other courses may be covered in the Mathematics Seminar. This course helps meet the Fitchburg State LA&S speaking/listening requirement for mathematics majors. Students give oral presentations and engage in mathematical expository writing. As a result of their work in this class, some students have given presentations at conferences. Thus, students learn: to read, write, listen and speak mathematically, read and understand technically-based materials, and contribute effectively to group efforts. They are also better prepared for a mathematically oriented career.

The *upper level course requirements* allow students some flexibility in choosing courses germane to their interests while guaranteeing exposure to a reasonable amount of sophisticated and rigorous mathematics. When the requirements are completed, students will have engaged in complex mathematical problem solving, expository mathematical writing, oral presentations, group and individual projects, and will have used technology for many assignments in a variety of contexts including having students submit work in LaTeX. And utilize appropriate technology. *Probability and Statistics I and II* are offered every year. Most other electives are offered once every two years on a posted rotating schedule. See Appendix D.

Independent Study offers flexibility for the mathematics major to take courses outside of the standard offerings. Some of our students intending to go to graduate school take one or more independent studies at the rigorous graduate level in algebra, analysis, or topology to help them prepare. Other students simply seek knowledge of an area that has interested them that is not available in electives.

Directed Study offers students the opportunity to take a course that is in the catalog but not being offered at a time, day and/or semester that suits their schedule. In the past 5 years, our faculty members have collectively done about 20 directed studies to accommodate students in such situations.

Additional flexibility is available through the offering of a topics course, experimental courses that may run for up to two semesters prior to being submitted through governance for formal approval as a regular course offering. The following topics course is currently being offered for the second time: MATH 3001 Scientific Computing and Visualization (cross listed with CSC 3003). It serves as a math or computer science elective and offers students the opportunity to visualize and solve mathematics and science problems using appropriate computational software as well as write their own programs.

3.3.3 Curriculum for Initial Licensure in Mathematics, Grades 8-12

Fitchburg State University's *undergraduate and post-baccalaureate mathematics secondary teacher preparation programs* lead to the Initial Licensure to teach mathematics for grades 8-12 in the Commonwealth of Massachusetts. These programs are part of the Education Unit, which includes all teacher preparation programs at the University. Under the regulations of the Massachusetts Department of Elementary and Secondary Education (DESE), all candidates for Initial Licensure must pass the

Communication and Literacy and Mathematics subject area exams of the Massachusetts Tests for Educator Licensure (MTEL). Fitchburg State University has adopted the policy that students may not enroll in a teaching practicum until they have passed these exams. The test objectives for the Mathematics subject area exam are (1) Number sense and operations; (2) Patterns, relations, and algebra; (3) Geometry and measurement; (4) Data analysis, statistics, and probability; (5) Trigonometry, calculus, and discrete mathematics. The subject matter knowledge requirements set by the DESE are (1) Abstract algebra; (2) Number theory; (3) Calculus through differential equations; (4) Probability and statistics; (5) Non-Euclidean and transformational geometries; (5) Applied mathematics or mathematics modeling. Our curriculum is designed to help students meet these subject matter requirements. As the state changes the curriculum frameworks (as is currently underway), the objectives for the MTEL examinations change, we've active faculty who participate in these changes (both to the frameworks and the test-objectives) so that we can adjust the curriculum as the state makes changes.

These programs must also include field-based experiences in varied settings that are integrated into the courses or seminars that address these standards. These field-based experiences can include observation of a variety of classrooms as well as other pre-practicum activities. In addition, the students are required to complete a supervised practicum of at least 300 hours at the secondary level. The practicum must be supervised jointly by someone from the sponsoring program and a supervising practitioner with at least three years of teaching experience under an appropriate Initial or Professional License. The program supervisor and supervising practitioner must complete a performance assessment of the teacher candidate using the professional standards.

To address these requirements, candidates in Secondary Education Mathematics at Fitchburg State complete 90 hours of pre-practicum. Each candidate completes a 25-hour pre-practicum in mathematics in conjunction with each of three different pedagogy courses, *MATH 2860* Introduction to Secondary School Teaching, and *ENGL 4700* Teaching Writing in Secondary Schools as well as 30 pre-practicum hours in *MATH 4850* Special Methods in Teaching Mathematics. Candidates must also complete a 15-hour pre-practicum in Special Education as part of the course *SPED 3800* Secondary Programs for Adolescents (14-22) with Disabilities. The completion and nature of the pre-practicum experience are supervised jointly by the faculty member teaching the associated class and the supervising practitioner in whose classroom the candidate is conducting the pre-practicum. The supervising practitioner documents the candidate's involvement in pre-practicum activities that are categorized as groups A, B and C. Type A activities involve passive observation of the class. Type B activities require interaction with the students either directly or through grading, and type C activities include running all or portions of the class. By the time candidates complete all pre-practicum experiences they must have documented participation in all three types of activities. In addition, each supervising practitioner must complete a Candidate Dispositions form.

Candidates in our program can only be accepted into the teaching practicum if, by the end of their junior year they have:

- completed 75 credits of coursework.
- earned a 2.75 overall GPA and a 3.0 GPA in their education courses.
- completed all the pre-practicum requirements.
- received passing scores on the Mathematics subtest of the MTEL.
- received at least four Candidate Dispositions Assessments (at least one from a supervising practitioner in a pre-practicum and one from a full-time faculty member in Education).

- completed the Mantoux TB screening test and a criminal background check.

In addition, candidates must have positive evaluations of at least 75 hours of pre-practicum experience, a portfolio review, and positive recommendation from their advisor, the faculty of the Mathematics Department, and the Dean of Education.

When candidates have met these requirements, and have completed all other requirements for graduation, they start their student teaching. Candidates are observed during their student teaching practicum by the college supervisor a minimum of eight times during the semester-long practicum. A unit-wide assessment of each observation is completed by the University supervisor and inserted into the candidate's practicum file. Lesson plans are also evaluated at each visit with the unit's rubric and these evaluations are also compiled in the candidate's practicum file. During the practicum, candidates' dispositions are also evaluated by the supervising practitioner and the college supervisor utilizing the Unit's Dispositions Assessment form. All of these assessment items are included in the Candidate's practicum file and serve as additional pieces of evidence that the candidate has satisfied the initial licensure requirements of the Massachusetts Department of Education.

At least twice during the practicum the Massachusetts Pre-service Performance Assessment is reviewed by the college supervisor, supervising practitioner and the candidate to assess the candidate's performance in meeting state standards for licensure. This assessment involves completing the Practicum Evaluation Report. During the final review of these standards, it is determined if a candidate will/will not be recommended for licensure based on the compilation of evidence in the candidate's file and his/her ongoing work in the practicum. The evidence for meeting the standards must be described in detail on the Massachusetts Pre-service Performance Assessment form. See Appendix E for sample portfolios.

The Fitchburg State mathematics secondary programs have national certification from the Council for the Accreditation of Educator Preparation (CAEP).

3.3.4 The Mathematics Major with Applied Mathematics Concentration

With the exception of MATH 4300 Abstract Algebra, this concentration includes the same requirements as in the regular Mathematics Major. See section 3.1. In addition, it includes physics, applied mathematics courses and a minor in another field. The descriptions and goals of the required applied mathematics courses are explained below.

The *Freshman Seminar in Applied Mathematics* is a one credit course consisting of a series of talks given by members of the Applied Mathematics community (either in academia or industry) demonstrating an application of applied mathematics with preparatory and follow-up work.

The goal of the course is to present students with real-world applications of mathematics. It introduces students to possible areas of study and the mathematics used in the talks. The students are introduced to background mathematics that is used in the talks, which gives them motivation for a thorough grounding in mathematics as well as the application.

The *Methods of Applied Mathematics* course is designed for students to learn the basic techniques necessary for performing research in an application of Mathematics to another field of study. The students also learn to use a Computer Algebra System for analysis and visualization. The goal is to give the students a firm foundation for pursuing further study in Applied Mathematics, as well as have a good appreciation for the use of Computer Algebra Systems to aid the analysis and visualization of mathematical problems. In addition to gaining a thorough understanding of the topics covered, this course aims to improve students' mathematics communication skills both in written and oral form.

The *Ordinary Differential Equations* requirement addresses linear first and second order differential equations, methods of solution and applications. Series solutions and higher order linear equations are also considered.

The *Mathematical Modeling/Operations Research* requirement emphasizes the mathematics used in applications to the physical, social and life sciences. Operations Research includes linear programming, network modeling, dynamic programming and stochastic models. Mathematical Modeling includes some of these concepts but studies applications of mathematics more broadly. In both courses students are exposed to using computer programs to help solve problems.

The *Senior Seminar in Applied Mathematics* is a one credit course designed for seniors in applied mathematics to develop and complete a senior project. This is the capstone course in Applied Mathematics and the project should be a synthesis of his/her previous courses. The students will meet regularly with the instructor to provide consultation with their project and work in conjunction with other students as needed.

These courses, in addition to the mathematics major requirements aim to develop and enhance the skills noted in the goals for the mathematics major and prepare students for a 21st century job involving applied mathematics.

3.3.5 The Mathematics Minor

The *minor in mathematics* includes a core of three courses along with four elective courses. The *Calculus I* and *II* requirement gives the students a solid background in differential and integral calculus. The *Linear Algebra/Abstract Algebra* requirement exposes the students to abstract mathematical thought and gives them a good base in reading and writing mathematical proofs. See section 3.1 for more details on these courses and their attributes. The electives students choose further enhance and broaden their mathematical abilities and problem solving skills. The skills they obtain should complement their major studies and will give them an edge when applying for jobs. The majority of students who minor in mathematics are either Computer Science majors or Middle School Education majors in the Math/Science Track.

3.3.6 The Mathematics Minor for Early Childhood, Elementary and Special Education

This minor includes mathematics courses specially designed for education majors as well as a variety of other mathematics courses aimed to give students a deep understanding of the concepts they will teach and how these concepts grow into more advanced mathematics.

The *Informal Number Theory* and *Informal Geometry* requirements dig deep into the mathematics taught in the elementary classroom and stress explanations and multiple representations of concepts and solutions. The students do a lot of writing and explaining in both of these courses. Furthermore, Informal Geometry is a discovery learning lab based course which uses a wide variety of manipulatives that the students will one day use in their own classrooms.

The *Discrete Mathematics/Introduction to Mathematical Thought* requirement exposes the student to set theory and mathematical logic which is essential to successfully communicating mathematics. In *Calculus I,* the students learn about the ubiquitous concept of instantaneous rate of change and gain the mathematical maturity to take higher level courses

Students completing this program have a solid understanding of the mathematical theory that unifies the concepts taught in the elementary schools. They understand how theories in arithmetic are generalized to algebraic theories and how these concepts are further developed and expanded in other mathematical fields such as calculus, statistics, or geometry.

This program allows students to become mathematics specialists in the elementary school. Improvement of mathematics programs in the elementary schools is a continuous goal of not only the Massachusetts' Department of Elementary and Secondary Education, but of every state and national education conference or professional organization. Education students completing this minor will be prepared to take a leadership role in improving the teaching of mathematics in the elementary school classrooms.

3.3.7 Other Programs/Courses

Requirements for other majors detail the importance of the Mathematics Department to cognate departments and to other departments which require mathematics courses as part of their major program. These courses are concentrated in various areas of applied mathematics as they relate to such disciplines as business, biology, chemistry, computer science, education, earth & geographic sciences, industrial technology, nursing, psychology and sociology.

Service courses are designed to achieve maximal applicability with respect to the need and desire of the other departments. Courses are frequently updated as a result of consultation, both formal and informal, with faculty in other disciplines. For instance, since our last program review in 2012, the Mathematics Department solicited feedback from other departments on what topics in applied statistics are important for their majors. It is worth noting that applied statistics is our largest service course offering with approximately 20 sections run each year. We used this feedback to adjust the list of topics for applied statistics and select common texts. More recently we have solicited feedback from appropriate departments on what topics in Precalculus, our second largest service course offering, are important for their majors. This information was used to develop a detailed topics list for Precalculus and develop corresponding modules for use in and out of the Precalculus class as needed. Furthermore, a common text was selected and the course was increased from 3 to 4 credits to allow more time for material coverage and absorption.

In addition, the Mathematics Department has increased the offerings of online classes since the last program review. Math 1300 Precalculus was the first course we offered online in 2007, but over the last 5 years we have increased the number of sections we offer through Graduate and Continuing Education (GCE) offer some sections for undergraduate matriculating students in the fall and/or spring. We now offer Precalculus and Applied Statistics online in addition to offer *Business Statistics* and *Business Calculus* as part of the online Bachelor of Science in Business Administration program. More recently, we began to offer *Introduction to Functions*, which is a prerequisite for *Business Calculus*, online as well as *Basic Mathematics II* which is the second course in our developmental mathematics sequence. Last but not least, 3 faculty members from mathematics and one from education taught an online graduate level topics course for in service teachers, MTED 7027 Mathematics for General and Special Educators: Content and Pedagogy. This ran for a few semesters from 2014 to 2015 and may run again in the future depending on demand and faculty availability. See Appendix D for the departmental guidelines for online courses. See Appendix E for samples of student work.

The *Mathematics Readiness Program* at Fitchburg State University consists of the Mathematics Readiness Requirement (MRR) which requires students, who are not exempt, to take a mathematics placement test (the Elementary Algebra Accuplacer) to determine whether they are ready for college level mathematics or if they need mathematics remediation first. Exemptions include students who transfer in Calculus I or higher or a college level mathematics course from a Massachusetts state institution of higher education. The full policy can be found at www.fitchburgstate.edu/placementtest. We have a two-course developmental mathematics sequence as follows and students are placed based on their test scores.

Basic Mathematics I: review of basic arithmetic skills and introduction to elementary algebra.

Basic Mathematics II: review of some material in basic math I and coverage of elementary algebra through quadratic equations.

These courses have a common syllabus and common exams created by the program coordinator. They are offered during each semester and in the summer. Students get 3 institutional credits for each course which do not count toward graduation. In fall 2015 the grading system for these courses was restricted to S (satisfactory) or U (unsatisfactory) for students not receiving an incomplete. This proposal came from the administration and some members of the mathematics department did not agree with it but it passed nonetheless.

More details on the developmental mathematics program and other service courses can be found in Appendix D (Advisors Guide to Math Courses).

3.4 Curriculum Trends

Campus initiatives in STEM (Science, Technology, Engineering and Mathematics) Education have been growing along with statewide initiatives. In 2015 Fitchburg State formed a PKAL (Project Kaleidoscope) Regional Network. Project Kaleidoscope (PKAL) is AAC&U's STEM higher education reform center dedicated to empowering STEM faculty, to graduate more students in STEM fields who are competitively trained and liberally educated. More information can be found at http://www.aacu.org/pkal. Since creating this network, STEM departments on our campus have been engaging in many related activities, including but not limited to, attending conferences, securing grants, holding a STEM summit, engaging in organized discussions and making changes to improve STEM education on campus. Our main STEM gateway course is Precalculus and historical data shows a failure rate of approximately 40%. To address this issue, the mathematics department, in consultation with other STEM departments made significant changes to our Precalculus course. These changes included increasing the course from 3 credits to 4 credits, creating modules in WebWorK, an open source online homework system, to be used in and out of class, selecting a common (free online) text and developing a detailed list of topics for all sections to follow. In addition, tutors were hired to help Precalculus students both in and out of class.

Another trend in mathematics education in Massachusetts is redesigning mathematics placement testing and remediation programs including using HS GPA to place students into college level mathematics course and tracks in developmental mathematics. As part of the Visions Project, the Massachusetts BHE (Board of Higher Education) called together a Developmental Mathematics Task Force which released a report in August 2013 with recommendations including that students with HS GPA 2.7 or above be exempt from taking a mathematics placement exam and be placed directly into college level mathematics. The BHE directed state institutions to run corresponding pilots in AY 2014/2015 and continue piloting and collecting data in AY 2015/2016. Most recently the BHE announced that institutions should continue piloting until AY 2018/2019 and place as many students as possible into college level math courses using one or more of the following standards:

- Pilot A1 Standard: 2.7 GPA or above
- Pilot A2 Standard: 2.7 GPA and a "B" or higher in Algebra II
- Pilot A3 Standard: 2.7 GPA and four years of high school math

The Developmental Mathematics Task Force recommendations also included the development of tracks in developmental mathematics. With the help of a BHE Performance Incentive grant, the Fitchburg State Mathematics Department has been working on these initiatives over the past 3 years beginning in Fall 2013 at which time we hired a developmental mathematics coordinator, raised the passing standards of developmental mathematics and piloted modular self-paced versions of our developmental mathematics courses. By fall 2014, all sections of developmental mathematics were module and tracked with STEM and non-STEM options. In fall 2015 we conducted a pilot where we placed students with HS GPA 2.7 or higher directly into applied statistics with an extra hour of required supplemental instruction, even if they did not pass the math placement test. This coincides with efforts of the Complete College America's "Co-requisite at Scale Initiative" of which Massachusetts is now a member. We ended up adding the extra hour to all sections of applied statistics, not just those with students who placed by HS GPA but are considering moving to a more restricted model. Corresponding data are in the Assessment section below.

The Mathematics Department also piloted the use of Starfish software designed (in part) to monitor student success and send automated messages to students as needed. We used Starfish for all developmental mathematics classes and several introductory level classes including applied statistics. Through this system we were able to monitor attendance and tutor center visits as well. Due to lack of full campus buy in and investment in SSC Advising Platform, the administration ended our contract with Starfish. The expectation is that we will adopt similar capabilities in the new advising platform.

In Fall 2013, Fitchburg State implemented a policy now titled the Mathematics Progress Requirement (MPR) which in summary, requires students needing developmental mathematics to enroll in their first year and continue taking math classes until they complete their gateway mathematics course (i.e. required introductory level mathematics course). Furthermore, students who do not need remediation must complete their gateway mathematics course in their first year. The full MPR can be found in the Curriculum section of the course catalog at www.fitchburgstate.catalog and also in Appendix D (Advisors Guide to Math Courses). The corresponding proposal, as approved by the AUC (All College Committee) is in Appendix D. Although the proposal states that registration blocks will be put in place to enforce this policy, the administration at the time did not approve these blocks and we ended up sending emails instead. This has worked well but is time consuming and obviously does not catch everyone. We plan to revisit the registration blocks with the new administration. Along with the implementation of the MPR came preregistering freshmen for mathematics classes which helped with getting freshmen to complete their mathematics requirement(s) in a timely manner. There is still the issue of follow up on students who do not pass mathematics in their first semester or those who do but still have not completed their gateway mathematics course.

4. Assessment

4.1 Outcomes Assessment Plan (for the mathematics major program)

The department has been continuing to work under the Assessment Plan that was initiated in the Fall 2005 Semester; the plan included the following Goals for the Mathematics Major and the related objectives for each goal. It is expected that each undergraduate mathematics major, upon graduation from Fitchburg State University, should

1. possess an understanding of the breadth of the mathematical sciences and their deep interconnecting principles.
   To meet this goal each undergraduate mathematics major has:

   - demonstrated an understanding of the concept of a function and its related topics.
   - demonstrated an understanding of the basic concepts of calculus.
   - demonstrated a knowledge of the abstract structures in mathematics.
   - demonstrated competency in several mathematical subfields outside of abstract algebra.
   - demonstrated an understanding of the commonality of different branches of mathematics.

2. be able to apply mathematics to a broad spectrum of complex problems and issues by formulating and solving problems.
   To meet this goal each undergraduate mathematics major has:

   - demonstrated using mathematics as a tool in solving applied problems.

3. be able to read, write, listen, and speak mathematically, as well as to be able to read and understand technically-based materials and to contribute effectively to group efforts.
   To meet this goal each undergraduate mathematics major has:

   - given oral presentations on mathematical topics.
   - demonstrated the ability to write correct proofs.
   - demonstrated the ability to write expository mathematics.
   - participated in group assignments or projects

4. have an understanding of the appropriate use of technology in mathematics.

   To meet this goal, each undergraduate mathematics major has:

   - demonstrated correct use of technology in mathematical situations.

5. be adequately prepared for a mathematically-oriented career.

   To meet this goal, each undergraduate mathematics major has:

   - demonstrated adequate preparation for his/her postgraduate experience.

Evidence of student achievement in these goals (and each goal's related objectives) was to be compiled in a student dossier that would include:

- a proof involving the concepts of a function and its related topics
- lab report from Calculus I or Calculus II (or other writing assignment)
- a proof from Abstract Algebra, Linear Algebra, or Number Theory
- a problem from an area of mathematics that uses concepts from another area
- a solution of an applied problem from each of two different courses
- a proof from Abstract Algebra and Introduction to Mathematical Thought
- report of a group project
- an assignment from Calculus I, Calculus II, or Linear Algebra, and an assignment using technology from another mathematics course

Other tools used in the Outcomes Assessment Plan include: MTEL scores, skills evaluation report (including items on the concept of a function and the basic concepts of calculus), transcripts, presentations, exit interviews or surveys, and alumni surveys. Not all evidence may be present for each student. The implementation of this plan was left to the Mathematics Assessment Committee.

Summary of past work:

From 2005 to the last review the Mathematics Assessment Committee (MAC) developed rubrics to assess student progress on these goals, implemented these rubrics, and closed the loop by either modifying the rubric, developing new assignments for students, or modifying the plan. As of the last review the MAC had rubrics for technology lab report rubric, student presentation rubric, proof writing rubric. In addition the assessment committee has developed skills lists for Calculus II, Applied Mathematics and a proof reading quiz.

Work since 2012:

Since the last review the MAC has developed an exit survey for graduating majors, a rubric for the writing expository mathematics goal, and begun the process of revising the goals and assessment plan. The latter was initiated by the large change in full-time faculty employed (five new faculty have joined the department in the last three years). The MAC sees this change as an opportunity to revisit the plan and goals to (a) make sure they align with faculty understanding of the mathematics major and (b) reflect lessons learned since the inception of the plan. This revision began with a survey of all faculty on attributes of a successful student in the program and will continue in AY16/17. This revision will respond directly to the Mathematics Association of America's 2014 Curriculum Guide.

A. Assessment of the Initial Licensure program (including post-baccalaureate)

As part of the University's Education Unit the program for Initial Licensure in Secondary Education in Mathematics (8-12) is subject to both Council for the Accreditation of Education Programs (CAEP) and Massachusetts' Department of Education licensure requirements and assessment plans. Student work in education courses are assessed using unit rubrics (lesson plan rubric, and Teacher Work Sample) and the assessment data for this work is regularly reviewed. Mathematics department representatives have been involved in deepening the assessment work in the (shared) secondary courses aligning the courses, student work, and assessment plan with the newly adopted Professional Standards for Teachers. While changes to the state licensure or national accrediting standards can require changes to mathematics courses, no such changes have occurred in this review period.

B. **Assessment of service to other programs**

Much of the work of the Mathematics department during the review period has focused on courses not required for the major, but those that serve other programs on campus (including the general education requirements by means of the Mathematics Readiness Requirement). As noted in the Curriculum Trends section above, the department has redesigned the developmental mathematics program and piloted a form of supplemental instruction.

The table below shows how pass and AB rates in applied statistics (math 1700) increased with the pilot . The slight drop in pass rate (and rise in AB rate) after going all modular and tracking may be due to the fact that the modular format required a higher passing standard (students had to pass all tests with an 80% instead of only 70% as in the lecture sections).

	Pass rate in math 1700 (rounded to the nearest %)	**AB rate in math 1700 (rounded to the nearest %)**
AY 13/14 (after raising BM standards and implementing MPR)	76%	37%
AY 14/15 (after making all BM sections modular and tracked)	73%	40%
AY 15/16 (with alternate math placement and SI pilot)	78%	42% (this was for fall only)

Pass, withdrawal, failure and D rates for freshmen cohorts only are shown below. This includes both students who were placed by HS GPA (and did not pass the math placement test) as well as those who pass the math placement test. ACPM refers to the math placement test.

Entering freshmen cohort	n	Ave. HSGPA	Ave. ACPM	Pass rate in Math 1700 (rounded to the nearest %)	Withdrawal rates in Math 1700	Failure rate in Math 1700	D rate in Math 1700
Fall 2013	233	3.17	91	81%	8.36%	10.93%	13.83%
Fall 2014	234	3.22	92	84%	6.84%	8.55%	14.1%
Fall 2015	311	3.21	83	86%	5.15%	8.15%	17.6%

After changes to MATH 0200 Basic Mathematics and the implementation of the MPR, pass rates in MATH 1700 increased from 60% (before fall 2013) to over 70% (over 80% for freshmen cohorts).

Below is similar data for those students who did NOT pass the ACPM and had HSGPA at or above 2.7. Those in Fall 2015 were placed directly into applied statistics (with an extra hour) and those in previous years went through developmental mathematics as a prerequisite before taking math 1700.

Entering freshmen cohort	n	Ave. HSGPA	Ave. ACPM	Pass rate in Math 1700 (rounded to the nearest %)	Withdrawal rates in Math 1700	Failure rate in Math 1700	D rate in Math 1700
Fall 2013	46	3.22	66	80%	4.35%	15.22%	23.91%
Fall 2014	35	3.29	64	83%	8.57%	8.57%	14.29%
Fall 2015	46	3.19	60	80%	10.87%	8.7%	26.09%

The SI pilot results show that this co-requisite model is comparable (in terms of pass rates) to the pre-requisite model for developmental mathematics for students with sufficient HS GPA. Withdrawal rates went up slightly which may be due to the fact that the pilot included students with very low math placement test scores. We adjusted the pilot thereafter to student with a higher range of math placement test scores. There was also an increase in D rates which shows that more students are just passing with the co-requisite model.

4.2 Effectiveness of the Curriculum

All of our available evidence indicates that overall the mathematics program at Fitchburg State is sound, the teaching/learning process is usually satisfactory and sometimes exemplary, and students are quite satisfied with the time and attention they receive from their mathematics instructors. Recent survey information obtained from both current students and alumni of our program support these conclusions. Students and alumni alike are satisfied with the Fitchburg State mathematics program. They rate the mathematics faculty members as knowledgeable, caring and respectful instructors who are available to students and go the extra mile to insure student success.

Moreover, current students and current faculty have very similar perceptions concerning those characteristics of the Fitchburg State mathematics program that foster students' success and those that can be viewed as program limitations. The most often cited strength of the Fitchburg State mathematics program is the personal attention students receive from the faculty. The minimal number of advanced level required or elective courses that can be offered each semester is cited as a definite limitation of the program.

The small number of mathematics majors at Fitchburg State contributes to both the availability of instructor's time for giving personal attention to students, and the lack of choice for elective classes. The recruitment and retention of qualified mathematics majors is an ongoing goal of the department. For the past 5 – 10 years, the number of mathematics majors has hovered around 40 give or take but has recently increased to an at an all time high of 57. The number of minors doubled from 2011 – 2013 and then decreased in 2015. The number of minors is now about 50% higher than it was back in 2011 with approximately 30 minors total.

4.3 Effectiveness from the Perspective of our Students

In Fall 2016 the department conducted a survey of the Mathematics Department Curriculum and Advising for Mathematics Majors. See Appendix A. The advising data is addressed in the Student Data Section and the curriculum results are summarized here. All the respondents were satisfied with the overall mathematics program and felt their questions to instructors would receive a prompt, accurate, courteous and respectful response. The weakness that was mentioned the most was regarding course offerings, over 30% of respondents were dissatisfied with course offerings. Concerns were expressed about frequency of course offerings and the fact that some desirable courses are not offered often enough. Currently most upper division mathematics majors must take any mathematics elective offered each of their last three or four semesters and hence they are not selecting courses based off of their interests. This has been a persistent problem, one that is hard to solve given our size.

Two students raised the issue of lecture style teaching but based on other responses, most were satisfied with the teaching techniques used by the mathematics faculty. This is highlighted in the following responses from the question about the strengths of the program: "Amazing and approachable faculty; most every professor I have had here I can feel their love of the subject and/or specific course come through in their lecture.". Other responses include: "I think one strength of the mathematics program is that since the program has a small amount of students compared to other programs, you connect frequently with your fellow students and with all of the professors. You also feel like anyone in the department is there to help you and are always willing to give their service to help you succeed.". Some suggestions were to offer evening or online courses, increase the number of mathematics related activities, and to improve transfer and first year advising.. Most of the respondents said they would recommend the Fitchburg State mathematics program to others with comments including "absolutely", "of course" and "without a doubt", but this responses was lower than when the survey was last deployed.

See the **Student Data** section under *Assessment of Mathematics Program Effectiveness* for more details.

4.4 Effectiveness from the Perspective of our Alumni

Our most recent survey of Alumni (which was run from May 2016 through September 2016) garnered 35 responses from alumni who graduated between 1974 and 2014. See Appendix A. The responses were overwhelmingly positive, especially given the diversity of post-baccalaureate experiences reflected in the alumni responses. Of those alumni providing information on their current profession 37% were in the education field and 31% were doing some form of data management or analysis. 94% of the respondents indicated that their experiences at Fitchburg State adequately prepared them for their professional needs. 94% also indicated that they would recommend the Mathematics program at Fitchburg State to someone whom they cared about. Comments offered by our alumni were very positive.

When prompted to identify weaknesses or suggestions for improvement a few themes appear. Firstly, there is the call for more guidance on the role mathematics can play in various careers. Secondly, there is advice to offer more courses that highlight the applications of mathematics. There were also roughly equal calls for additional courses that would help students with actuarial sciences and computer science. Here students also expressed frustration with the cancelling of classes.

See the **Student Data** section under *Assessment of Mathematics Program Effectiveness* for more details.

4.5 Effectiveness from the Perspective of our Faculty

In addition to the student survey discussed in section 6.1, the department also conducted a survey of the Mathematics Department Curriculum and Advising for Faculty. Once again, the advising data is addressed in the Student Data Appendix and the curriculum results are summarized here. There were 17 respondents, including 9 full time tenure track faculty and 8 part time faculty. All of the respondents felt that students' questions to instructors would receive a prompt, accurate, courteous and respectful response and 94% were satisfied with the overall mathematics program. Most faculty were satisfied with the course offerings which is an improvement from the last time the survey was deployed, however this is not met with equal satisfaction from students past and present.

Areas for improvement mentioned included the need for more student choice in upper-level courses, more connection to students' future work plans, and increased internship opportunities.

A reoccurring theme in the responses for strengths of the program is our dedicated and accessible faculty. Our faculty members are certainly competent and talented instructors who love to teach and it shows. In addition to putting copious amounts of time and effort into their regularly scheduled classes, faculty routinely give encouragement to students who have expressed the desire to continue the study of mathematics at the graduate level. When such students are identified early, several of our faculty members endeavor to offer support via independent study projects designed to introduce these particularly capable and motivated students to more advanced topics and more rigorous development of these topics than would be possible for most of our other students. This adds greatly to the strength of the program and is especially notable since this type of faculty work is on top of a full teaching load and not regularly compensated.

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5. FIVE YEAR PLAN/PLANS FOR CHANGE

5.1 Five-Year Plan

In the future, the mathematics department would like to work on its interconnectedness with other departments, local community colleges, and organizations that can provide career opportunities for our students. In addition, we plan to focus on the needs of our students and how we can better meet those needs.

In particular, we are discussing the following:

1) **STEM resource center (math and science) --** we are talking with other departments and offices on campus about the possibility of a STEM resource center. This would be similar to the math center, but it would also serve students in science classes, who often face mathematical hurdles in their courses.
2) **Math Center--** We are also interested in collaborating more with the Math Center, which often seems disjoint from the department. The math center is located in a beautiful new facility in Hammond, but it is physically and practically detached from our department. One possible solution to help with collaboration is to have a Math Center Liaison from the department.
3) **Careers—**We are working on collecting information for career-based advising and internships. Specifically, we are interested in what particular skills and dispositions industry is currently looking for and what careers and jobs are in demand and are well suited for our students. We can use this information to inform advising and curriculum decisions. This work is also part of Mary Ann's sabbatical in Spring 2017.
4) **Assessment Plans**—Our current assessment plan was written almost 15 years ago. In that time, our department has almost completely turned over. It has become clear that our assessment plan needs to be revisited and revised. Therefore, beginning this year the Assessment Committee is working on a reboot of our Assessment Plan.
5) **Math Software**—The department currently uses Maple and several other mathematics software programs. We now have many new faculty, some of whom have experience with other software. We will be reevaluating what software we would like to retain and which we would like to remove, replace, or add.
6) **QR requirement** – The University is currently working on a LAS program. The new requirements may include a quantitative reasoning course. Quantitative reasoning is also gaining attention in the mathematical community and the country as a whole. We will be discussing how to address the need for a quantitative reasoning course. This may involve transforming developmental math into a QR requirement, transforming our current Finite Mathematics into a QR course, or creating a new QR credit-bearing course.
7) **Supplemental Instruction**—We are currently looking at adjusting and expanding supplemental instruction (SI). This may involve including Supplemental Instruction sections in more of our courses. As SI expands, we will be in need of a Developmental Math and SI coordinator position, which would ideally be a staff position. One possible adjustment to SI is to include longer sessions and/or giving students credit for the extra time spent in class.
8) **BHE plans for Developmental Math**—Our current SI program is a response to the guidelines from the BHE regarding math placement testing. We are currently using student's high school GPA

to place students into courses supported by SI sessions. We will continue to respond to recommendations and requirements dispensed by the BHE.

9) **Grad programs in STEM ED**—We are in discussions about streamlining graduate programs for in-service teachers for professional licensure. We have eliminated the inactive MAT program that has been lingering on the books for more than 10 years, and are considering replacing it with a program that will service in-service teachers in mathematics and other sciences, such as biology, chemistry or physics.
10) **Statistics** – Although some faculty in the department have taken some statistics classes, we do not currently have a statistician on the faculty in this department. Since statistics is an area of mathematics that is highly useful in industry, we will be looking for ways to strengthen our department in that area.
11) **Collaboration with other Departments—**With the inception of the division of Natural and Health Sciences, there have been more opportunities for the mathematics department to communicate with other departments, such as the STEM Summit, which was held in January, and the STEM Working Group, which is an interdisciplinary group tasked with improving the student experience in STEM on this campus. We plan to continue discussions with our cognate fields on things such as what mathematics their students need to know prior to taking their courses, what mathematics courses their students should take to get that material, and other ways to support students in STEM courses to facilitate their success.
12) **Collaboration with Mount Wachusett Community College**—For the past few years, we have been in greater communication with our colleagues at Mount Wachusett. This communication has been through meetings organized by the chair of the Biology and Chemistry department, work on assessment organized by the director of assessment, and work on the Mass Transfer program organized by the BHE. We would like to continue our connections with our closest community college neighbor and continue to collaborate for student success in transfer between our two colleges.

5.2 Strengths/Weaknesses

Background information for this section is based on observations, informal conversations and surveys of current faculty members and current and former students. See Appendix A survey results.

5.2.1 Strengths

- The Mathematics Department continues to be student-centered. All relevant decisions are made with students in mind and the way that the faculty conduct classes and other activities have the students first in mind.
- Faculty members are dedicated to their students and are very creative in the classroom. Many utilize a variety of teaching techniques and foster active learning in the classroom. Each semester we hold a Math DoT (Discussion on Teaching) to share best practices and new ideas.
- The full-time tenure track faculty to math major ratio is about 1:4 and this lets the faculty get to know the students in class well and give ample attention to majors.
- Faculty are active in research and improving teaching. Currently, all faculty attend at least one national meeting and many go to other meetings that focus on general mathematical topics, specific research or teaching-focused topics. At least half attend local conferences that have

specific campus goals in mind. In particular, our faculty members have attended and participated in conferences and workshops on STEM education, general education, supplemental instruction and inquiry based learning which has been used to enhance their own teaching techniques.
- Many faculty work with undergraduate students in research. During the past 5 years, at least 10 students have benefitted from independent studies/research projects with faculty members.
- The numbers of applied mathematics majors, secondary education majors and mathematics minors (including math ed. minors) has grown over the past 5 years (see Student Data Appendix). This shows that 1) students are increasingly interested in mathematics and 2) we have strong attractive programs with supportive faculty.
- The faculty are active on campus committees. All of our faculty members serve on at least one departmental committee and in most cases two. Each also serves on at least one university committee, working group and/or taskforce. Each year the department ensures representation on certain committees (e.g. Curriculum, Academic Policies, LA&S) as well as pertinent working groups and task forces (e.g. STEM working group, Student Success Task Force)
- We have several new and enthusiastic faculty members who have brought lots of good energy to the department. In particular, we have hired 4 new faculty members in the past 2 years.

5.2.2 Areas for Improvement

- Some students are seeking out internships, however the Mathematics Department does not have a program to facilitate this. Also, more guidance is needed for students, on the role mathematics can play in various careers.
- The upper division course offerings are very restricted leaving majors little choice of what mathematics electives to take. In any given semester, there are typically 3 courses above Multivariate Calculus.
- The class sizes for some lower-level service courses are too large, making it difficult to give individual attention to the students that need it most.[[this has actually improved quite a bit – now our largest cap is 30 but most courses are at 25 or lower]]
- Only a few of the faculty members have recently pursued their scholarly activity to the point where the results were submitted for peer review and eventual publication. That said, faculty members continue to be active professionally despite the limited time available to them as members of an institution focused on teaching.
- In the 2012 self-study, it was indicated that alumni had wished for more computing to help with their career prospects. This has improved with the increasing enrollment in Applied Mathematics, many of whom fulfill a Computer Science minor. In addition, all majors now take a 3-credit Symbolic Computation course (which was formally embedded in the Calculus sequence) and twice over the past three years, a topics class in Computational Mathematics. Except for the required course, only a few majors have increased their computational skills. The Mathematics Department should continue to require or advise students of the marketability of such skills.
- There could be more widespread use of technology for the mathematics classes. In particular, appropriate computer algebra systems should be used as often as appropriate to better prepare the students for careers in industry. Such programs are already being used in Calculus I & II, Linear

Algebra and some applied mathematics courses but they could be useful in other courses as well.
- The large number of part time faculty members creates considerable strain on the Department in many ways. While these faculty members are well qualified for their teaching assignments, they are not easily integrated into the life of the Department.
- As noted in the Five-Year Plan section, none of our faculty members has a strong background in advanced statistics which is a field with high demand in industry.
- Although the department currently has a developmental mathematics coordinator who also handles SI coordination, this is a temporary position and there is no current plan for long term support.

5.3 Plans for Change

Future plans and changes for the Department of Mathematics will, as in the past, be designed to enhance and improve strengths of the Department and to rectify and eliminate those things which are seen as weaknesses. Survey results indicate that the quality of the course offerings is high and that, especially for upper level major courses, the relatively small class size provides for a good learning environment. Complaints about cancellation of upper level electives and a perceived lack of planning of upper level courses need to be addressed. However, a study of the surveys reveals that what is considered a major weakness in the Department is a lack of career planning. Procedures and potential actions to address some of these shortcomings are addressed in the Five-Year Plan section. After our program review sit visit the department plans on developing a five-year strategic plan to prioritize our efforts to improve both the major programs as well as our service offerings.

APPENDIX A: STUDENT DATA

A.1 Enrollments

A.1.1 Majors

The Mathematics Department currently has 57 students registered as Mathematics majors. Of these, approximately 20 (38%) are officially pursuing initial certification in Secondary Mathematics Education, and an additional five seeking initial licensure through our post baccalaureate program. Ten are enrolled in the Applied Mathematics concentration in the department. The remaining 21 students are Mathematics majors pursuing a B.S. or B.A. in Mathematics. These numbers are fluid, however, as students change majors from or to Mathematics often during the course of a given academic year.

Before 2011, the number Mathematics majors had remained relatively constant at 35–40; however, we can see a short trend of increase, as is evident from the table:

Table 1: Number of Mathematics majors at the end of the Fall term

Term	Fall 2011	Fall 2012	Fall 2013	Fall 2014	Fall 2015	Fall 2016
Total # of majors	36	44	35	45	53	57
Applied Math	2	3	5	6	12	9
Sec. Ed.	11	18	14	18	19	21
No conc.	23	23	16	21	22	27

The University has collected data pertaining to diversity for the number of math majors divided by race ethnicity and gender. The University did not include the data for 2011.

Table 2: Number of Mathematics majors at the end of the Fall term by Race/Ethnicity and Gender (2012-2016)

	2012			2013			2014			2015			2016		
	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Non-resident Alien															
Black or				1		1	3		3	1		1	2	1	3

African-American															
American Indian/Alaskan Native							1		1					3	3
Hispanic or Latino	3		3		3	3		4	4	3	3	6	3		3
White	22	13	35	16	11	27	20	12	32	17	22	39	22	19	41
Unknown	1	3	4	1	1	2	1	2	3	2	2	4	2	1	3
Cape Verdean															
Two or More		1	1	1		1	1		1	1		1	1		1
Asian	1		1	1		1	1		1	1	1	2	1	2	3
Native Hawaiian/Pacific Islander															
Total	27	17	44	20	15	35	27	18	45	25	28	53	31	26	57

Currently, 54% of the Mathematics majors are male, and 46% are female. The number of students (male/female) graduating with a bachelor's degree in mathematics during the six-year period AY 2010/11 to AY 2015/16 is given in the following table:

Table 3: Students receiving a Bachelor's degree in Mathematics

(2011–2016)

Academic Year	Male	Female	Total
Fall 10–Spring 11	3	2	5
Fall 11–Spring 12	4	3	7
Fall 12–Spring 13	4	1	5
Fall 13–Spring 14	4	2	6
Fall 14–Spring 15	3	3	6
Fall 15–Spring 16	4	2	6

We have approximately six graduating students each year.

The University keeps records pertaining to diversity, and 6-year graduation rates of first-time full-time freshman. The "6-year graduation rate" is defined to be the percentage of students who entered in a particular Fall semester, and graduated within 6 years of their entering (with any major). These data are summarized in the tables below.

Table 4 summarizes the average years to graduation for freshmen entering in the Fall semester of the years 2007-2010 and graduating within six years and the average years to graduation of those students who entered during this time as mathematics majors. This table does not reflect students who joined or left the major during this time. These students will be reflected in a table below.

Table 4: Average Years to Graduation (students graduating within six years). Each entering cohort contained fewer than 10 stude

Entering Cohort Year	Math freshmen	All Entering freshmen
2007	4.75	4.54
2008	4.70	4.31
2009	4.50	4.39
2010	4.33	4.32

The table indicates, for instance, the average time to graduation for students who enrolled for the first time in Fall 2007 as a mathematics major was 4.75 years.

Given the small number of students entering Fitchburg State as mathematics majors and uncounted change of majors (in or out), it is difficult to draw any conclusions from this data.

The data for the 6-year graduation rate by ethnicity and gender for students who entered as mathematics majors between Fall 1998 and Fall 2005, and graduated with any major from Fitchburg State, is given in the next table.

Table 5: 6-year Graduation Rate by Race/Ethnicity (requested from Anthony)

(Mathematics Majors entering Fall 2012–Fall 2016)	Men			Women			Total		
Race/ Ethnicity	enter	grad	% grad	enter	grad	% grad	enter	grad	% grad
non-resident alien	1	0	0%	0	0	–	1	0	0%
Black	0	0	–	0	0	–	0	0	–
American Indian	0	0	–	0	0	–	0	0	–
Asian/Pacific Islander	3	1	33%	1	0	0%	4	1	25%
Hispanic	0	0	–	1	1	100%	1	1	100%
White	19	9	47%	16	7	44%	35	16	46%
Cape Verdean	0	0	–	1	1	100%	0	0	–
Unknown	3	0	0%	1	0	0%	4	0	0%
Total	26	10	38%	20	9	45%	46	19	41%

The 6-year graduation rate for these students is 41%, compared to the University average over the same period of approximately 50%.

University records relating to first-time full-time freshman enrollee Fitchburg State mathematics majors who returned to the University the following Fall semester are summarized below

Table 6: Students Retained in the Major from Fall of Admission to Following Fall

Fall Entering Cohort	Retention Rate
2010*	66.67%
2011*	37.50%
2012*	80.00%
2013	50.00%
2014*	75.00%
2015*	75.00%
6-Year Average	64.03%

*N<10

A.1.2 Minors

The number of students pursuing a minor in Mathematics is even more fluid than the number who have declared a major in Mathematics, as students (particularly in Computer Science) frequently do not officially declare a minor in Mathematics until very late in their academic career. The number of Mathematics minors can be seen in the following table. "Math for Education" refers to the Mathematics Minor for Early Childhood Education, Elementary and Special Education majors.

Table 7. Number of Mathematics Minors (Fall 2011–Fall 2016)

Minor	Fall 2011	Fall 2012	Fall 2013	Fall 2014	Fall 2015	Fall 2016
MATH	13	22	19	17	14	11
Math for Education	6	8	15	24	22	20

A.1.3 Enrollment in Major and Service Courses

Every student at Fitchburg State University is required to take a college-level mathematics course. In addition, students are not allowed to take such a course unless they have first satisfied the Mathematics Readiness Requirement (MRR). The MRR is satisfied by obtaining a score of 82 or higher on the Accuplacer Elementary Algebra Placement examination in mathematics, or by taking and passing our "developmental" course, *Math 0200: Basic Mathematics II*. Exemptions apply to transfer students who have satisfied the MRR at another Massachusetts State institution of higher education or if they transferred in a college level math class from such an institution. Students who score below 50 on the Algebra

Accuplacer are determined to be unprepared for Basic Mathematics II andare placed into *Math 0100: Basic Mathematics I.*. With the implementation of the Mathematics Progress Requirement (MPR) in Fall 2013, student are now required to take the Math Placement Test before enrolling for their first semester, unless they are exempt. Furthermore, the MPR requires students to take a mathematics course in their first year. See Appendix D for more details on the MPR.

Many of the departments at Fitchburg State University require specific mathematics courses, and the Mathematics Department supports these requirements through its various service courses. Typically, the Department offers 35 to 50 sections of mathematics service courses each term (up to 60 in recent semesters), as well as 13 to 17 sections of courses required for the major in mathematics. The average enrollment in service courses is approximately 24, and that in major courses is approximately 10. In the following table, we give the enrollment in all mathematics courses for each academic year.

Table 9. Enrollments in Mathematics courses (Fall 2005–Spring 2016)

AY	2011-12		2012-13		2013-14		2014-15		2015-16	
Fall/Spring	F	S	F	S	F	S	F	S	F	S
Service	1130	909	1172	905	1438	1021	1382	1016	1341	865
# sections	43	35	45	35	53	41	60	46	65	40
avg/section	26.3	26.0	26.0	25.9	27.1	25.0	23.0	22.1	20.6	21.6
Major	132	113	120	131	127	173	183	173	168	190
# sections	15	15	13	15	13	15	19	17	16	19
avg/section	8.8	7.5	9.2	8.7	9.7	11.5	9.6	10.2	10.5	10.2
Total	1262	1022	1292	1036	1565	1194	1565	1189	1509	1055

AY	2005-06		2006-07		2007-08		2008-09		2009-10		2010-11	
Fall/Spring	F	S	F	S	F	S	F	S	F	S	F	S
Service	973	754	979	804	981	802	1085	920	1161	950	1201	906
# sections	37	32	40	32	39	32	44	36	43	38	44	38
avg/section	26.3	23.6	24.5	25.1	24.7	25.1	24.7	25.6	27.0	25.0	27.3	23.8
Major	98	111	86	126	102	109	98	91	97	88	115	125
# sections	10	13	9	10	10	11	10	11	9	9	11	11
avg/section*	9.8	8.5	9.5	12.6	10.2	10	9.8	8.1	10.8	9.8	11.1	11.4
Total	1071	865	1065	930	1083	911	1183	1011	1258	1038	1201	906

*does not include Math 2860 (Introduction to Secondary Education), which is taught outside the department, or courses done as an independent or directed study.

It is unclear which courses were considered service courses vs. major courses in the previous review (years 2005-2011 in the second table); however, for 2011-2016 courses, the courses were sorted as follows:

Service	Major
MATH 0100 Basic Mathematics I	MATH 1850 Fresh Sem. in Applied Math
MATH 0200 Basic Mathematics II	MATH 2300 Calculus I
MATH 1200 Finite Math	MATH 2400 Calculus II
MATH 1250 Introduction to Functions	MATH 2500 Intro to Math Thought
MATH 1300 Precalculus	MATH 2550 Symbolic Computation Math
MATH 1500 Informal Number Theory	MATH 2600 Linear Algebra
MATH 1600 Informal Math Modeling	MATH 2860 Intro to Sec School Teaching
MATH 1700 Applied Statistics	MATH 3000 Geometry 1
MATH 1800 Business Statistics	MATH 3001 Tpcs: Sci. Comput. & Visualiz.
MATH 1900 Discrete Mathematics	MATH 3150 Elementary Number Theory
MATH 2000 Informal Geometry	MATH 3200 History of Mathematics
MATH 2100 Technical Calculus	MATH 3300 Calculus III
MATH 2200 Business Calculus	MATH 3350 Multivariate Calculus
	MATH 3400 Calculus IV
	MATH 3500 Methods of Applied Math
	MATH 3550 Ordinary Diff Equations
	MATH 3900 Mathematics Seminar
	MATH 4000 Real Variable Theories
	MATH 4012 Practicum Seminar
	MATH 4150 Adv. Multivariate Calculus
	MATH 4200 Probability and Statistics I
	MATH 4250 Probability and Statistics II
	MATH 4300 Abstract Algebra
	MATH 4350 Complex Analysis
	MATH 4400 Operations Research
	MATH 4450 Mathematical Modeling
	MATH 4500 Numerical Analysis
	MATH 4600 Sen Seminar in Applied Math
	MATH 4850 Meths. and Mater in Sec Ed
	MATH 4860 Math Prac. in Sec Sch. I
	MATH 4870 Math Prac. in Sec Sch. II
	MATH 4880 Math Practicum in Sec Ed
	MATH 4901 Ind St: Fourier Analysis
	MATH 4903 Ind St: Abstract Alg. II

The total annual enrollment in mathematics courses is given in Table 10 below. There was conflicting data from the Universities Institutional Research and Planning. We were given both the enrollments per professor and the enrollments per course. These two values were not the same. We present both values and it is clear from the table that enrollment in Mathematics courses has increased over the past five years. The previous program review saw a 20% increase in enrollment. It appears that enrollment has increased substantially more than that in the past five years.

Table 10a. Total Enrollment in Mathematics Courses by Course

(Fall 2011–Spring 2016)

AY	Fall	Spring	Total
2011-2012	1262	1022	2284
2012-2013	1292	1086	2328
2013-2014	1565	1194	2759
2014-2015	1565	1189	2754
2015-2016	1509	1055	2564

Table 10b. Total Enrollment in Mathematics Courses by Professor

(Fall 2010–Spring 2016)

AY	Fall	Spring	Total
2010-2011	1316	1031	2347
2011-2012	1490	1267	2757
2012-2013	1374	1096	2470
2013-2014	1603	1260	2863
2014-2015	1786	1282	3068
2015-2016	1953	1383	3336

A.1.4 Recruitment

The Mathematics Department makes extensive attempts to recruit majors in mathematics. Departmental faculty actively participate in “open house” presentations run by Fitchburg State Admissions for prospective students. Since 1980, the Department has also sponsored the Elizabeth Haskins Mathematics Contest for area high school students, which draws an average 500 participants from approximately 15 local high schools. We also send letters to incoming freshmen who have a strong mathematics background, encouraging them to take mathematics courses, and to consider a major or minor in mathematics.

A faculty member organizes and proctors the American Mathematics Contest (AMC) 10/12 exam in February of each year, and with the help of another faculty member hosted the AMC 8 exam for the first time at Fitchburg State University in November 2011. Both of these exams are part of a national contest sponsored by the Mathematical Association of America. Since Fitchburg State University is the only institution of higher education in Massachusetts that offers the opportunity for Middle School and High School students to take this exam, this offers quite a bit of publicity for the university.

In addition, one of our faculty members leads a weekly Math Circle at the Fitchburg Arts Academy Middle School in Fitchburg with the help of several Fitchburg State University students. The purpose of the Math

Circle is to get, and keep, children interested in mathematics. Our hope is that some of those students will one day consider attending Fitchburg State University and study mathematics here.

Informal recruitment also occurs in the classroom. If a faculty member has a particularly talented student in a service course, he or she will often encourage that student to take more mathematics courses and perhaps pursue a minor or major in mathematics. There have also been a few students in the past who have started out as mathematics minors and ended up doing a double major in mathematics and their initial field of study, with the encouragement and assistance from members of the mathematics faculty.

A.2 Academic Advising

The Chair of the Mathematics Department assigns incoming students to faculty advisors so that each faculty member will have approximately the same number of advisees, subject to several informal criteria. We assign all of our Initial Certification students to one member of the department. Middle School Education majors with a concentration in mathematics have an advisor in the Education Department and a second advisor in the Mathematics Department. However, many of the Education majors rely only on the Education Department for advice. New faculty members are given a smaller advising load as they adjust to the university. Additionally, if students request a particular member of the department for their advisor, they are generally accommodated. We have also begun advising students minoring in mathematics. All mathematics minors currently have a mathematics advisor they can go to for questions and guidance. As of right now, all math minors are advised by the department chair or another designated faculty member of the department. . A list of mathematics majors and their advisors is given in Appendix D.

A.3 Assessment of Mathematics Program Effectiveness

After each pre-registration advising session, students are asked to fill out a college-wide advising questionnaire. The Spring 2015, Fall 2015, and Spring 2016 results of this assessment are given below and indicate that the students' advising experiences are generally extremely positive.

Table 11. Student Informational Questionnaire on Departmental Academic Advising

Spring 2015-Spring 2016 (23 respondents)

	None	**One**	**Two**	**Three-Five**	**Six-Ten**	**Ten or More**
How many advising sessions, including telephone and e-mail contacts, have you had with your advisor during this academic year?	0	10	4	5	2	2
	Less than 15 Minutes	**15 to 30 Minutes**	**31 Minutes to 1 Hour**	**More than 1 Hour**		
How much time was spent in those sessions on average?	0	16	5	2		

	Almost Always				Rarely	NA
	1	**2**	**3**	**4**	**5**	**6**
I have been able to visit my advisor when I need to.	20	3	0	0	0	0
I have been able to spend as much time as I needed with my advisor.	18	3	2	0	0	0

	Very Much				Not at all	NA
	1	**2**	**3**	**4**	**5**	**6**
Information from my advisor has helped me select courses.	17	6	0	0	0	0
My advisor's information about programs has helped me clarify my college plans.	16	7	0	0	0	0
My advisor's information about career opportunities has helped me clarify my career goals.	12	9	0	0	2	0
Information from advisor has helped with college requirements/procedures	16	7	0	0	0	0
I have obtained helpful information from my advisor about resources and/or services on campus	12	7	1	0	1	1

	Strongly Agree				Strongly Disagree	NA
	1	**2**	**3**	**4**	**5**	**6**
As appropriate, my advisor places final responsibility for making decisions on me	15	5	2	0	0	0

	Extremely Positive				Extremely Negative	NA
	1	**2**	**3**	**4**	**5**	**6**
How would you rate your overall advising experience with your present advisor?	16	6	0	0	0	0

In addition, the Department administered surveys to current, graduating, and former students from 2008-2016 that included a number of questions about the mathematics program. These results are summarized in the following sections.

A.3.1 From the Perspective of the Recent Students

The Graduating Student Survey is administered online to both graduate and undergraduate students. Students are notified of the survey via e-mail when they submit an application for graduation. Participation in the survey is voluntary and resulting response rates are low. The following consists of responses from 2008-2016. In total, 9 students responded to questions about their experiences in the major and the university.

Table 11. Students responses when asked to rate their experiences within the major

Questions	n	Excellent	Very Good	Good	Fair	Poor
Availability of classes	9	22%	56%	11%	11%	0%
Frequency of course offerings	9	0%	56%	22%	22%	0%
Size of classes	9	56%	22%	22%	0%	0%
Overall quality of instruction	9	44%	22%	34%	0%	0%
Overall quality of texts and other instructional materials	9	22%	56%	22%	0%	0%
Availability of faculty outside of class time	9	44%	56%	0%	0%	0%
Timeliness and relevance of course content	9	34%	66%	0%	0%	0%
Helpfulness of non-teaching staff in your major department	9	22%	56%	11%	11%	0%
Quality of facilities for learning in my major department	9	44%	56%	0%	0%	0%
Quality of extracurricular experiences related to my major	9	22%	78%	0%	0%	0%
Match between career goals and course of study requirements	9	11%	66%	11%	11%	0%
Overall level of challenge	9	22%	78%	0%	0%	0%

Most graduating students had a Very Good or Excellent response to the quality of the teaching, the availability of faculty outside of class time, and the relevance and challenge of course content. Categories where the department may seek to improve would be frequency and availability of course offerings and the helpfulness of non-teaching staff.

A.3.2 From the Perspective of the Alumni

In Spring 2016, the Department sent out an alumni survey with a variety of questions including those regarding their experience at Fitchburg State. The survey and responses can be found in Appendix A. There were 35 alumni who answered the survey (11 of which responded to a similar survey in Spring 2011) and all percentages are based on that number of respondents. A summary of the responses is given below.

- 89% are currently employed.
- 57% went on to further education programs.
- 91% responded that mathematics plays a role in their professional life.
- 86% said they received adequate mathematical preparation for their profession at Fitchburg State.
- 91% would recommend the mathematics program at Fitchburg State.

Responders had an opportunity to make comments on their responses to some of the questions on the survey. A summary of such comments follows.

Did Fitchburg State adequately prepare you for your profession?

Most respondents interpreted this question as meaning "How" did Fitchburg State adequately prepare them. Several students mentioned the benefits of a small department and class sizes, saying that being able to work closely with their peers and faculty as a major contribution to their success. Many educators mention opportunities to present/teach material in courses as highly impactful and those in engineering positions reference research projects as a helpful opportunity. Even those respondents not using the mathematics they learned at Fitchburg State in their daily professional lives, mention that the challenges of the mathematics courses made them better problem solver and less afraid to tackle hard questions inside and outside the field of mathematics.

> *The attention I received from the Mathematics Faculty both in and out of class was by far the greatest asset to my undergraduate career. Their passion for mathematics and their genuine interest in student learning was the driving force behind my success. I now constantly strive to emulate those qualities in my professional career.*

> *Performing research under Dr. Peter Staab helped me gain the skills and confidence needed to perform advanced research and scientific writing.*

> *While I had to basically learn my new career from scratch, a lot of the concepts were much easier to grasp with a math background. Particularly with programming.*

[...] As for the work I do now the best thing about having a background in mathematics is not that I know a lot of mathematics (I don't) but that if I encounter a topic, technique, or concept that I'm unfamiliar with then I know how to read mathematics and can teach myself. The symbols no longer frighten me.

What are the weaknesses in the academic program at Fitchburg State?

Nearly 40% of the surveyed alumni specifically stated there were no weaknesses in the program or left the question blank. Of those who cited weaknesses, at least half were preceded by a positive comment. A common observation was there were not many opportunities for internship programs. Many students would have taken advantage of these programs and claim they would have had an easier time finding a job or knowing what type of career they wanted. Many students would have liked to see more upper level courses in general, either for more exposure to material or because scheduling courses was difficult. A couple of students mention a more rigorous track for those preparing for graduate school. A larger number say they wish they had learned more statistics as it is such a “hot field” right now. Even more would have liked to have seen more programing languages integrated into mathematics courses.

How could the program be improved?

The responses to this question mirrored the issues raised in the previous question. In particular, a number of respondents said that the department should better make students aware of job opportunities in mathematics, and that internships should be developed with local businesses. A number of respondents mentioned increasing the opportunities for work with other majors; interdisciplinary courses and learning how mathematics applies to other fields of study.

General comments

The most common comment made by responders was that they were very satisfied with the education they received as mathematics majors at Fitchburg State, several mentioning specific professors by name as having had a positive influence on them.

I wouldn't trade my time in the FSC mathematics department for anything. It was the best experience of my life learning more about what I love with a lot of really smart and hard working people, both professors and peers.

The one thing that I valued the most, was the care that professors had for the students. They actually listened and took the time to give extra help!

I am forever thankful for the education that I received at FSU.

A.4 Life after Fitchburg State University

Our graduating majors have gone on to a variety of careers. According to our Alumni Database, of the 115 former students for whom we have records, about 40% have gone on to jobs in education. These are primarily classroom teaching in Massachusetts public high schools, but also include teachers and administrators in middle and elementary schools, private and charter schools, and institutes of higher education. The remaining alumni have jobs in a wide range of industries and professions, from actuarial science and publishing to financial services and the United States Military and National Security Administration. In the last ten years, at least 8 of our students have gone on to graduate school in Mathematics. Our first alumnus to earn a Ph.D. in Mathematics received this in June of 2011.

APPENDIX B: FACULTY DATA

The follow are the curriculum vitae of the full-time and part-time faculty in the Department. The actual CVs can be found in electronic form accompanying this document.

B.1 Full-Time Faculty Vitae

B.1.1 Mary Ann Barbato

B.1.2 Nermin Bayazit

B.1.3 Jennifer Berg

B.1.4 Catherine Buell

B.1.5 Gerald Higdon

B.1.6 Lori Leonard

B.1.7 Benjamin Levy

B.1.8 Jenna Reis

B.1.9 Peter Staab

B.1.10 Amy Wehe

B.1.11 Sarah Wright

B.1.12 Abdul Zekeria

B.2 Part-Time Faculty Vitae

B.2.1 Ann Anderson

B.2.2 Mark Charalambous

B.2.3 Nina Fernandes

B.2.4 Festus Kiprono

B.2.5 Jody Clapp

B.2.6 Ron Lange

B.2.7 Bob Laverne

B.2.8 Michael Stassen

B.2.9 Ken Takvorian

B.2.10 Christopher Watson

B.2.11 Jared Weed

B.2.12 Tom Weiderman

APPENDIX C: Resources

This section lists resources for the Mathematics Department. In particular, the headings for the following sections are listed below: budget, library holdings, technology, space and other materials. The actual appendices can be found in the electronic documents.

C.1 Operating Budget

C.2 Library Resources

C.3 Physical Space and Technology

C.4 Equipment and Materials

C.5 List of Departmental Books

C.6 Library Director's Report

APPENDIX D: Curriculum Documents

The following documents are separate from this self-study. It can be found electronically through the attached files.

D.1 Suggested Four-Year Plans

D.1.1 Mathematics Major Four-Year Plan

D.1.2 Applied Mathematics Four-Year Plan

D.1.3 Secondary Education Four-Year Plan

D.1.4 Middle School Math Four-Year Plan

D.2 Mathematics Department Scheduling Plan

D.3 Advisor’s Guide to Math Courses for non-majors

D.4 Math Progress Requirement (AUC proposal)

D.5 Mathematics Department Online Course Policies

D.5.1 Online Math Course Requirements

D.5.2 Proctored Exam Form for online courses

D.5.3 Proctored Exam Process for online courses

D.6 Advising Assignments

D.6.1 Advising Assignments for Majors

D.6.2 Advising Assignments for Minors

APPENDIX E: Student Work

This appendix lists sample student work for various courses in the Mathematics Department at FSU. The actual work is in electronic form accompanying this document.

E.1 Math 2000 Examples

E.1.1 Quadrilateral Problem

E.2 Math 2550 Student Work

E.2.1 Math 2550 HW 06 (sample homework)

E.2.2 Math 2550 student 1 work (HW 06)

E.2.3 Math 2550 student 2 work (HW 06)

E.2.4 Math 2550 HW 08 (sample homework)

E.2.5 Math 2550 student 1 work (HW 08)

E.2.6 Math 2550 student 2 work (HW 08)

E.3 Math 3900 Student Work

E.3.1 Student 1 final paper

E.3.2 Student 2 final paper

E.3.3 Student 1 final presentation

E.3.4 Student 1 final presentation

E.4 Math 4600 Student Work

E.4.1 Student 1 final paper

E.4.2 Student 2 final paper

E.5 MTED 7027 Student Work

E.5.1 Student 1 sample

E.5.2 Student 1 assessment

E.5.3 Student 2 sample

E.5.4 Student 2 assessment

E.6 Math 2500 Student Work

E.6.1 Final exams for 3 students

APPENDIX F: Academic and Assessment Plan

These are documents related to the Mathematics Departments Academic and Assessment plans. The document can be found in electronic form accompanying this document.

F.1 FSU Mathematics Department Academic Plan

F.2 FSU Mathematics Department Assessment Plan

APPENDIX G: 2012 Self Study and Reviewer Comments

This appendix lists electronic documents related to the 2012 self-study document and the comments from David L. Abrahamson, Rhode Island College. The

The actual work is in electronic form accompanying this document.

G.1 FSU Math Department Self Study Report, 2012

G.2 External Reviewer Report for Program Review, David Abrahamson, 2012

G.3 Math Program Review Response and Future Plans (2013)