PROGRAM REPORT SUMMARY

Department: Mathematical Sciences	Report Type: FULL REPORT
Program Name: Mathematics	Program Level: BA
Report Preparer: Frederic Latour	Date Completed: 10/11/2019
Program Structure: Non-Accredited	Academic Year: 2018-19

Program Assessment Question	Response
1) **URL**: Provide the URL where the Learning Outcomes (LO) can be viewed.	http://www.ccsu.edu/mathematics/files/BA_ProgramLearningOutcomes.pdf
2) **Assessment Instruments**: Please list the source(s) of the data/evidence, other than GPA, that is/are used to assess the stated outcomes? (e.g., capstone course, portfolio review and scoring rubric, licensure examination, etc.)	Faculty use a rubric to assess levels of performance for each student taking most of our required courses. Professors complete a Course Learning Outcome rubric for each student and they use these results to determine the level of performance for the associated Program Learning Outcome. The current performance levels are: (2) Strong Performance of the Learning Outcome; (1) – Acceptable Performance of the Learning Outcome; (0) – Does Not Meet the Learning Outcome.
3) **Interpretation**: Who interprets the evidence? (e.g., faculty, Admin. assistant, etc	Faculty
4) **Results**: Using this year's Findings, list: a. The conclusion(s) drawn b. The changes that were or will be made as a result of those conclusion(s)	Students are struggling to perform at an acceptable level for outcomes tied to courses taken early in the program, especially MATH 152 and 221. New course outlines have recently been approved for the Calculus sequence in response to this. Students have traditionally done well in the objectives tied to the early parts of MATH 228; the course is now taught from a different, richer perspective that offers more to the students. We should examine the preparation of students taking MATH 152 and 221 to see if it is adequate.
5) **Strengths**: List ways in which your assessment process is working well.	The Mathematical Sciences department has begin to make changes to its courses, partly based on findings from previous assessment reports.

6) **Improvements**: List ways in which your assessment process needs to improve based on student data (A brief summary of changes to assessment plan can be reported here).	The department should consider creating a permanent assessment committee in order to provide more continuity to our assessment efforts, since the current system relies too much on a small number of people doing work over a short timeframe. The department should also update some of the program and course learning outcomes.

GENERAL EDUCATION SUMMARY

1. All departments contribute to the general education foundation of CCSU students (i.e., the CCSU General Education Learning Objectives/Outcomes) and must submit the General Education Summary below.
2. If your department participated in the General Education Assessment initiative (Multi-State model), complete Section 1 below.
3. If your department assesses GenEd Learning Objectives/Outcomes at the department-level, complete Section 2 below. Complete one Summary table for each LO assessed.
4. URL for the list of CCSU Learning Objectives/Outcomes, click **here**.

Department: Mathematical Sciences	Report Type: GenEd Summary
General Education LO Assessed: 5 & 6	Academic Year: 2019-20
Report Preparer: Frederic Latour	Date Completed: October 11, 2019

Participation in General Education Assessment Initiative (Multi-State Collaborative model)	Section 1 Responses
1) Our departmental faculty participated in the assessment of the GenEd Learning Objectives/Outcomes by contributing to the GenEd Assessment Initiative (Multi-State Collaborative model).	Faculty member(s): Marian Anton, Frederic Latour GenEd Learning Outcome(s)/Objective(s): 5 & 6 Course(s): MATH 102, 218, 450

PREAMBLE

The mission of the Department of Mathematical Sciences is to foster effective teaching and research in support of developing students as mathematical problem solvers and effective users of mathematical knowledge, no matter their current or future profession. In support of this mission, the department focuses in the development of intellectual enhancement and the dissemination of knowledge and application in the areas of mathematics, mathematics education, and statistics, including actuarial science and data science. We seek to supply the mathematical needs of students who are our majors and minors, our Master's students, those in related fields, all current and future teachers, and the general education needs of all students.

Within the scope of this mission, the Bachelor of Arts program in the Department of Mathematical Sciences is designed to give students a deep understanding of the foundations of mathematics. Students will study a variety of mathematical disciplines, including discrete mathematics, analysis, and algebra, and are expected to be able to understand sophisticated mathematical ideas by the conclusion of their studies. The capstone experience is a semester spent studying proof techniques. Graduates should be able to continue their studies in either Master's or Ph.D. programs, or enter the workforce in jobs requiring sophisticated quantitative skills.

Major requirements include a three-course sequence in single-variable and multivariable calculus; a discrete mathematics course intended as a gateway to abstract mathematics; in-depth courses in linear and abstract algebra; an introduction to the theory of functions; and an in-depth seminar on significant mathematical theorems and the proofs behind them. Required major electives will allow students to further customize their academic track with course options such as Number Theory, Symbolic Logic, Differential Equations, Vector Calculus; Introduction to Mathematica; advanced studies in statistics and actuarial science; and more, plus internship and independent study options. Students also complete a minor in an area of their choice; the breadth of interests of our students is demonstrated by the vast number of different choices for their minors: 25 different minors over the last 5 years, including such varied disciplines as Physics, Management Information Systems, Geography, and Religious Studies. Many of our students also complete double majors, including Chemistry, Engineering, and Physics. There are also options for students to specialize in Statistics or Actuarial Science; these options involve foregoing the minor in favor of an in-depth study of a subfield of mathematics.

Three significant changes to our program have been approved in the last few years, partly based on the results of assessment:
1) Requiring students to take MATH 218 before MATH 377;
2) Using different textbooks and a different approach for MATH 228;
3) Updating the course outlines for the Calculus sequence.

For more details, including the relationship between these changes and assessment, please consult Section 4 of this report.

SECTION 1 – LEARNING OUTCOMES (LO)

There are five program learning outcomes for the Bachelor of Arts in Mathematics.

After completing the program, the student should be able to:

1) Understand basic analytic arguments using such common notions as epsilon/delta, infinite sums, and limits.
2) Understand basic algebraic and discrete notions, such as facts about vector spaces and counting arguments.
3) Be able to follow and recreate algebraic proofs, with a good understanding of groups.
4) Be able to both follow and recreate analytic proofs, including basic ideas involving abstract metric spaces and differential equations.
5) Be able to independently investigate more advanced topics in mathematics and present their results to others in a clear way.

SECTION 2 – FINDINGS

Learning Outcome #1 - Understand basic analytic arguments using such common notions as epsilon/delta, infinite sums, and limits.
This learning outcome is the focus of the Calculus sequence. The instruments that are used to obtain the data are Problem Sets, Quizzes, In-Class Exams and the Final Exam, for MATH 152 (Calculus I) and 221 (Calculus II). Each course has a few course learning outcomes. The instructor rates each student for each of the learning outcomes, using the following rubric:

2 – Strong Performance of Learning Outcome
1 – Acceptable Performance of Learning Outcome
0 – Unacceptable Performance of Learning Outcome

The course learning outcomes are the following:

For MATH 152:

i.The student will be able to compute and understand limits;

ii.The student will be able to compute and understand derivatives;
iii.The student will be able to solve application problems using derivatives.

For MATH 221:
i.The student will be able to compute definite and indefinite integral using varied techniques;
ii.The student will be able to determine the convergence of sequences and series;
iii.The student will be able to apply integration and compute areas and volumes of revolution.

The instructor then evaluates the overall performance of each student with respect to the overall program learning outcome, using the same rubric as above.

Summary of results:

	Number of Students Performing at each level (2,1,0) for learning objective #1		
Level of Performance	**2**	**1**	**0**
MATH 152	5 (19%)	10 (37%)	12 (44%)
MATH 221	9 (19%)	16 (33%)	23 (48%)

Learning Outcome #2 - Understand basic algebraic and discrete notions, such as facts about vector spaces and counting arguments.

This learning outcome is primarily covered by two courses: MATH 218 (Discrete Mathematics) and MATH 228 (Introduction to Linear Algebra. The instruments that are used to obtain the data are Problem Sets, Quizzes, In-Class Exams and the Final Exam, for these two courses. Each course has a few course learning outcomes. The instructor rates each student for each of the learning outcomes, using the following rubric:

2 – Strong Performance of Learning Outcome

1 – Acceptable Performance of Learning Outcome

0 – Unacceptable Performance of Learning Outcome

The course learning outcomes are the following:

For MATH 218:

i.The student will be able to prove mathematical statements;
ii.The student will be able to understand sets and functions (including properties and applications);
iii.The student will be able to prove suitable mathematical statements by induction;
iv.The student will be able to solve basic combinatorial problems.

For MATH 228:

i.The student will be able to solve systems of linear equations;

ii.The student will be able to perform computations involving matrices;

iii.The student will be able to apply integration and compute areas and volumes of revolution.

The instructor then evaluates the overall performance of each student with respect to the overall program learning outcome, using the same rubric as above.

Summary of results:

	Number of Students Performing at each level (2,1,0) for learning objective #2		
Level of Performance	**2**	**1**	**0**
MATH 218	9 (38%)	10 (42%)	5 (21%)
MATH 228	10 (59%)	5 (29%)	2 (12%)

Learning Outcome #3 - Be able to follow and recreate algebraic proofs, with a good understanding of groups.

This learning outcome is primarily covered by the course MATH 366 (Introduction to Abstract Algebra). The instruments that are used to obtain the data are Problem Sets, Quizzes, In-Class Exams and the Final Exam, for this course. The course has a few course learning outcomes. The instructor rates each student for each of the learning outcomes, using the following rubric:

2 – Strong Performance of Learning Outcome

1 – Acceptable Performance of Learning Outcome

0 – Unacceptable Performance of Learning Outcome

The course learning outcomes are the following:

For MATH 366:
i.The student will be able to understand and apply definitions of group, subgroup;
ii.The student will be able to understand and apply definitions and properties of cyclic group, permutation group, factor group;
iii.The student will be able to understand and apply definitions and properties of homomorphism, isomorphism.

The instructor then evaluates the overall performance of each student with respect to the overall program learning outcome, using the same rubric as above.

Summary of results:

	Number of Students Performing at each level (2,1,0) for learning objective #3		
Level of Performance	**2**	**1**	**0**
MATH 366	25 (50%)	16 (32%)	9 (18%)

Learning Outcome #4 - Be able to both follow and recreate analytic proofs, including basic ideas involving abstract metric spaces and differential equations.

This learning outcome is primarily covered by the course MATH 377 (Introduction to Real Analysis). The instruments that are used to obtain the data are Problem Sets, Quizzes, In-Class Exams and the Final Exam, for this course. The course has a few course learning outcomes. The instructor rates each student for each of the learning outcomes, using the following rubric:

2 – Strong Performance of Learning Outcome
1 – Acceptable Performance of Learning Outcome
0 – Unacceptable Performance of Learning Outcome

The course learning outcomes are the following:

For MATH 377:
i.The student will be able to understand the topology of the real line;
ii.The student will be able to rigorously determine/prove convergence of sequences;
iii.The student will be able to rigorously determine/prove continuity and uniform continuity of functions;
iv.The student will be able to understand distinct types of convergence of sequences of functions.

The instructor then evaluates the overall performance of each student with respect to the overall program learning outcome, using the same rubric as above.

Summary of results:

	Number of Students Performing at each level (2,1,0) for learning objective #4		
Level of Performance	**2**	**1**	**0**
MATH 377	10 (59%)	5 (29%)	2 (12%)

Learning Outcome #5 - Be able to independently investigate more advanced topics in mathematics and present their results to others in a clear way.

This learning outcome is primarily covered by the course MATH 450 (Seminar in Proof). Since this is a capstone course, instead of taking examinations and completing problem sets, the students in this class complete a final project in which they investigate a mathematical result and/or research article. The instruments that are used to obtain the data are the students' final papers and their final in-class presentation. The course has a rubric with six items; it can be found in table 9. The instructor rates each student for each of the six criteria, using the following scale:

2 – Strong Performance of Learning Outcome
1 – Acceptable Performance of Learning Outcome
0 – Unacceptable Performance of Learning Outcome

The instructor then evaluates the overall performance of each student with respect to the overall program learning outcome, using the same scale as above.

Summary of results:

	Number of Students Performing at each level (2,1,0) for learning objective #5		
Level of Performance	**2**	**1**	**0**
MATH 450	6 (46%)	7 (54%)	0 (0%)

SECTION 3 – ANALYSIS

Learning Outcome #1

Our data indicate that, for the period from Fall 2015 through Summer 2019, 56% of MATH 152 students and 52% of MATH 221 students perform at an acceptable or better level for Learning Outcome #1. This is a decrease from past periods, where 78% of MATH 152 students and 70% of MATH 221 students performed at an acceptable or better level. This decrease might be attributable to several factors:

- Some students may have received a weaker preparation for Calculus at the high school level;
- More students may have taken Precalculus at Community Colleges, where the quality of the courses may be hard for us to measure because we are not familiar with the way that the material is covered;
- The student cohort that we measured in the last few years may have been weaker overall;
- Our current MATH 119 course may need to be reviewed to provide students with better preparation for the Calculus sequence.

We should perform a full analysis of the preparation of our students taking MATH 152 and/or 221, so as to see what could be done in order to increase their chances of success in these courses. We should also create course learning objectives for MATH 222, which is the third course of the Calculus sequence, but has never been assessed.

We are hopeful that, with the newly updated course outlines for the Calculus sequence, instructors will have more guidance in order to navigate the pitfalls of these course.

Learning Outcome #2

Our data indicate that, for the period from Fall 2015 through Summer 2019, 79% of MATH 218 students and 88% of MATH 228 students perform at an acceptable or better level for Learning Outcome #2. This is a slight decrease from past periods, where 83% of MATH 218 students and 97% of MATH 228 students performed at an acceptable or better level.

We recommend closely monitoring the performance of MATH 218 students, since this course is crucial for recruiting Mathematics majors, as it is the first encounter that most students will have with the more theoretical aspects of mathematics, and with proof-writing.

The course learning objectives for MATH 218 should be updated to reflect the fact that not all instructors spent the same amount of time covering certain topics (for instance, there are no learning objectives pertaining to number theory, but there is one pertaining to combinatorics; some instructors will cover much more number theory than combinatorics).

In the past, the performance of students in the MATH 228 course learning objectives related to the early part of the course was very high. The department has since adopted a different (more theoretical) approach towards this course, and has been using more advanced textbooks, in order to provide our students with a richer experience. Our data show that this has been a success; the students still perform well, but we have been able to cover more material in the course. We should consider revising the course learning objectives, as well as the course outline and official course description, to better reflect the new approach.

Learning Outcome #3

Our data indicate that, for the period from Fall 2015 through Summer 2019, 82% of MATH 366 students perform at an acceptable or better level for Learning Outcome #3. This is a slight decrease from past periods, where 89% of MATH 366 students performed at an acceptable or better level.

The high performance of these students may seem surprising, because MATH 366 is generally regarded by student as a challenging course; however, the students taking it have already completed MATH 152 and 218, which means that they have already conquered two of the significant obstacles that students encounter towards graduation. As such, they are more prepared than the beginners.

Learning Outcome #4

Our data indicate that, for the period from Fall 2015 through Summer 2019, 88% of MATH 377 students perform at an acceptable or better level for Learning Outcome #4. This is similar to past periods, where 86% of MATH 377 students performed at an acceptable or better level.

The high performance of these students may seem surprising, because MATH 377 is generally regarded by student as a challenging course; however, the students taking it have already completed MATH 152, 218 and 221, which means that they have already conquered three of the significant obstacles that students encounter towards graduation. As such, they are more prepared than the beginners. These data also seem to indicate that requiring students to take MATH 218 before MATH 377 was a reasonable decision.

Learning Outcome #5

Our data indicate that, for the period from Fall 2015 through Summer 2019, 100% of MATH 450 students perform at an acceptable or better level for Learning Outcome #5. This is similar to past periods, where 95% of MATH 450 students performed at an acceptable or better level.

This is not surprising at all, since students who make it all the way to MATH 450 are definitely well prepared for the challenges of that course, having already completed MATH 366 or 377 and all of the prerequisites.

The department should consider changing the title of the course to "Research Seminar" or "Senior Seminar", and updating the course description to emphasize the centrality of the "project" component of the course (that is, most of a student's work and grade will be based on a written project and oral presentation).

Overall

While we do feel that overall, our program is very strong, we should consider the following:

- It seems that, for many students, Calculus I and II and Discrete Mathematics are significant roadblocks. While this is not surprising, and is most likely consistent with mathematics programs and courses at most universities in the United States, it would be worthwhile to analyze more closely the reasons why students do not succeed at the early stages of their college career. This is especially important, since the early mathematics courses can be substantial recruiting grounds for mathematics majors.
- While the current set of learning objectives is reasonable, one could point to some weaknesses. For instance, there is no learning objective, and no required course, in the area of geometry. This is surprising, given the historical importance of geometry as a branch of mathematics, and the fact that geometry is a significant strength of our department in terms of research. In addition, one of the learning objectives mentions differential equations, but there is no required course in differential equations, which is also surprising because we have a thriving course in the subject (the course mostly serves the needs of Engineering majors). The Department is currently working on the creation of an additional concentration within the Mathematics BA program, which would better serve the needs of students who wish to acquire a stronger background in Pure and Applied Mathematics.

SECTION 4 – USE OF RESULTS

1) Starting in Fall 2014, the Department began requiring students to take Discrete Mathematics (MATH 218) before Introduction to Real Analysis (MATH 377), because two of the four Course Learning Objectives for MATH 377 relate to "proving" statements, and the course that introduces students to proofs is MATH 218.
2) The Department has moved away from teaching Introduction to Linear Algebra (MATH 228) using the previous textbook (Lay), which put a lot of emphasis on calculations and applications, and moved towards using more challenging textbooks that provides the students with an in-depth study of the theory. One motivation for this change was the fact that our students performed absurdly well in the learning objectives related to the early part of MATH 228 (as discussed in Section 3), and there was an understanding among the faculty that our students were not truly challenged intellectually by the material, and therefore would benefit more from a different approach.
3) The Department has approved revised course outlines for the Calculus sequence (MATH 152, 221, 222). This was done to address the concern (evidenced by the assessment data, as discussed in Section 3) that MATH 152 and 221 can be significant obstacles for the students on their road to academic success, so it is important to give faculty a guide to which topics need to be covered, which ones are optional, and which ones are likely to require additional time.

SECTION 5 – DEPARTMENTAL PROGRAM ASSESSMENT PLAN

The Department should follow the following timeline to implement the recommendations of this report:

2019-20: Work on the possible creation of a new concentration, as explained in Section 3; revise the learning outcomes and course learning objectives for the program, as discussed in Section 3.

2020-21: Study the students' backgrounds in the prerequisite courses for MATH 152, 218, 221. Make recommendations for possible changes. (It is difficult to say which changes should or will be made without knowing what we will find, so no specific recommendations will be made at this time.)

2021-22: Complete a revision of all course outlines, so as to provide up-to-date guidelines for instructors.

2022-23: Perform other necessary tasks as identified in the last three years.

As seen in the tables, data are not collected every year for every course and every learning outcome. This is partly because there is no permanent committee in charge of assessment at the department level; it would be beneficial to create one. In addition, the

department should plan ahead in order to select ONE class per instructor per semester and collect data from that class. The class should be selected in such as way that:

- If an instructor is teaching a single-section class (MATH 228, 366, 377, 450), that class is selected;
- Otherwise, another class (MATH 152, 218, 221, 222) is selected, in such a way as to make sure that at least one section of each course is assessed every semester.
- In all situations except ones where the learning outcomes or course learning objectives are changed, the data that will be collected will be the same as in the past, in order to enable easy comparison with past data.
- It may be helpful to change the assessment strategy in the future; for example, we could ask instructors to include common questions tied to specific course learning objectives on their final examinations. This would provide the department with some more objective data on student learning and success. However, the decision to implement this would have to be made by the department. This will be discussed by the department in 2019-20.

SECTION 6 – GENERAL EDUCATION LEARNING OBJECTIVES/OUTCOMES ASSESSMENT

Our department offers many courses that are part of the General Education program.
MATH 102, 103, 105, 106, 110, 113, 115, 116, 119, 123, 124, 125, 135, 136, 152, 213, 217, 218, 221, 344, and STAT 104, 200, 201, 215, 216 are used in the General Education program. MATH 344 aligns with objective 2; all other courses, with objective 6.

Professor Marian Anton has provided artifacts from MATH 102 and 218, for Quantitative Reasoning (LO#6).
Professor Frederic Latour will soon provide artifacts from MATH 218, for Quantitative Reasoning (LO#6), and possibly from MATH 450, for Written Communication (LO#5).

APPENDIX A

Findings for Degree Program Learning Outcomes

Table 1. Findings for Degree Program Learning Outcomes

	Number and Percent of Students at each Level (2, 1, 0)								
	Fall 2011 through Summer 2014			Fall 2014 through Summer 2015			Fall 2015 through Summer 2019		
Program Learning Outcomes	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
1. Understand basic analytic arguments using such common notions as epsilon/delta, infinite sums, and limits									
Math 152	36 (40%)	35 (38%)	20 (22%)	31 (43%)	26 (35%)	17 (23%)	5 (19%)	10 (37%)	12 (44%)
Math 221	13 (13%)	63 (62%)	25 (25%)	6 (15%)	17 (41%)	18 (44%)	9 (19%)	16 (33%)	23 (48%)
2. Understand basic algebraic and discrete notions, such as facts about vector spaces and counting arguments.									
Math 218	14 (27%)	28 (55%)	9 (18%)	19 (40%)	20 (43%)	8 (17%)	9 (38%)	10 (42%)	5 (21%)
Math 228	34 (39%)	50 (57%)	3 (3%)	5 (25%)	15 (75%)	0 (0%)	10 (59%)	5 (29%)	2 (12%)
3. Be able to follow and recreate algebraic proofs, with a good understanding of groups.									
Math 366	20 (29%)	39 (57%)	10 (14%)	12 (57%)	9 (43%)	0 (0%)	25 (50%)	16 (32%)	9 (18%)
4. Be able to both follow and recreate analytic proofs, including basic ideas involving abstract metric spaces and differential equations.									
Math 377	7 (18%)	23 (61%)	8 (21%)	9 (50%)	9 (50%)	0 (0%)	10 (59%)	5 (29%)	2 (12%)
5. Be able to independently investigate more advanced topics in mathematics and present their results to others in a clear way.									
Math 450	9 (53%)	8 (47%)	0 (0%)	10 (40%)	13 (52%)	2 (8%)	6 (46%)	7 (54%)	0 (0%)

APPENDIX B

Findings for Course Learning Outcomes

Table 2. Mathematics 152

		Number of Students at each Level (2, 1, 0)																	
		Spring 2011 (n = 2)			Fall 2011/Spring 2012 (n= 4)			Fall 2012/Spring 2013 (n = 46)			Fall 2013/ Spring 2014 (n=41)			Fall 2014/Spring 2015 (n = 74)			Spring 2016 (n = 27)		
Course Learning Outcomes		**2**	**1**	**0**	**2**	**1**	**2**	**1**	**0**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
I.	Compute and understand limits	n/a	n/a	n/a	n/a	n/a	32	31	11	n/a	19	15	7	32	31	11	10	12	5
II.	Compute and understand derivatives	1	1	0	3	1	28	22	24	4	18	15	8	28	22	24	8	7	12
III.	Solve application problems using derivatives	1	1	0	2	1	12	25	37	10	4	17	20	12	25	37	8	9	10

Table 3. Mathematics 218

	Number of Students at each Level (2, 1, 0)																	
	Spring 2011 (n=7)			Fall 2011/Spring 2012 (n=14)			Fall 2012/Spring 2013 (n=11)			Fall 2013/Spring 2014 (n=27)			Fall2014/Spr15 (n=49)			Spring/ Summer 2019 (n=24)		
Course Learning Outcomes	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
I.Prove mathematical statements	3	3	1	5	6	3	3	8	0	10	12	5	17	19	13	18	2	4
II.Understand sets and functions (including properties and applications)	3	0	4	8	4	2	10	1	0	13	10	4	19	20	10	11	5	8
III.Prove suitable mathematical statements by induction	3	1	3	5	1	8	2	7	2	11	12	4	13	23	13	8	13	3
IV.Solve basic combinatorial problems	2	5	0	1*	4*	0*	4	7	0	7	14	6	18	22	9	13	4	7

* One section of Math218 (n=9) did not cover the material corresponding to course learning outcome IV.

Table 4. Mathematics 221

	Number of Students at each Level (2, 1, 0)														
	Fall 2011/Spring 2012 (n=11)			Fall 2012/Spring 2013 (n=48)			Fall 2013/Spring 2014 (n=44)			Fall 2014/Spring 2015 (n=41)			Fall 2015/Spring 2016 (n=48)		
Course Learning Outcomes	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
I. Compute definite and indefinite integrals using varied techniques	2	5	3	42	5	0	5	25	14	19	11	11	11	18	19
II. Determine convergence of sequences and series	2	6	3	29	18	1	3	19	22	9	15	17	13	13	22
III. Apply integration to compute areas and volumes of revolution	3	7	1	20	26	2	11	18	15	24	8	9	19	11	18

Table 5. Mathematics 228

		Number of Students at each Level (2, 1, 0)																	
		Spring 2011 (n = 14)			Fall 2011/Spring 2012 (n=30)			Fall 2012/Spring 2013 (n=17)			Fall2013/Spring2014 (n=40)			F14/Spr15 (n=20)			Summer 2017/2018 (n=17)		
Course Learning Outcomes		**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
I.	Solve systemsof linear equations	12	2	0	30	0	0	17	0	0	37	2	1	20	0	0	12	5	0
II.	Perform computations involving matrices	14	2	0	30	0	0	17	0	0	35	4	1	19	1	0	12	5	0
III.	Apply andverify linearity of transformations	4	4	6	21	9	0	14	3	0	20	19	1	12	8	0	8	8	1
IV.	Understand and applyvectorspace definitions and properties	5	7	2	12	17	1	8	9	0	15	22	3	10	10	0	9	6	2

Table 6. Mathematics 366

		Number of Students at each Level (2, 1, 0)																	
		Spring 2011 (n=9)			Fall 2011/Spring 2012 (n=43)			Fall 2013/Spring2014 (n=26)			Fall 2014/Spring2015 (n=21)			Fall 2015 (n=13)			Spring 2017/18 (n=38)		
Course Learning Outcomes		**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
I.	Understand and apply definitions of group, subgroup	4	3	2	25	13	5	14	9	3	14	7	0	6	5	1	21	10	7
II.	Understand and apply definitions and properties of cyclic group, permutation group, factor group	2	4	3	18	20	5	9	13	4	10	10	1	6	4	2	18	15	5
III.	Understand and apply definitions and properties of homomorphism, isomorphism	2	4	3	14	24	5	15	8	3	6	10	5	5	4	3	16	14	8

Table 7. Mathematics 377

	Number of Students at each Level (2, 1, 0)														
	Spring 2011 (n=9)			Fall 2011/Spring 2012 (n=16)			Fall 2013/Spring 2014 (n=22)			Fall 2014/Spring2015 (n=18)			Fall2016 (n=18)		
Course Learning Outcomes	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
I. Understand the topology of the real line	5	1	0	11	4	1	7	14	1	7	9	2	6	8	3
II. Rigorously determine/prove convergence of sequences	4	2	0	7	7	2	9	8	5	12	6	0	11	5	1
III. Rigorously determine/prove continuity and uniform continuity of functions	2	3	1	3	10	3	6	14	2	8	7	3	15	1	1
IV. Understand distinct types of convergence of sequences of functions	0	5	1	1	11	3	NR	NR	NR	6	9	3	NR	NR	NR

Note: NR – not reported by faculty, due to the material corresponding to this learning outcome not being covered.

Table 8. Mathematics 450

Course Learning Outcomes	Number of Students at each Level (2, 1, 0)								
	Spring 2014 (n=17)			Spring 2015 (n=25)			Spring 2018 (n=13)		
	2	**1**	**0**	**2**	**1**	**0**	**2**	**1**	**0**
1.2 Completeness /Thoroughness	10	5	2	11	12	2	6	5	2
1.2 Correctness	8	9	0	12	10	3	6	6	1
1.3 Motivation	7	9	1	n/a	n/a	n/a	7	4	2
2.2 Completeness /Thoroughness	11	6	0	15	9	1	9	3	1
2.2 Correctness	10	7	0	17	7	1	9	4	0
2.3 Motivation	8	9	0	n/a	n/a	n/a	12	1	0

Note: The spring 2015 professor did not grade for motivation because s/he did not ask students for their broader motivation for their proofs.

Table 9. Mathematics 450 Assessment Rubric for Written Assignment

(1) The student will be able to present a mathematical topic or proof in writing.	2 - Strong performance	1 - Acceptable performance	0 - Unacceptable performance
1.1 Completeness /Thoroughness	The student's written presentation is thorough. It includes a large amount of relevant information about the topic or proof, and reflects a deep understanding.	The student's written presentation covers some useful information about the topic or proof, but is missing some important parts.	The student's written presentation is superficial. It is missing a large amount of relevant information and provides only limited information about the topic or proof.
1.2 Correctness	The student's written presentation contains no, or few, mathematical mistakes.	The student's written presentation contains a significant number of mathematical mistakes.	The student's written presentation contains pervasive mathematical mistakes that would impede a reader's understanding of the subject.
1.3 Motivation	The student's written presentation makes clear why the topic or proof is important.	The student's written presentation contains limited information about why the topic or proof is important.	The student's written presentation does not contain information about why the topic or proof is important, or the information is incorrect.

Table 10. Mathematics 450 Assessment Rubric for Oral Assignment

(2) The student will be able to present a mathematical topic or proof orally to his or her peers.	2 - Strong performance	1 - Acceptable performance	0 - Unacceptable performance
2.1 Completeness /Thoroughness	The student's oral presentation is thorough. It includes a large amount of relevant information about the topic or proof, and reflects a deep understanding.	The student's oral presentation covers some useful information about the topic or proof, but is missing some important parts.	The student's oral presentation is superficial. It is missing a large amount of relevant information and provides only limited information about the topic or proof.
2.2 Correctness	The student's oral presentation contains no, or few, mathematical mistakes.	The student's oral presentation contains a significant number of mathematical mistakes.	The student's oral presentation contains pervasive mathematical mistakes that would impede a reader's understanding of the subject.
2.3 Motivation	The student's oral presentation makes clear why the topic or proof is important.	The student's oral presentation contains limited information about why the topic or proof is important.	The student's oral presentation does not contain information about why the topic or proof is important, or the information is incorrect.