

## Bachelor's Degree Program in Mathematics

### Goals and Associated Outcomes

**Goal 1:** Graduates will have acquired a firm foundation of knowledge of fundamental mathematical concepts, methods, language, and modes of reasoning sufficient to support further academic work or careers in fields that require mathematical understanding.

**Outcomes:** The student exhibits the ability to:

- (a) Use important definitions and results correctly.
- (b) Apply mathematical results and procedures to concrete problems.
- (c) Generate straightforward extensions of mathematical procedures and results.
- (d) Analyze quantitative data using appropriate mathematical tools.
- (e) Use mathematical software to investigate and solve problems.
- (f) Identify logical errors in mathematical arguments.
- (g) Prove immediate consequences of basic theorems.

**Goal 2:** Graduates will be able to communicate mathematical ideas and results clearly and with appropriate precision, both orally and in writing.

**Outcomes:** The student exhibits the ability to:

- (a) Use mathematical notation and terminology correctly.
- (b) Organize computations and proofs clearly and logically.
- (c) Explain the reasoning that supports solutions to mathematical problems.

**Goal 3:** Graduates will have acquired sufficient mathematical background and experience to use the professional literature to progress further on their own.

**Outcomes:** The student exhibits the ability to:

- (a) Use the professional literature (journal articles, articles available on the web, higher-level textbooks, etc.) to write a paper on a mathematical topic not covered in formal study.

### Overview

Our principal assessment tool is our capstone course, MTH 495 (Senior Seminar), in which students are required to write and present a paper on a mathematical topic not covered in previous formal study. We also collect work from one 200-level course and one 300-level course, MTH 288 (Linear Algebra) and MTH 301 (Introduction to Applied Mathematics). Thus, we will have samples of most majors' work at three stages of their undergraduate careers. Each spring these samples are evaluated against the specified outcomes by the department's Undergraduate Assessment Committee. The Chair and Associate Chair are actively involved and a report is made to the Undergraduate Program Committee (UPC).

## **Goals and Outcomes**

Early attempts at departmental self-assessment of the undergraduate program lacked measurable outcomes and were excessively complex. The present collection above was developed in Fall 2002 using input from the UPC and open meetings and agreed to by the entire department. They have served us well and have not been changed since then.

## **Research Methods**

For MTH 288, we collect all of the final exams from the Fall Semester each year and evaluate each with a 5 point rubric on Goal 1, Outcomes a and b, and Goal 2, Outcomes a, b, and c. This instrument has not been modified. The checksheet and scoring rubric is attached.

For MTH 301, we collect the major projects from the Fall Semester each year and evaluate each with a 6 point rubric on Goal 1, Outcomes a, b, d, and e, and Goal 2, Outcomes a, b, and c. This instrument has not been modified. The checksheet and scoring rubric is attached.

For MTH 495, we collect the course papers from the Fall Semester each year and evaluate each with a 9 point rubric that covers all of Goals 1, 2, and 3 above with each of their Outcomes. This instrument was modified this year to fit the projects more closely and allow for a more substantial, differentiated evaluation. This new checklist is attached.

One indirect method the chair used in the past was exit interviews for graduating math majors. We were told several years ago and again last year by the outside consultant that this was not a valid approach, so exit interviews are no longer scheduled. A new chair will begin July 1, 2006, and the exit interview and other indirect methods will be considered.

## **Findings**

For MTH 288, the average score for the 16 students was 18.5, which was vastly higher than the 11.42 average of the previous year. Reasons for the increase are the much better performance of the students, the clarity of expectations of the instructor, and the fact that part of the final (for the first time) was completed outside of class.

For MTH 301, the average score for the 19 students was 32.77, which was significantly higher than the 24.9 average of the previous year. We had focused on a better alignment of the project with the goals and outcomes and also did a better job of selecting possible topics for the students to work on. The instructor also required a first draft that was to be re-worked prior to the final submission.

For MTH 495, the average score for the 20 students was 7.91, which was significantly higher than the 5.41 average of the previous year. This reflects the improved instrument as well as the instructor's expertise in dealing with these papers, and the students' response to more explicit instructions.

## Review

For MTH 288, the data were analyzed in the Spring Semester, 2006, by a three-person committee with input from the Chair. Each committee member evaluated each final exam.

For MTH 301, the data were analyzed in the Spring Semester, 2006, by a three-person committee with input from the Chair. Each committee member evaluated each project.

For MTH 495, the data were analyzed in the Spring Semester, 2006, by a three-person committee with input from the Chair. Each committee member evaluated each course paper.

Results of each of these three components are reviewed by the Chair, Associate Chair, and UPC Chair, as well as members of the UPC. This year, there was substantial discussion in two department meetings on what we've learned and how we can improve our courses as a result of our assessment results.

## Actions

For MTH 288, generally speaking, the process is working well and the students are performing. It was a nice improvement to have part of the final worked on outside of class and we shall repeat this.

For MTH 301, we were able to align the projects much better with the goals and objectives desired. We will continue to require a first draft and will also refer students with serious writing issues to the CSU Writing Center. We also have to incorporate more preparation for writing mathematics in each of our 200-level courses this coming year.

For MTH 495, improvement is evident, especially over the papers from several years ago. A general problem that other subjects have had to contend with, but not so much as math, is starting to emerge. This is the notion of different forms of plagiarism and will have to be very actively combated. The department will draft and adopt a clear plagiarism policy that will be given to students at the beginning of the course. The instructor will be encouraged to do simple phrase searches with GOOGLE when grading the projects if plagiarism is suspected.

When we began with assessment in the late 1990's, we used just the capstone course, MTH 495, which had been in place for several years. But experience then showed that it would be desirable to have samples of majors' work from earlier in their academic careers; hence the current version. Now, we are considering incorporating some measure from the 100-level from our calculus courses. We have used a form of a proficiency test for several years in MTH 181, Calculus I, but there are differing opinions if this should become part of our assessment program.

MTH 288 Assessment

STUDENT NAME: \_\_\_\_\_

		4 Excellent	3 Good	2 Satisfactory	1 Almost Satisfactory	0 Unsatisfactory
6	0					
1	a					
1	b					
2	a					
2	b					
2	c					

TOTAL: \_\_\_\_\_

RATER: \_\_\_\_\_

Item 1.

- Excellent: Gives a complete, clear, coherent, and unambiguous response.
- Good: Gives a fairly complete response that is reasonable clear.
- Satisfactory: Conveys the basic idea but the working is imprecise or muddled, and parts of the statement may be omitted.
- Almost satisfactory: Conveys the basic idea but makes minor errors or major omissions; wording is difficult to understand
- Unsatisfactory: Shows no understanding of the statement, or shows no comprehension of the need for precision.

Item 2.

- Excellent: Applies the correct result or procedure correctly, with a full and precise explanation of why this applies.
- Good: Applies the correct result or procedure correctly or with minor errors, with some explanation as to why this applies.
- Satisfactory: Applies the correct result or procedure correctly or with minor errors, but leaves parts of the solution out; inadequate explanation as to why this applies.
- Almost satisfactory: Begins to apply the correct result or procedure, but with major errors or with significant parts of the problem unsolved; little or no useful explanation as to why this applies.
- Unsatisfactory: Applies the correct result or procedure with several major errors, or attempts to apply results or procedures that are not applicable.

Item 3.

- Excellent: Writes in a manner suitable for a textbook or written report.
- Good: Writes in an understandable manner but with minor technical flaws or omissions.
- Satisfactory: Writes in a muddled but understandable way, may include unnecessary symbols or other confusing material.
- Almost satisfactory: Has some knowledge of the notation and terminology, but could not be understood by someone who did not already know the solution.
- Unsatisfactory: Misuses terminology and notation, shows little or no knowledge of syntax.

Item 4.

- Excellent: Gives a complete, clear, coherent, and unambiguous response. Shows all necessary steps in the correct order.
- Good: Gives a fairly complete response that is reasonably clear. Some necessary steps may be omitted and unnecessary steps may be included.
- Satisfactory: Gives an understandable response that is generally correct. Parts of the response may be muddled or irrelevant.
- Almost satisfactory: Gives a response that could not be understood by someone who did not already know the solution. Parts of the response may be muddled, incorrect, or irrelevant.
- Unsatisfactory: Has major errors in computation and/or logic, or has no understanding of the problem.

Item 5.

- Excellent:** Gives a complete, clear, logical, coherent, correct, and unambiguous response.
- Good:** Gives a fairly complete response that is reasonably clear. Any omissions are minor.
- Satisfactory:** Gives a fairly complete response that is reasonably clear, but parts may be muddled. Any omissions are minor.
- Almost satisfactory:** Gives a fairly complete response that is generally muddled, and could not be understood by someone who did not already know the solution. Shows incomplete knowledge of the solution, and there may be major omissions.
- Unsatisfactory:** The reasoning contains a major logical error, or is irrelevant to the problem, or just incorrect.

STUDENT NAME \_\_\_\_\_

Checksheet for Projects in MTH 301

Goal	Outcome	Description	6	5	4	3	2	1
1	a	Uses important definitions and results correctly	6	5	4	3	2	1
	b	Applies mathematical results and procedures to concrete problems	6	5	4	3	2	1
	d	Analyze Quantitative Data using appropriate mathematical tools (Applies proper methodology)	6	5	4	3	2	1
	e	Uses mathematical software to investigate and solve problems (Uses software correctly and labels graphs correctly)	6	5	4	3	2	1

Goal 2 Outcomes:

2	a	Uses mathematical notation and terminology correctly	6	5	4	3	2	1
2	b	Organizes computations and proofs clearly and logically (Layout and professionalism of project)	6	5	4	3	2	1
2	c	Explains the reasoning that supports solutions to mathematical problems (Gives correct conclusions and provides thorough summary)	6	5	4	3	2	1

TOTAL \_\_\_\_\_

GRADER \_\_\_\_\_

## Scoring Rubric for MTH 301 Projects

### Goal 1 Outcomes:

#### Use important definitions and results correctly.

**6=Exemplary Response**– Uses appropriate terms and results in a complete, clear, coherent manner. Presents strong supporting arguments with diagrams as needed.

**5=Competent Response** – Gives a fairly complete response that is reasonably clear and may include an appropriate diagram.

**4=Minor Flaws, Satisfactory** –Completes the project, but the explanation may not be clearly tied to appropriate results. Diagrams may be inappropriate or unclear.

**3=Serious Flaws, Nearly Satisfactory** – Fails to show complete understanding of ideas. May omit significant connections to math results.

**2=Begins, but Unsatisfactory** – Fails to make connections to necessary ideas or results. Shows little understanding of problem situation.

**1=Unable to Begin Effectively** – Words do not reflect the problem. Drawings misrepresent the problem situation.

#### Apply mathematical results and procedures to concrete problems.

**6=Exemplary Response** – Uses appropriate results and procedures to mathematize the problem at hand. Includes a full and precise explanation of why these apply.

**5=Competent Response** – Uses necessary approaches but the project is lacking some important characteristic. Does identify the most important aspects of the problem.

**4=Minor Flaws, Satisfactory** – Completes project with appropriate procedures but contains 2 or more errors or omissions involving the translation from the concrete to the theoretical.

**3=Serious Flaws, Nearly Satisfactory** – Completes project but could not answer one of the major questions of interest. Shows some signs of understanding but errors/omissions make the project not satisfactory.

**2=Begins, but Unsatisfactory** – Completes project with incorrect or inappropriate results. Necessary connections to original problem are incomplete.

**1=Unable to Begin Effectively** – Misrepresents the concrete problem. Fails to indicate where information is appropriate to problem.

#### Analyze quantitative data using appropriate mathematical tools.

**6=Exemplary Response** – Uses the correct methodology to answer the questions of interest. If any assumptions are necessary for analysis, those are clearly stated. Student also produces the appropriate graphics for the questions of interest.

**5=Competent Response** – Student uses appropriate methodology to answer questions of interest, but the paper is lacking in some important characteristic. This may include not stating assumptions or not including appropriate graphics.

**4=Minor Flaws, Satisfactory** – Student completes project with appropriate methodology, but contains 2 or more errors/omissions involving the statement of assumptions or inclusion of appropriate graphs.

**3=Serious Flaws, Nearly Satisfactory** – Student did not apply the correct methodology to answer one of the major questions of interest. Student could be consistent in making the mistake throughout paper. Student does the appropriate steps for their chosen methodology, and it is well-described, but flawed from the beginning.

**2=Begins, but Unsatisfactory** – Student completes project with inappropriate or incorrect methodology in more than one instance. Student does not seem to grasp the correct way in which to conduct the needed analysis. Student does not include the assumptions or graphs appropriate for the questions of interest.

**1=Unable to Begin Effectively** – Incoherent approach to questions of interest. Complete failure to understand what methods are needed to complete the project.

### **Use mathematical software to investigate and solve problems**

**6=Exemplary Response** – Uses software appropriately to answer the questions of interest. Provides documented results from the analysis with the appropriate interpretation of the output. Student does not include meaningless output that is not needed to answer the questions of interest. Student uses the software correctly to label graphics with necessary information.

**5=Competent Response** – Uses software appropriately, but fails to provide complete documentation or fails to label all graphs sufficiently. The student did successfully interpret the results correctly.

**4=Minor Flaws, Satisfactory** – Student used software appropriately, but failed to understand what was needed as adequate documentation of the results. Student has almost provided enough information to justify conclusions, but sufficient omissions occur to warrant concern.

**3=Serious Flaws, Nearly Satisfactory** – Student shows inappropriate or incorrect use of software to complete the project. The student shows some signs of understanding what is needed to complete the project, but sufficient errors/omissions make the project not satisfactory.

**2=Begins, but Unsatisfactory** – Student completes project with inappropriate or incorrect results of software. Necessary output and/or graphs are missing in almost all cases.

**1=Unable to Begin Effectively** – Incoherent approach to questions of interest. Complete failure to understand how to use software for the completion of this project.

### **Goal 2 Outcomes:**

#### **Uses mathematical notation and terminology correctly:**

**6=Exemplary Response** – Student uses proper notation throughout the paper. Student creates his own notation correctly as needed.

**5=Competent Response** – Student makes only one flaw with notation in paper. May have that same flaw occurring throughout paper, but it is essentially one misunderstanding of the notation.

**4=Minor Flaws, but Satisfactory** – Student makes only a minor number of mistakes/omissions with regard to notation.

**3=Serious Flaws, but nearly Satisfactory** – Student shows a problem with notation. There are too frequent misuses of notation to warrant satisfactory.

**2=Begins, but Fails to Complete Problem** – Students shows a complete misunderstanding of notation.

**1=Unable to begin** – Student has no understanding of notation to the point that the paper is unreadable.

### **Organizes computations and proofs clearly and logically**

(This outcome adapted for projects rather than proofs).

**6=Exemplary Response** – Student submits a professional looking report that is well-organized and very easy to read. The paper provides adequate introduction. In addition, the reader can understand the inquiry of interest and the results of the analysis without having read the assignment page. This category also includes style elements so that there are not inappropriate page breaks or non-consistent font usage.

**5=Competent Response** – Student makes only minor errors in the presentation of their project. Minor errors could include a minor page break problem, a minor font issue. Student may have forgotten to clearly state goals or background effectively enough so that the reader can understand the inquiry without the assignment sheet.

**4=Minor Flaws, but Satisfactory** – Student fails to make the project clear enough for the reader to understand. This may entail failing to include an adequate introduction or just providing enough written information to make the purpose or the results of the analysis clear.

**3=Serious Flaws, but Nearly Satisfactory** – Student fails to make project clear to reader and also fails to make the project well-organized and professional looking. The project may include large blocks of unused white space, or several fonts.

**2=Begins, but Unsatisfactory** - Begins project, but the result is not professional or complete. Students does understand what professionalism and complete entail.

**1=Unable to Begin** – Project is organized so poorly, that it is unreadable. Student has no idea how to write so that the project can be understood without the original assignment sheet.

### **Explains the reasoning that supports solutions to mathematical problems**

**6=Exemplary Response** – Student gives a complete interpretation of the results that is correct and appropriate for the questions of interest. Student use clear and concise language to describe the results of the test and the summary is thorough.

**5=Competent Response** – Students give the correct interpretation, but reasoning is not complete. Student may also not include a thorough summary. This may occur when student gives bare-bones answers to questions and does not give complete answers.

**4=Minor Flaws, Satisfactory** – Student gives correct interpretations in most cases, but may slip for one or two questions. Student may also give proper interpretations, but then not give sufficient explanations or a complete summary to the project.

**3=Serious Flaws, Nearly Satisfactory** – Student makes sufficient mistakes concerning interpreting results and making conclusions to warrant unsatisfactory. The student is clearly understanding the proper techniques to use, but then does not know to successfully interpret the results. Student does not include a sufficient summary to the project.

**2=Begins, but Unsatisfactory** – Student clearly does not understand how to successfully interpret output. Can give proper conclusions and/or fails to provide an adequate summary at the end of the paper.

**1=Unable to begin Effectively** – Student fails to give correct conclusions and fails to provide any kind of summary at the end.

Student Name \_\_\_\_\_

## Senior Seminar Project Checklist

Mark each question from 1-9 (9 being best) or with NA when it does not apply to the project at hand. At the end, take the average of the non-NA scores. This is the overall evaluation for the project.

- |  |       |
|--|-------|
| 1. Organizes project well with main results clearly stated | _____ |
| 2. Includes crucial definitions and background information | _____ |
| 3. Uses important definitions and/or results correctly     | _____ |
| 4. Analyzes information well                               | _____ |
| 5. Uses mathematical language and symbols appropriately    | _____ |
| 6. Uses mathematical techniques well                       | _____ |
| 7. Uses mathematics appropriate for the problem            | _____ |
| 8. Uses software appropriate for the problem               | _____ |
| 9. Formulates appropriate and convincing conclusions       | _____ |
| 10. Explains the problem and work clearly                  | _____ |
| 11. Displays a knowledge of literature on the subject      | _____ |
| 12. Displays an in-depth analysis of the problem or area   | _____ |

Overall Score: \_\_\_\_\_

A score of 7-9 rate the project as **High**; 4-6 as **Medium**; and 1-3 as **Low**.

**High** represents a project displaying a complete response to the problem set forth. The general analysis and write-up should be correct, clear and coherent, communicating the problem and the relevant mathematics effectively to the intended audience. The project should display an understanding of the ideas and processes involved and, where appropriate, should contain examples and/or counterexamples.

**Medium** represents a complete solution to the problem set forth, but the explanation may be unclear in places, there may be minor mathematical mistakes or understanding of the underlying concepts or techniques may not be displayed in a convincing manner. In general, however, the analysis and conclusions are correct.

**Low** represents either a lack of solution of the problem set forth or an explanation which lacks coherence and/or clarity. There may be gross mathematical errors or errors in analysis and conclusions which do not (or apparently do not) follow from the analysis.

Rater \_\_\_\_\_