# Semester Reports For Math 401

## 1 Relevant Student Learning Outcomes (SLOs)

In discussion with the faculty, the undergraduate committee created the student learning outcomes for the pure and applied math majors. The following SLOs are pertinent to the course content in Math 401.

1. Students will be able to compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.
2. Students will be able to write rigorous and well written proofs which show comprehension of formal mathematical definitions, recognize hypotheses, and form logical conclusions.
3. Students will be able to work with the fundamentals of logic, including mathematical statements and their converses and contrapositives.
4. Students will be able to construct counterexamples to mathematical statements and understand the importance of hypotheses.

Math 401 offers several opportunities for creating exam questions which assess student performance in these areas. Outcome #1 can be assessed by asking students to prove the existence of a limit or convergence of a sequence using the formal $\epsilon$-$\delta$ or $\epsilon$-$N$ definition. Outcome #2 will be naturally be assessed in most exam questions. Outcome #3 can be assessed by questions which involve an "if and only if" statement or by questions which naturally involve a proof by contrapositive or proof by contradiction. Outcome #4 can be assessed by questions which ask students to disprove a mathematical statement, perhaps after a certain hypothesis is relaxed.

Every instructor for Math 401 is asked to complete a "Semester Report", which provides data on the performance of these students in achieving these outcomes. Instructors will be asked to separate the results from different concentrations and majors. To that end, students should be asked to self-identify which major or concentration they have declared, perhaps with a question on the first exam or on a survey administered to the class.

Finally, instructors should ask students to self-assess their performance on these SLOs through questions on an electronically administered survey.

## 2 Rubrics

The purpose of the rubrics is to ensure that assessment occurs independently from the instructor's chosen grading scale. For example, some instructors may view that a student who gets 80-90% of the points to have given a "very good" solution while others may expect 100% credit to be rated at this level, using the "excellent" rating to distinguish exceptional solutions.

### 2.1 Rubric for SLO #1:

Students will be able to compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

| | |
|---|---|
| Excellent | Exemplary $\epsilon$-$\delta$ or $\epsilon$-$N$ proof, with full justification for each step and the logic of argument flows naturally. Choice of the threshold $\delta$ or $N$ is well motivated and effective for the given problem. Mathematical and English language is highly articulate. |
| Very Good | Cogent $\epsilon$-$\delta$ or $\epsilon$-$N$ proof, with most key steps clearly justified. Choice of the threshold $\delta$ or $N$ is effective for the given problem. Mathematical and English language is easily understandable. |
| Satisfactory | Comprehensible $\epsilon$-$\delta$ or $\epsilon$-$N$ proof, with justification for the essential steps. Choice of the threshold $\delta$ or $N$ is effective for the given problem. Errors are relatively minor. Mathematical and English language is decipherable. |
| Questionable | Partial progress on the $\epsilon$-$\delta$ or $\epsilon$-$N$ proof, only some essential steps are justified. Some visible progress on selecting the choice of the threshold $\delta$ or $N$ for the given problem. Errors are significant. Mathematical and English language is incomplete. |
| Unacceptable | Poorly written $\epsilon$-$\delta$ or $\epsilon$-$N$ proof, essential steps lack justification. Choice of the threshold $\delta$ or $N$ is unclear or is ineffective for the given problem. Errors are striking. Mathematical and English language is unclear. |

### 2.2 Rubric for SLO #2:

Students will be able to write rigorous and well written proofs which show comprehension of formal mathematical definitions, recognize hypotheses, and form logical conclusions.

| | |
|---|---|
| Excellent | Exemplary proof, with full justification for each step and the logic of argument flows naturally. The chosen strategy for the proof is natural, well motivated, and effective. Proof shows full comprehension of the pertinent mathematical definitions. Mathematical and English language is highly articulate. |
| Very Good | Cogent proof, with most key steps clearly justified. The chosen strategy for the proof is apparent and effective. Proof shows good comprehension of the pertinent mathematical definitions. Mathematical and English language is easily understandable. |
| Satisfactory | Comprehensible proof, with justification for the essential steps. The chosen strategy for the proof is recognizable and mostly effective. Proof shows reasonable comprehension of the pertinent mathematical definitions. Errors are relatively minor. Mathematical and English language is decipherable. |
| Questionable | Partial progress on the proof, only some essential steps are justified. The chosen strategy for the proof has potential. Proof shows an indication of some comprehension of the pertinent mathematical definitions. Errors are significant. Mathematical and English language is incomplete. |
| Unacceptable | Poorly written proof, essential steps lack justification. The chosen strategy for the proof is unclear and/or ineffective. Comprehension of the pertinent mathematical definitions is uncertain. Errors are striking. Mathematical and English language is unclear. |

### 2.3 Rubric for SLO #3:

Students will be able to work with the fundamentals of logic, including mathematical statements and their converses and contrapositives.

| | |
|---|---|
| Excellent | Exemplary proof which demonstrates full comprehension of the fundamentals of logic. The chosen strategy for the proof is natural, well motivated, and effective. Student has a clear understanding of what constitutes the converse or contrapositive statement. Mathematical and English language is highly articulate. |
| Very Good | Cogent proof which demonstrates good comprehension of the fundamentals of logic. The chosen strategy for the proof is apparent and effective. Student has a good understanding of what constitutes the converse or contrapositive statement. Mathematical and English language is easily understandable. |
| Satisfactory | Understandable proof which demonstrates reasonable comprehension of the fundamentals of logic. The chosen strategy for the proof is recognizable and mostly effective. Student has an understanding of what constitutes the converse or contrapositive statement. Errors are relatively minor. Mathematical and English language is decipherable. |
| Questionable | Incomplete proof which demonstrates a partial comprehension of the fundamentals of logic. The chosen strategy for the proof has potential. Proof shows an indication of some comprehension of the pertinent mathematical definitions. Student indicates a partial understanding of what constitutes the converse or contrapositive statement. Errors are significant. Mathematical and English language is incomplete. |
| Unacceptable | Poorly written proof which demonstrates little or no comprehension of the fundamentals of logic. The chosen strategy for the proof is unclear and/or ineffective. Student does not demonstrate an understanding of what constitutes the converse or contrapositive statement. Errors are striking. Mathematical and English language is unclear. |

### 2.4 Rubric for SLO #4:

Students will be able to construct counterexamples to mathematical statements and understand the importance of hypotheses.

| | |
|---|---|
| Excellent | Exemplary proof which disproves a mathematical statement by constructing a natural counterexample. Proof includes full justification for why the example satisfies the hypothesis but not the conclusion. Student has a complete understanding that the mathematical statement is false. Mathematical and English language is highly articulate. |
| Very Good | Cogent proof which disproves a mathematical statement by constructing an effective counterexample. Proof includes justification for why the example satisfies the hypothesis but not the conclusion. Student has a good understanding that the mathematical statement is false. Mathematical and English language is easily understandable. |
| Satisfactory | Comprehensible proof which disproves a mathematical statement by constructing an effective counterexample. Student gives at least some indication why the example satisfies the hypothesis but not the conclusion. Student has some understanding that the mathematical statement is false. Mathematical and English language is decipherable. |
| Questionable | Incomplete proof with only partial progress towards a counterexample. Student may show some comprehension of the relevant concepts, but not necessarily that the statement is false. Student understands that the statement is false, but does not justify why the hypotheses are satisfied but not the conclusion. Errors are significant. Mathematical and English language is incomplete. |
| Unacceptable | Poorly written proof which casts some doubt as to whether or not the student understands the falsity of the statement. Errors are striking. Mathematical and English language is unclear. |