Section 1 – Program Mission

The mission of the Applied Mathematics degree program is to prepare students for immediate participation in the workforce, or for graduate study. Graduates will have knowledge and appreciation of the breadth and depth of mathematics, including the connections between different areas of mathematics, and between mathematics and other disciplines.

The mission, objectives, and student learning outcomes for the Applied Mathematics program are reviewed annually by the department at the fall retreat during convocation.

Section 2 – Program Educational Objectives

Graduates of the Applied Mathematics Program will be prepared to do the following in the first few years after graduation.

1) Apply critical thinking and communication skills to solve applied problems.
2) Use knowledge and skills necessary for immediate employment or acceptance into a graduate program.
3) Maintain a core of mathematical and technical knowledge that is adaptable to changing technologies and provides a solid foundation for future learning.

Section 3 – Program Description and History:

The Applied Mathematics Degree was approved by the Oregon University System in the spring of 2006, and the program was implemented beginning in the fall of that year. The program graduated its first student in the spring of 2008.

Coursework for Applied Mathematics is intended to provide a solid foundation of mathematical theory and a broad selection of applied work both in and outside mathematics and across many fields. Graduates with a B.S. in Applied Mathematics work for such organizations as pharmaceutical companies (doing statistical analysis, or modelling the behavior of developing drugs using differential equations), insurance companies (as actuaries), publishing companies (as editors of technical publications), government agencies (like the National Security Agency), and public schools and colleges.

Program Location: Klamath Falls Campus Only.

Program Graduates:

2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
7	1	**5**	3	7	4	4	5	7	8

Enrollment:

2013-14	2014-15	2015-16	2016-17	2017-18
38	47	42	33	29

Employment Rates and Salaries:

The following data were combined with information collected for the classes of 2015, 2016 and 2017. More information regarding the data used is available from Oregon Tech's Career Services.

Employed	Continuing Education	Median Salary	Success Rate
70%	30%	$47,000	100%

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Section 4 – Program Student Learning Outcomes

Upon graduation, students will be able to

1. apply mathematical concepts and principles to perform computations
2. apply mathematics to solve problems
3. create, use and analyze graphical representations of mathematical relationships
4. communicate mathematical knowledge and understanding
5. apply technology tools to solve problems
6. perform abstract mathematical reasoning
7. learn independently

Section 5 – Curriculum Map

Freshman Year

Fall
MATH 251 - Differential Calculus (4)
SPE 111 - Public Speaking (3)
WRI 121 - English Composition (3)
Social Science Elective (3)
Elective Credit Hours: (3)
Total: 16 Credit Hours

Winter
ENGR 266 - Engineering Computation (3)
MATH 252 - Integral Calculus (4)
PHY 221 - General Physics with (4)
WRI 122 - Argumentative Writing (3)
Social Science Elective (3)
Total: 17/18 Credit Hours

Spring
MATH 253N - Sequences and Series (4)
PHY 222 - General Physics with Calculus (4)
Humanities Elective (3)
Social Science Elective (3)
Total: 14 Credit Hours

Sophomore Year

Fall
MATH 254N - Vector Calculus I (4)
MATH 327 - Discrete Mathematics (4)
PHY 223 - General Physics with Calculus (4)
Elective (3)
Total: 15 Credit Hours

Winter
MATH 341 - Linear Algebra I (4)
MATH 354 - Vector Calculus II (4)
Elective (4)
Humanities Elective (3)
Total: 15 Credit Hours

Spring
MATH 361 - Statistical Methods I (4)
Elective (3)
Elective (3)
Elective (3)
Humanities Elective (3)
Total: 16 Credit Hours

Junior Year

Fall
MATH 321 - Applied Differential Equations I (4)
SPE 321 - Small Group and Team Communication (3)
Focused Elective (3)
Elective (4) (upper division)
Total: 14 Credit Hours

Winter
MATH 311 - Introduction to Real Analysis (4)
WRI 227 - Technical Report Writing (3)
Focused Elective (3)
Elective (3) (upper division)
Elective (3)
Total: 16 Credit Hours

Spring
MATH 322 - Applied Differential Equations II (4)
MATH 451 - Numerical Methods I (4)
Focused Elective (3)
Math/Physics Elective (3) (upper division)
Elective (2)
Total: 16 Credit Hours

Senior Year

Fall
MATH 421 - Applied Partial Differential Equations I (4)
Focused Elective (4)
Math/Physics Elective (4)(upper division)
Elective (3)
Total: 15 Credit Hours

Winter
Mathematics Core (4) (upper division)
Focused Elective (3)
Social Science Elective (3)
Elective (3)
Elective Credit Hours: 3
Total: 16 Credit Hours

Spring
Mathematics Core (4) (upper division)
WRI 327 - Advanced Technical Writing Credit Hours: 3 **or** WRI 350 - Documentation Development (3)
Elective (3)
Elective (3)
Total: 13 Credit Hours

BS Applied Mathematics
Total Credit Hours: 183-184

Section 6 – Assessment Cycle

The department assesses the 7 Program student learning outcomes using a 3-year cycle. The following table shows the schedule.

Table 1. Assessment Cycle

	Academic Year Assessed		
Learning Outcomes	**’17-18**	**’18-19**	**’19-20**
1. Apply mathematical concepts and principles to perform symbolic computations.			**X**
2. Apply mathematics to solve problems.		**X**	
3. Create, use and analyze graphical representations of mathematical relationships.	**X**		
4. Communicate mathematical knowledge and understanding.	**X**		
5. Apply technology tools to solve problems.		**X**	
6. Perform abstract mathematical reasoning.			**X**
7. Learn independently.	**X**		

Section 7 – Assessment Activities 2017-18

Assessment of three learning outcomes was conducted during this academic year. A combined rate of proficiency and high proficiency of at least 60% is considered a minimum acceptable performance. We used three direct measures for each outcome. We had planned to also include an indirect measure for each by using the student exit survey. Since the response rate was only 3 students, we decided to omit this data as it was deemed statistically insignificant.

Outcome 3: *Create, use and analyze graphical representations of mathematical relationships* was assessed in Math 452, in the Winter of 2018. The instructor was Dr. Tiernan Fogarty. There are two performance criteria for this PSLO.

a) Create a graph using Technology.
b) Interpret Graphical Data with Respect to Error Analysis

All 13 students in Math 452 during winter 2018 were Applied Mathematics majors. The criteria were measured through technical report-projects. All students were expected to solve the problems numerically and create a code resulting in a graphical representation of the solution.

Table 2. Rubric for Outcome 3 Create and Use Graphs,

Create, use and analyze graphical representations of mathematical relationships.

	High Proficiency (3 pts)	**Some Proficiency (2 pts)**	**Little or No Proficiency (1 pt)**
Create a Graph using Technology (1.000, 50%) OIT-BMTH.3	Graph is correct. Good labeling: title, axes labeled, legend included. Good use of colors and symbols. Appropriate use/identification of scale.	Graph is correct, lacking some labels or proper details.	Graph is not correct.
Interpret Graphical Data With Respect to Error Analysis (1.000, 50%) OIT-BMTH.3	Explain in words and with a graph, error analysis by comparing numerical and theoretical results.	Correct written interpretation of the graph. No graph provided that further explains error analysis	Incorrect explanation of graphical results. Explanation does not include graphical interpretation.

Table 3. Assessment results for Outcome 3.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
(a) Create a Graph	0%	31%	69%
(b) Interpret Graphical Data with Respect to Error Analysis	15.5%	15.5%	69%

For the first criteria, all of the students were successful in creating the correct graph but four of the 13 did not properly label / title the graph

For the second criteria, 9 of 13 were able to provide correct wording and a graph(s) of error analysis. Two of the students performed proper error analysis but did not graph the analysis and two of them did not perform error analysis.

Based on this assessment exercise, our students met or exceeded our stated 60% performance minimum.

Outcome 4: *Communicate mathematical knowledge and understanding* was assessed in Math 311, in the Winter of 2018. The instructor was Dr. Kenneth Davis.

All students were expected to be present "proofs" for the final presentations. The instructor gave out grading rubrics for grading the proofs students presented.

Step 1:

For the first presentations, students presented proofs from our textbook. We used "Rubric for in class start:" Score of well done if they tried.

Step 2:

The students presented their proofs from the homework, which followed examples from our text. We used "Rubric for in developing proofs:"

Step 3:

The students are accustomed to presenting proofs so we focused on doing a good job. We used "Rubric for presenting proofs:" Students earned 90% if they made it through steps 1 - 4. They could earn higher points by attempting aspects of step 5.

Students, in the audience, were encouraged to make sincere positive comments about a presentation.

Final presentations:

I used "Rubric for in class final:" with the scoring shown. We tried to make this fun, if not funny. The idea was the class was trying to support each other and myself to try to make better presentations of proofs. We had fun.

Scores on final presentations:

The nine students made two presentations of proofs from the homework which the student developed and then presented. The students chose their proofs. Easy proofs earned groans for the students. The highest of the two presentations was the score they received.

100% Three students

98% Three students

80% One student (Also no positive comments from peers.)

0% One student did not present.

Based on this assessment exercise, our students met or exceeded our stated 60% performance minimum.

A suggestion for the future, give the students the instructor rubrics and have them rate instructor presentations of proofs, say one a day. The following 4 rubrics were used in Math 311 when grading presentations of proofs.

First, starting Rubric: <u>Rubric for in class start:</u>

MATH 311 Name:__________________________

<u>Rubric for in class start:</u> Direct proofs

Presenting A Proof:

0) Get up and start to present, smile. __________ Done

1) The statement of the problem was given in context. __________ Done
   - Ok to write statement of the problem on Smart Board:
   - Ok to write the problem out on the sheet.

2) Start the proof
   - The proof has a clear starting point.
   - Label this: Starting Point: “Proof:” __________ Done

3) Step through the proof
   - Label each step; “1)”, “2)”, until you are done __________ Done
   - Go slowly, go clearly.

- Then proceed, step by step, being able to justify each step.
  - Make sure you can force a person in the audience to agree with you that step “n+1” must follow form step “n”. _________ Can do
  - I will try to ask one question. Like: “You lost me at step 3. How did we get from statement “2” to statement “3”.
    - This is not to embarrass or humiliate you. Rather to provide an opportunity to show off. Think: **<u>Extra Credit: smile.</u>**

Comments: Thanks for going up!

Good start!

Thanks for presenting the proof!

You presented the proof well!

Good job of answering the questions!

Second Rubric: Rubric for in developing proofs:

MATH 311 Name:__________________________

Rubric for in developing proofs:

Presenting Your Proof:

4) The statement of the problem was given in context. __________ Done
   - Ok to show problem on Smart Board:
   - Ok to write the problem out on the sheet.

5) The proof has a clear starting point. __________ Done
   - I have a clear understanding of the type of proof:
     - If a proof by contradiction is used, that is clearly stated.
     - If a proof by induction is used, that is clearly stated.
     - If the proof is a notational proof, that is clearly stated.
     - If you proof is short, make sure the audience has as an agreed starting point.

6) Step through your proof. __________ Done
   - Go slowly, go clearly.
     - If a proof by contradiction is used, that is clearly stated.
       - The negation of the problem is clearly stated.
       - Make sure the contradiction is clearly reached.
         - Wait for audience to agree.
         - Then clearly state why the original statement must be true.

     - If a proof by induction is used, that is clearly stated.
       - The statements for k = 1, 2, 3, . . n, are clearly given.
       - Basis step is clearly made.
       - Induction step is clearly made.
       - Thus, by "Mathematical Induction, the proof is complete."

     - If the proof is a notational proof, that is clearly stated.
       - Try not to make it too loooong.

     - If you proof is short, make sure the audience has as an agreed starting point.
       - Make the one or two steps to the conclusion.
         - Wait for audience to see the proof is done.
         - Then state "the proof is complete."□

- The conclusion is clearly reached and stated, finishing the proof. __________ Done

Comments: Good start but________________________ (B)

By Ken

Good job, just what I was looking for. (A-)

Good job, I especially liked ______________________________ (A)

MATH 311 Name:___________________________

Rubric for presenting proofs:

Presenting Your Proof:

7) The statement of the problem was given in context. __________ Done
   - Ok to show problem on Smart Board:
   - Ok to write the problem out on the sheet.

8) The proof has a clear starting point. __________ Done
   - I presented a clear understanding of the type of proof:

9) Step through your proof. __________ Done
   - Go slowly, go clearly.
     - If a proof by contradiction is used, that is clearly stated.
       - The negation of the problem is clearly stated.
       - Make sure the contradiction is clearly reached.
         - Wait for audience to agree.
         - Then clearly state why the original statement must be true.
     - If a proof by induction is used, that is clearly stated.
       - The statements for k = 1, 2, 3, . . n, are clearly given.
       - Basis step is clearly made.
       - Induction step is clearly made.
       - Thus, by "Mathematical Induction, the proof is complete."
     - If the proof is a notational proof, that is clearly stated.
       - Try not to make it too loooong.
     - If you proof is short, make sure the audience has as an agreed starting point.
       - Make the one or two steps to the conclusion.
         - Wait for audience to see the proof is done.
         - Then state "the proof is complete."□

10) The conclusion is clearly reached and stated, finishing the proof. __________ Done

(90%)

11) Advanced steps of the proof presentation:
   - The assumption of the problem, if used is clearly stated or reviewed. What do you need to remind the audience? _________ I will try.
   - **The proof flows clearly from the assumptions.** _________ I will try.
     - A logical flow, top of the page and downwards.
     - Drop the numbering each step.
   - Your presentation showed you thought of how your audience would think their way through the proof. _________ I will try.
   - Try to engage your audience. _________ I hope to.

I received positive comments from my audience.

Comment by Ken:

MATH 311 Name:__________________________

Rubric for in class final:

We are good at giving proofs. Let us become excellent!

Presenting Your Proof:

12) The statement of the problem was given in context. __________ Done

13) The proof has a clear starting point. __________ Done
    - I presented a clear understanding of the type of proof:

14) Step through your proof. __________ Done
    - Go slowly, go clearly.
    - **The proof flows clearly from the assumptions.**
    - A logical flow, top of the page and downwards.
    - I was neat.

15) The conclusion is clearly reached and stated, finishing the proof. __________ Done

16) Advanced steps of the proof presentation:
    - The assumption of the problem, if used is clearly stated or reviewed.
    - **The proof flows clearly from the assumptions.**
    - Your presentation showed you thought of how your audience would think their way through the proof. __________ Done

(90%)

The proof has a good flow: (I did better than my professor!)

- There is some use of English in the proof. __________ Yes! (+4%)
    - Use punctuation in your proof.
        - Comma: the idea continues.
        - Period: the reader should be able to stop and agree.
- I am neat in my presentation. __________ Yes! (+2%)
- I purposely sought engagement of the audience. __________ Yes! (+2%)
    - Stop, step away: When the eyes turn back to you: you can continue.
        - State the problem -> **engage**.
        - Start the proof (step 2), -> **engage**. Give a brief outline.
        - Every two or three steps. Stop the presentation -> **engage**.
- When you are done, **engage**. __________ Yes! (+2%)

Comments by Ken:

Outcome 7: *Independent learning* was assessed in Math 354 Vector Calculus II, during Winter term 2018. The instructor was Dr. Cristina Negoita. There are three performance criteria for this PSLO.

a) Determine or recognize an application of vector calculus.
b) Read and analyze an application not studied in the class.
c) Give a presentation that relates the application to the material studied in class.

Rubric Used:

Problem:
Introduce Problem ("word" and "mathematical")
Solution methods/analysis/numerical examples
connections with class material/computations
conclusions/ comments
References
Presentation - Written
use "itemize"/bullet notation
proper mathematical symbols/notation
Capital letters for sentences, other proper use of language
Oral Delivery
addressing the audience (eye contact, clear voice)
speaking fluently, making good connections/analogies
addressing questions from the audience
thank you/asking for questions

The Independent learning assessment was done in Math 354 winter term, 2018. The criteria (a) was measured by requiring the students to submit an abstract that summarizes their choice of application. The abstract was collected around mid-term. Criteria (b) and (c) were measured by student presentation – both written and oral**. Students worked in groups of two, and presentations were required to be approximately 15 minutes, with 5 minutes available for questions. Each student in the group had to present for an equal amount of time.** There were 15 students enrolled in the class, 10 were math majors (some as dual majors).

Table 3 demonstrates the students' performance. The group performance is recorded as a percent indicating low proficiency, proficient, or highly proficient on each of the three assessment questions

	Student Performance

Criterion	%-Some/no proficiency	%-Proficient	%-High Proficiency
Recognition of application	10	20	70
Research of application	10	30	60
Quality of Presentation	10	0	90

Table 4. Assessment results for Outcome 7.

For the first criteria, determine or recognize an application of one of the integral theorems, the group exceeded the mathematics department's stated 60% performance minimum. Of the 10 Math Majors, 9 students submitted a reasonable abstract that clearly indicated an application of vector calculus that was relevant to the course. One student failed to submit an abstract.

For the second criteria, do research on the application or problem, the group exceeded the stated 60% performance minimum. The students were either graded based on their ability to introduce their problem in the context of the application being studies, as well as in its mathematical formulation. The application had to be clearly connected to one the theorems learned in class. Appropriate analysis and a conclusion had be included as part of the research. Three students were proficient only based on their lack of making a strong connection between their application and classroom material. The rest were Highly Proficient.

For the third criteria, quality of a presentation, students were given a rubric two weeks prior to their presentation. Their presentations were graded using the rubric and a point score for each presentation was converted to a percent. Students were determined to be Some or Not Proficient if their presentation score was under 70% and Highly Proficient if their score was over 90%. With the exception of one student who did not submit any work for this assessment, all students performed as Highly Proficient.

Based on this assessment exercise, our students met or exceeded our stated 60% performance minimum for Outcome 7.

8. Evidence of Improvement – Closing the Loop PSLO 6

In the last assessment cycles when we assessed PSLO 6 *Perform Abstract Mathematical Reasoning* we found that students' performance was not meeting expectations. The problem occurred in the course Math 311 *Introduction to Real Analysis.* The instructors for this course felt that the students were not adequately prepared. We decided students needed more instruction on how to write mathematics including appropriate logical structure of proofs. In 2017 the applied mathematics program committee decided that an introductory course in abstract reasoning should be developed and required by all majors. During the 2017-18 the course Math 310 Mathematical Structures was created to serve as a prerequisite to Math 311. Math 310 was offered for the first time Fall term 2018. (As of October 23, 2018 there are 12 students enrolled). In the winter term of 2019, student performance in Math 311 will be reassessed. Results of that assessment will be included in the 2018-19 Program Assessment Report.

9. Data-driven Action Plans: Changes Resulting from Assessment

The faculty assessed three program student learning outcomes during the 2017-18 academic year. The faculty reviewed the results during the fall term 2018 during a faculty meeting and had the following conclusions.

Outcome 3: Create, use and analyze graphical representations of mathematical relationships.

Students met all performance criteria and no further action is required at this time.

Outcome 4: Communicate mathematical knowledge and understanding.

Students met all performance criteria and no further action is required at this time.

Outcome 7: Learn independently.

Students met all performance criteria and no further action is required at this time.

Changes Resulting From Assessment

Based on our assessment results for the learning outcomes PSLO 3,4 and 7, no changes were deemed necessary.