Oregon TECH

Applied Mathematics
2020-21 Program Assessment Report

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. Employment opportunities include pharmaceutical companies, government agencies (like the National Security Agency), insurance companies (as actuaries), publishing companies (as editors of technical publications) and public K-12 and higher education.

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. We have had problems identifying the number our students because some of them are dual majors and are not required to declare themselves as an Applied Math major or have a math advisor until two terms before graduating. However, we currently estimate there are approximately 35-40 Applied Mathematics majors, about 20 of which are earning dual degrees.

Coursework for Applied Mathematics intends 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 Headcounts*:

Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020			
32	28	35	31	36			

* The headcount is often difficult to measure since many students are dual majors and sometimes not counted.

Program Graduates:

2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
7	4	4	5	7	8	4	7	11

Employment Rates and Salaries:

More information regarding the data used is available from Oregon Tech's Career Services.

Years	Employed	Continuing Education	Median Salary	Success Rate
2015/2016/2017	70%	30%	$47,000	100%
2016/2017/2018	33%	44%	$47,000	78%
2017/2018/2019	57%	19%	NA	81%
2018/2019/2020	50%	17%	NA	72%

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Dates for when course objectives have been last revisited:

The department has created course objectives, student learning outcomes and supporting criteria for each course that is offered thru the department. The following dates list the last time the course objectives file was reviewed/modified. The courses in red will be reviewed this year.

Course	Date Last Updated	Months since last update
MATH 070	3/27/2005	197
MATH 111	11/1/2009	142
MATH 221	10/12/2010	131
MATH 354	11/21/2011	117
MATH 311	1/24/2012	115
MATH 465	1/24/2012	115
MATH 362	1/28/2014	91
MATH 346	6/17/2014	87
MATH 251	4/20/2015	76
MATH 341	4/27/2015	76
MATH 100	11/2/2015	70
MATH 371	11/2/2015	70
MATH 310	11/10/2016	58
MATH 243	10/5/2017	47
MATH 327	11/8/2017	46
MATH 414	3/7/2018	42
MATH 252	5/14/2018	40
MATH 112	9/28/2018	35
MATH 321	10/11/2018	35
MATH 322	10/11/2018	35
MATH 342	10/17/2018	35
MATH 451	11/7/2018	34
MATH 452	11/19/2019	21
MATH 453	11/19/2019	21
MATH 361	1/24/2020	19
MATH 421	5/1/2020	16
MATH 422	5/1/2020	16
MATH 423	5/1/2020	16
MATH 253N	5/28/2020	15
MATH254N	5/29/2020	15

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 310 – Mathematical Structures (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: 180

		Program Student Learning Outcome							ESLO					
Semester	**Course**	1	2	3	4	5	6	7	Com	Team	Ethics	IA	QL	DivP
Fresh-Fall	MATH 251	F	F	F	F								F	
	SPE 111								F					
	WRI 121								F					
	Social Science Elective										F			
	General Elective													F
Total Credits	16													
Fresh-Winter	MATH 252	F	F	F	F									
	ENGR 266					F								
	PHY 221 & lab	F	F	F								F		
	WRI 122								F					
	Social Science Elective											F		
Total Credits	17/18													
Fresh-Spring	MATH 253	F	F	F	F									
	PHY 222 & lab	F	F	F	F									
	Humanities Elective													F
	Social Science Elective													
Total Credits	16													
		Program Student Learning Outcome							ESLO					
Semester	**Course**	1	2	3	4	5	6	7	Com	Team	Ethics	IA	QL	DivP
Soph-Fall	MATH 254	F	F	F	F									
	MATH 310	F			F		F		F					
	PHY 223 & lab	F	F	F										
	WRI 227								P					
Total Credits	15													
Soph-Winter	MATH 341	F	F	F	F	F	F							
	MATH 354	F/P	F/P	F/P	F			F						
	General Elective													
	Humanities Elective													F
Total Credits	15													
Soph-Spring	MATH 361			F									F	
	Humanities Elective													F
	General Elective													
	General Elective													
	General Elective													
Total Credits	16													
		Program Student Learning Outcome							ESLO					
Semester	**Course**	1	2	3	4	5	6	7	Com	Team	Ethics	IA	QL	DivP
Junior-Fall	MATH 321	F/P	F/P	F/P	P				P	P				
	SPE 321								P	P				
	Focused Elective		F											

	Elective (Upper Div)													
Total Credits	14													
Junior-Winter	MATH 311	P			C		C	P						
	WRI 227								P					
	Focused Elective	P	P	P	P	P								
	Elective (Upper Div)													
	Elective													
Total Credits	16													
Junior-Spring	MATH 322									P				
	MATH 451	P	P	P	P	P								
	Focused Elective	P	P	P	P	P								
	MATH/PHY Elec UD	P	P	P	P	P								
	Elective													
Total Credits	16													
		Program Student Learning Outcome							**ESLO**					
Semester	**Course**	1	2	3	4	5	6	7	Com	Team	Ethics	IA	QL	DivP
Senior-Fall	MATH 421	C	C	C	C	P	P	C						
	Focused Elective	P	P	P	P	P								
	MATH/PHY Elec UD	P	P	P	P	P								
	Elective													
Total Credits	15													
Senior-Winter	MATH CORE UD	C	C	C	C	C	C	C						
	Focused Elective	P	P	P	P	P								
	Social Science Elective													P
	Elective													
	Elective													
Total Credits	16													
Senior-Spring	MATH CORE UD	C	C	C	C	C	C	C						
	WRI 327 -0r- WRI 350								P					
	Elective													
	Elective													
Total Credits	16													
Total Program	180 - 184													

Key: F = Foundation, P = Practicing, C = Capstone

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	**'20-21**	**'21-22**	**'22-23**
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**		

Applied Mathematics B.S. Cycle for PSLOs and ESLO's			
Outcome	2020/2021	2021/2022	2022/2023
PSLO 1	Act	Plan	Assess
PSLO 2	Plan	Assess	Act
PSLO 3	Assess	Act	Plan
PSLO 4	Plan	Assess	Act
PSLO 5	Act	Plan	Assess
PSLO 6	Assess	Act	Plan
PSLO 7	Assess	Act	Plan
ESLO: Communication	Plan	Assess	Act
ESLO: Teamwork	Plan	Assess	Act
ESLO: Ethical Reasoning	Plan	Assess	Act
ESLO: Inquiry & Analysis	Assess	Act	Plan
ESLO: Quantitative Lit	Assess	Act	Plan
ESLO: Diverse Perspectives	Act	Plan	Assess

Section 7 – Assessment Activities 2020-21

Assessment of three learning outcomes was conducted during this academic year (Outcomes 3,6,7). 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 and one indirect measure. We had planned to also include an additional indirect measure for each by using the student exit survey, however, since the response rate was only 1student, 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 422, in the Winter of 2021. 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 12 students in Math 422 during winter 2021 were Applied Mathematics majors. The criteria were measured through technical report-projects. All students were expected to solve the problems analytically and create a code resulting in a graphical representation of the solution. For this particular problem, the students were asked solve the spherical wave equation with a given initial disturbance and graph the solution as a function of time and space. Creating the graph (multiple graphs or an animation) from the analytical solution is a very non-trivial exercise. Students were left to their own devices to create a method to demonstrate error analysis.

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 graphical 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	0.09%	36%	63.1%
(b) Interpret Graphical Data with Respect to Error Analysis	9.9%	27%	63.1%

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

For the second criteria, 7 of 13 were able to provide correct wording and a graph(s) of error analysis. Three 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 6: *Perform abstract mathematical reasoning"*. MATH 311 was taught by Dr. Dibyajyoti Deb during Winter 2021. A total of 12 students took the course. Assessment was done by looking at

- Indirect measures – student final exam scores and student course grades.
- Direct measure – assess performance on two criteria directly from student work.

Indirect Measure

The table below lists the final exam score (out of 100) and the course grades of the 12 student who took the course (in descending order of scores and their respective grades). Note that 2 of these students did not take the final exam.

Final Exam Score	88	83	74	66	61	54	53	52	50	16	0	0
Course Grade	B	A	B	C	C	C	B	C	C	F	F	F

Table 1: Final Exam Scores and Course Grades

Direct Measure

For direct measure, two performance criteria for this PSLO were assessed directly from student work. These were:

1. Present a formal proof of the limit of a function at a point.
2. Present a formal proof that a sequence is a Cauchy sequence.

The above criteria were measured by problems given in the final exam. Since two students did not take the final exam, hence, they were not included in the results of these measures. The results are shown in Table 2.

- Present a formal proof of the limit of a function at a point

This criterion was tested by presenting the students with a rational function and its limit at a point. The students were then asked to present a formal delta-epsilon proof. A response showed high proficiency if the student chose an appropriate delta and showed algebraically that this bounded the function to within epsilon of its limit. A response showed proficiency if the student bounded the difference between the function and its limit, but did not clearly tie together epsilon and delta.

- Present a formal proof that a sequence is a Cauchy sequence

This second criterion was tested by presenting the students with a sequence and asking them to use the definition of Cauchy sequence to prove that the sequence is Cauchy. The definition of a Cauchy sequence was asked as separate part of the same question. The proof requires constructing a choice of integer N and to follow thru by showing that the difference of any two terms "after N" is bounded by epsilon. A response showed high proficiency if the student constructed an appropriate choice of N and followed thru with appropriate proof that any two terms differ by at most epsilon. A response showed proficiency if one of these steps was either poorly done or omitted entirely.

Criterion	Some/No Proficiency	Proficient	High Proficiency
Proof of Limit	7	2	1

Proof of Cauchy Sequence	0	3	7

Table 2: Assessment results of direct measures of Outcome 6

Conclusion

MATH 311 is traditionally a challenging course for the majority of math majors. While the question that involved presenting a formal proof of the limit of a function did not have the best outcomes, the overall student performance in the course was quite good. 9 out of the 10 students who completed the course (i.e. took the final exam) earned a C or better. In addition, the question testing the proof of a Cauchy sequence had very good outcomes where all the 10 students were proficient or above, including 7 students who were highly proficient.

Outcome 7: *Independent learning* was assessed in Math 354 Vector Calculus II, during Winter term 2021. The instructor was Dr. David Hammond. 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.

The Independent learning assessment was done in Math 354 winter term, 2021. These three criteria were measured on the basis of the students' final presentations, as well as on a written abstract for the presentation. The written abstract was collected in week 7 of the term, and students gave their final presentations during week 10 of the term. These presentations were each 10-15 minutes long, and students were allowed to work in groups of up to 2 students. There were 10 students in the class, 9 of whom were math majors (several as a dual major). Only the math majors are included in the data presented here.

These three criteria were evaluated based on the rubric below:

a) determine or recognize an application of vector calculus
Student independently chooses relevant topic
Use of green's/stokes' and or divergence theorem is clearly described
b) read and analyze an application not studied in the class
The presented mathematics is correct
Correct mathematical notation is used
Results that are relevant to the application are presented
c) give a presentation that relates the application to the material studied in class
Presentation begins with clear statement of problem or topic
Slides laid out clearly, with clear figures if appropriate
Spoken presentation is clear and easy to follow
Presentation ends with a conclusion

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
Recognize an application	11	11	78
Analyze an application	11	11	78
Oral presentation	22	11	67

Table 4. Assessment results for Outcome 7.

For the first of the criteria, to recognize an application of one of the integral theorems,78 % of the class demonstrated high proficiency, by clearly identifying a relevant application of either green's theorem, stokes' theorem or the divergence theorem in their abstract and/or final presentation. One student did not mention these theorems at all in their presentation, and did not show any proficiency in this objective, whereas 1 other student showed some proficiency but not high proficiency.

Very similar results were observed for the second criteria, as assessed by the correctness of the mathematical content presented, the mathematical notation used, and the relevance of the mathematical results presented to the chosen application.

For the third criteria, 67% of the students demonstrated high proficiency through the quality of their spoken presentations, the design and layout of their slides, and through the organization of their presentation. 2 students showed little or no proficiency for the third criteria, and one showed some proficiency but not high proficiency.

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

We continue to feel strongly that the decision was correct to create a course Math 310 Mathematical Structures and require this course as a prerequisite to Math 311 Introduction to Real Analysis. Considering the PLSO #7 Independent learning, we continue to require students to submit their abstracts earlier in the term to allow time to get feedback before their presentations.

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

The faculty assessed three program student learning outcomes (3,6,7) during the 2020-21 academic year. The faculty reviewed the results during the fall term 2020 during a faculty meeting and had the following conclusions.

Outcome 3 (graphing): Students met all performance criteria and no further action is required at this time. The student performance was quite good except for one specific question. As noted above, the instructor felt that the student performance was over-all excellent. Students met all performance criteria and no further action is required at this time.

Outcome 6 (abstract reasoning): Overall, the assessments results for abstract reasoning were good. There was some concern about the low scores related to the proof related to the limit of a function at a point. We will see where else in the curriculum the formal definition of the limit is or can be introduced. We will make a note to revisit and assess formal limit proofs again in Math 311. Students met all performance criteria and no further action is required at this time.

Outcome 7 (independent learning): Overall, the assessment results were good. 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, 6 and 7 no formal changes were deemed necessary.