Oregon TECH

Applied Mathematics
2023-24 Program Assessment Report

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Grader: ?

Section 1 – Program Mission

- **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 during Fall convocation.

- **Mission Alignment:**
  The applied mathematics degree program mission provides students with strong quantitative reasoning and computational skills which are applicable in a broad variety of careers. The program also incorporates projects in a number of upper level courses. In these ways the Applied Mathematics degree program mission aligns with the university mission.

- **Changes to the Mission:**
  There were no changes made to the mission of the Applied Mathematics Department in the past year.

Section 2 – Program Student Learning Outcomes

- **PSLOs:**
  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 3 – Curriculum Map

This curriculum map is for the 2023-24 catalog, for the Applied Mathematics BS degree.

		Credits	PSLO's							ISLO's					
Semester	Course		1	2	3	4	5	6	7	Com	TW	Eth	IA	QL	DivP
Freshman - Fall	MATH 251	4	F	F	F	F								F	
	SPE 111Z	4								F					
	WRI 121Z	4								F					
	Social Science Elective	3										F			
Freshman - Winter	MATH 252	4	F	F	F	F									
	STAT 201	4			F		F						F	F	
	PHY 221 & lab	4	F	F	F								F		
	Social Science Elective	3											F		
Freshman - Spring	MATH 253	4	F	F	F	F									
	PHY 222	4	F	F	F	F									
	Humanities Elective	3													F
	Social Science Elective	3													
Sophomore - Fall	MATH 254	4	F	F	F	F									
	MATH 321	4	P	P	P	P				P	P				
	PHY 223	4	F	F	F										
	General Elective	3													
Sophomore - Winter	MATH 341	4	F	F	F	F	F	F							
	MATH 354	4	P	P	P	F			F						
	General Elective	4													
	Humanities Elective	3													F
Sophomore - Spring	MATH 361	4			F									F	
	General Elective	3													
	General Elective	3													
	General Elective	3													
	Humanities Elective	3													
Junior - Fall	MATH 310	4	F			F		F		F					
	SPE 321	3								P	P				
	Focused Elective	3			F										
	Upper Division Elective	4													
Junior – Winter	MATH 346	4				P		P	P						
	WRI 122Z or 227Z	4								P					
	Focused Elective	3	P	P	P	P	P								
	Upper Division Elective	3													
	General Elective	3													
Junior - Spring	MATH 322	4	P	P	P	P						P			
	MATH 451	4	P	P	P	P									
	Focused Elective	3	P	P	P	P									
	Math/Physics Elective	3	P	P	P	P									
	General Elective	2													
Senior - Fall	MATH 421	4	C	C	C	C	P	P	C						
	Focused Elective	4	P	P	P	P	P								
	Math/Physics Elective	4	P	P	P	P	P								
	General Elective	3													
Senior - Winter	Upper Division Math Core	4	C	C	C	C	C	C	C						
	Focused Elective	3	P	P	P	P	P								
	Social Science Elective	3													P
	General Elective	3													
	General Elective	3													
Senior - Spring	Upper Division Math Core	4	C	C	C	C	C	C	C						
	WRI 327 or 350	3								P					
	General Elective	3													
	General Elective	3													
Total Credits		181													

KEY : F = Foundation, P = Practicing, C = Capstone, Com = Communication, TW = Teamwork, Eth = Ethical Reasoning, IA = Inquiry and Analysis, QL = Quantitative Literacy, DivP = Diverse Perspectives.

Section 4 – Assessment Cycle

The Applied Mathematics department evaluates our Program Specific Learning Outcomes on a 3-year rotating schedule, as shown below.

	Academic Year Assessed		
Program Student Learning Outcomes	2024-25	2025-26	2025-27
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

The specific courses used to assess the PSLO's and the ISLO's are indicated in the table below

		Act	Collect	Plan
ISLO	**PSLO**	**2022-2023**	**2023-2024**	**2024-2025**
	PSLO 1	MATH 354		
	PSLO 2			MATH 321/322
	PSLO 3		MATH 422	
	PSLO 4			MATH 354
	PSLO 5	MATH 452		
	PSLO 6		MATH 346	
	PSLO 7		MATH 354	
Com				MATH 354
TW				**
Eth				STAT 201
IA			PHY 222	
QL			MATH 361	
DivP		**		

The years each PSLO/ISLO will be in the act/assess/plan phase are given in the table below.

Applied Mathematics B.S. Cycle for PSLO's and ISLO's			
Outcome	2024-25	2025-26	2026-27
PSLO 1	Plan	Assess	Act
PSLO 2	Assess	Act	Plan
PSLO 3	Act	Plan	Assess
PSLO 4	Assess	Act	Plan
PSLO 5	Plan	Assess	Act
PSLO 6	Act	Plan	Assess
PSLO 7	Act	Plan	Assess
ISLO : Com	Assess	Act	Plan
ISLO : TW	Assess	Act	Plan
ISLO : Eth	Assess	Act	Plan
ISLO : IA	Act	Plan	Assess
ISLO : QL	Act	Plan	Assess
ISLO : DivP	Plan	Assess	Act

Section 5 – Assessment Data Collection Processes 2023-24

This year we collected data to assess three PSLO's (3,6, and 7) and two ISLO's (IA and QL). Each of these was assessed by using an assignment from a single course as indicated in section 4, the data were collected and scored by the instructor for each course. Historically, the mathematics department has considered a rate of 70% for high proficiency or proficiency to be the minimum acceptable standard. The evaluations of each PSLO and ISLO were based on both direct and indirect measures, the exact number and character of each measure varied from course to course and is detailed in Section 6. These measures were determined by the individual faculty teaching the courses, but were discussed in advance by the entire department.

Section 6 – Assessment Data and Interpretations

PSLO 3 "Create, use and analyze graphical representations of mathematical relationships" was assessed in Math 452 (Numerical Methods II) taught by Professor Tiernan Fogarty. The performance criteria and rubrics used to assess these criteria are listed below.

	High Proficiency (3 points)	**Some Proficiency (2 pts)**	**Little or No Proficiency (1pt)**
(a) Create a graph using technology	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.
(b) Interpret graphical data with respect to error analysis	Explain in words and with a graph, error analysis by comparing graphical and theoretical results.	Correct written interpretation graph. No graph provided that further explains error analysis	Incorrect explanation of graphical results. Explanation does not include graphical interpretation.

Table : Rubric for assessing PSLO 3 performance criteria

A total of 10 students took the course, of which 7 were Applied Math 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 to numerically approximate the solution to four differential equations via four different computational methods and graph the solutions as a function of time and space. The students were also asked to compare the numerical solutions to exact solutions and discuss error and convergence (of the numerical methods). Error and convergence analysis was required to be based on data and entail graphical output. Students were left to their own devices to create a method to demonstrate error analysis and convergence.

The results of the assessment of these 7 students is given in the table below.

	High Proficiency (3 points)	**Some Proficiency (2 pts)**	**Little or No Proficiency (1pt)**
(a) Create a graph using technology	5	1	1
(b) Interpret graphical data with respect to error analysis	5	2	0

Table : Results of assessment for PSLO 3 performance criteria

For the first criteria, all but one of the students were successful in creating the correct graph and one of the (remaining 6) did not properly label / title the graph. For the second criteria, 5 of 7 were able to provide correct wording and a graph(s) of error analysis. Two of these (remaining five) students performed proper error analysis but did not graph the data used to analyze convergence in a useful way, even though they did calculate and use it. Based on this assessment

exercise, 86% of our students met the assessment criteria. These results do meet our departments agreed upon standard of 70% meeting proficiency or high proficiency.

PSLO 6 “Perform abstract mathematical reasoning” was assessed in Math 346 (number theory), where a total of 3 students took the course. The class was taught in Winter 2024 by Professor Dibyajyoti Deb. Two indirect measures (course grade and final exam grade) and two direct measures were collected.

For the direct measures, student performance on the following two questions was assessed :

1 – present a formal proof to show that $3^{1000} + 3$ is divisible by 28
2 – present a formal proof that if n is a composite number other than 4, that (n-1)! Is divisible by n.

The above criteria were measured by problems given in the mid-term (1) and in the final exam (2). Criteria for evaluating student responses is detailed below.

For “present a formal proof to show that $3^{1000} + 3$ is divisible by 28” :

Using any kind of brute force is out the of question as 3^{1000} is a very large number. A response showed high proficiency if the student used the theory of congruences and its various properties such as writing 3^{1000} as (3^3)^{333} + 3 and noting that 3^3 ≈ -1 (*mod* 28). A response showed proficiency if the student did not reduce the problem into simpler chunks but rather relied on computation.

For “Present a formal proof that if n is a composite number other than 4, then (n-1)! is divisible by n.”

The proof requires students to understand the definitions of a composite number and its factorial, in addition to interpreting the definition of a congruence. A response showed high proficiency if the student correctly ascertained that and composite number n has a factor less than or equal to $\sqrt{n}$ but greater than 1. A reasoning needs to be given for this conclusion. Then, the student needs to argue that the other factor is greater than $\sqrt{n}$. Finally, the student needs to give a reasoning that the product of these two factors is less than or equal to n, and complete the proof. A response showed proficiency if one of these steps was either poorly done or omitted entirely.

Indirect measure results :
Students were considered highly proficient if their course grade was an A, proficient If their course grade was a B.
Students were considered highly proficient if their exam grade was an 90-100, proficient If their exam grade was 80-90.

Final Exam	100/100	91/100	84/100
Course Grade	A	B	A

For these measures, all 3 students showed proficiency or high proficiency.

Direct measure results:

Criterion	Some / No proficiency	Proficient	Highly Proficient
Proof that 28 divides 3^1000 + 3	1	1	1
Proof that n divides (n-1)!	0	0	3

MATH 346 (Number Theory) is traditionally a challenging course for the majority of math majors. In spite of this, the performance of the 3 math majors that took this course was very good. Two of the students ended up with an A and another student had a B in the course. While the question that involved presenting a proof that 28 divides 3^{1000}+3 had mixed outcomes, the other assessed problem had high proficiency from all the students. This concludes that the majority of the objectives were met in this course.

PSLO 7 “Learn independently” was assessed in Math 354 (vector calculus II) in Winter 2024, taught by Kenneth Davis. There were a total of 14 students in the class. The performance criteria and are listed below:

Performance criteria	Student performance showing High Proficiency:
a) Determine or recognize an application of vector calculus	i. Students independently chose relevant topic which was approved by the instructor. ii. Use of Green's/Stokes'/and or Divergence Theorem was clearly described. Presenters had to pause and ask for any questions regarding the application of the relevant theorem.
b) Read and analyze an application not studied in class.	i. The presented mathematics was correct. ii. Correct mathematical notation was used and combined into English sentences when appropriate.
c) Give a presentation that relates to the application to the material studied in the class.	i. Presentation begins with a clear statement of the application or problem. ii. Presentation moves on to describe how the relevant theorem is applied to solve and answer the application or question. iii. PowerPoint slides (or similar software) were clearly laid out, with figures or diagrams expected to aid in the viewer understanding of the topic and or application. Most of the mathematical notation in the PowerPoint slides had to be typed by the student. iv. Spoken presentation is clear and easy to follow v. Presentation ends with a clear conclusion and time for questions and or discussions.

The three criteria were measured on the basis of the students' final presentation, as well as a written 3-page summary which included a brief written abstract for the presentation. The presentations were between 15 and 30 minutes long depending on the questions. Students were not allowed to work in groups. The results of the assessment of these 14 students are given in the table below.

	Some/No Proficiency	Proficient	Highly Proficient
Recognize an application	0	0	14
Analyzed an application	0	2	12
Oral Presentation and Quality of PowerPoint slides	0	3	11

For the first of the criteria, all students chose clear applications of the relevant theorem. The abstracts were discussed in class so no two students would do the same application, and the abstract was then approved by the instructor after the discussion. This discussion the various theorems and a relevant application led to a much deeper understanding of meanings and statements of the theorems as students disagreed initially in class discussions. The instructor found this to be a very valuable learning outcome of the entire evaluation of the program by student presentations. The instructor had not planned for this outcome.

In the second criterion, several of the best students chose to present first in week 9 of the term. Their presentations were quite engaging with lots of questions. The instructor made it clear that their presentation surpassed the stated expectations of the given rubric, but that their presentations were exceptional and quite fun. The rest of the class general strove to engage the other students with their presentations also. However, two students, who were seniors just needed to pass the course admitted during their presentations that they merely copied was stated in their sources without completely understanding all the mathematics going on. This became clear during the questions asked by other students. These two students student with the sick child made their presentations during finals week.
Of course, before their making their presentation students were allowed to ask the instructor and each other for help understanding the mathematics of their chosen application but did not make time to ask. With the permission of the instructor, students were allowed to show mathematics beyond our course and outline the direction of this more advanced mathematics. These two students did not seek help.

In the third criterion, beside the two students who just wanted to get it done, a third student understood the mathematics application, but had a sick child and did not have time to type set their mathematics in PowerPoint. So, the slides were mere a cut and paste presentation of mathematical content which the student clearly understood.

Based on this assessment exercise, 100% of our students showed proficiency or high proficiency for all of the criteria. This exceeds our stated goal of 70% performance minimum for Outcome 7.

ISLO IA :"Inquiry and Analysis" was assessed in PHY 222.

The math department made the decision to use a physics course as the basis for assessing this ISLO, as it was felt that the content of the ISLO IA aligned well with an experimental science course. For this ISLO a single indirect measure, course grade, was used to assess proficiency. A course grade of A corresponded to high proficiency, a course grade of B corresponded to proficiency, whereas course grades of C or lower corresponded to some/no proficiency. A total of 4 applied mathematics majors took PHY 222 in winter 2023. Of those, two received a grade of A and two received a grade of C or lower, indicating a rate of 50% demonstrating proficiency or high proficiency. This does not meet the departments agreed upon standard of 70% meeting proficiency or high proficiency.

ISLO QL : "Quantitative Literacy" was assessed in Math 361. A single applied mathematics major took Math 361 in Winter 2023. The evaluation criteria below based on the rubric for the QL ISLO, with the specific course topics applied to each rubric item in parenthesis. The scores for the student are also given.

Calculate (summary statistics, conditional probabilities, probabilities, test statistic, p-values) : 5/5
Interpret (sample designs, histograms/boxplots, p-values, regression results) : 5/5
Construct Representations (histogram and boxplots) : 4/4
Apply in Context (calculate probabilities and p-values using correct equations) : 8/8
Comminicate (study design flaws, hypothesis test results, regression results) : 4/4

The student achieved perfect results on all assessment items, showing high proficiency. This indicates a 100% rate demonstrating proficiency or high proficiency, which exceeds the agreed upon departmental minimum standard of 70%.

Overall assessment data for all assessed objectives are summarized in the table below:

1.C.6 Consistent with its mission, the institution establishes and assesses, across all associate and bachelor level programs or within a General Education curriculum, institutional learning outcomes and/or core competencies. Examples of such learning outcomes and competencies include, but are not limited to, effective communication skills, global awareness, cultural sensitivity, scientific and quantitative reasoning, critical analysis and logical thinking, problem solving, and/or information literacy.

1.D.2 Consistent with its mission and in the context of and in comparison with regional and national peer institutions, the institution establishes and shares widely a set of indicators for student achievement including, but not limited to, persistence, completion, retention, and postgraduation success. Such indicators of student achievement should be disaggregated by race, ethnicity, age, gender, socioeconomic status, first generation college student, and any other institutionally meaningful categories that may help promote student achievement and close barriers to academic excellence and success (equity gaps).

1.C.1 The institution offers programs with appropriate content and rigor that are consistent with its mission, culminate in achievement of clearly identified student learning outcomes that lead to collegiate-level degrees, certificates, or credentials and include designators consistent with program content in recognized fields of study.

1.C.9 The institution's graduate programs are consistent with its mission, are in keeping with the expectations of its respective disciplines and professions and are described through nomenclature that is appropriate to the levels of graduate and professional degrees offered. The graduate programs differ from undergraduate programs by requiring, among other things, greater: depth of study; demands on student intellectual or creative capacities; knowledge of the literature of the field; and ongoing student engagement in research, scholarship, creative expression, and/or relevant professional practice.

Performance Criterion	Assessment Methods	Performance Target	Results	Target met?
PSLO 3 "Create, use and analyze graphical representations of mathematical relationships"	Direct : based on technical report by students	70% Proficient or Highly Proficient	6/7 (86%) of students were Proficient or Highly Proficient	Yes
PSLO 6 "Perform abstract mathematical reasoning"	Direct : based on a problem from student HW Indirect : based on students course grade	70% Proficient or Highly Proficient	2/3 (67%) of students were Proficient or Highly Proficient for all assessments	No
PSLO 7 "Learn independently"	Direct : based on student presentations	70% Proficient or Highly Proficient	14/14 (100%) students were Proficient or Highly Proficient for all criteria	Yes
ISLO IA :"Inquiry and Analysis"	Indirect : based on student's course grade	70% Proficient or Highly Proficient	2/4 (50%) of students were Proficient or Highly Proficient	No
ISLO QL:"Quantitative Literacy"	Direct : based on students HW	70% Proficient or Highly Proficient	1/1 (100%) of students were Proficient or Highly Proficient	Yes

Table: Summary of all assessment results

Section 7 – Data-driven Action Plans:

The assessment data collected this year indicate potential issue with PSLO 6 : "perform abstract mathematical reasoning" and with ISLO IA "Inquiry and analysis". While the stated performance targets for these were not met, as the number of students assessed was so small (3 applied math students in the Math 346 course, and 4 applied math students in Physics 222 course), these results should not be viewed as strong evidence of problems in our program. Nonetheless, we will discuss these in our math department meeting and brainstorm for ideas of how to improve our performance for these objectives. In particular for the inquiry and analysis ISLO, we should consider assessing this based on a math course and not based on a physics course. As a department we have had a few discussions about possible courses in our program (in particular, some numerical experiments often done in Math 451 or 452) that would fit the inquiry and analysis ISLO.

The potential weakness in PSLO 6 should also be addressed, as abstract reasoning is an important core part of the mathematics curriculum. Over the past two years our department has introduced the Math 310 (mathematical structures) course, and is no longer teaching Math 311 (Introduction to real analysis). As Math 310 serves as an introduction to writing mathematical proofs, the results of this assessment indicate that we should discuss how this course is taught as a department, to see if we can strengthen the presentation of how to write mathematical proofs.

The assessment results for the PSLO 7 “Learn independently” and PSLO 3 “Create, use and analyze graphical representations of mathematical relationships “ were very positive and encouraging. These data do not imply any specific intervention necessary for these PSLO’s

The assessment results for ISLO QL involved only a single student. While that single student showed High Proficiency, there really isn’t enough data to conclude anything about how our department is performing for that ISLO. This indicates that in future we should broaden the number of students assessed for this ISLO. In particular, we may need to use data from multiple terms (rather than simply from winter term), so that we can assess a larger number of applied math students taking Math 361.

Section 8 – Closing the Loop: Reflection on previous work

A significant change in the applied math curriculum over the past year is the introduction of several “tracks” for the major : we now offer Computational Mathematics, Physics, and Statistics as “tracks”. As a department we are excited about this new way of organizing our major, and hope that it will help increase enrollment and student engagement. The introduction of these tracks was discussed in the previous 2022-2023 program assessment report as a way of improving student retention. This year we will be monitoring student engagement with the newly introduced tracks to gauge whether this is indeed effective for improving retention.

The replacement of Math 311 by Math 346 was motivated partly by efforts to improve the DWFI rates for the department, as Math 311 contributed to a higher DWFI rate. The assessment results from this year are mixed as to whether this was effective, as we did not meet our stated goal for the PSLO 6 that was assessed using Math 346. As the class was so small however, it is difficult to draw robust conclusions from this data. We as a department will continue to look at how this change in our curriculum is affecting our students.

Program Assessment Report Feedback Rubric

2022-23 Assessment Report

Program:

Department Chair:

Program Assessment Report Author:

Rubric Measure	Well Developed, Progressing or Not included.
Program mission is aligned to University Mission	
Educational Objectives Wording is Actionable	
PSLO's are justified by Professional Standards	
PSLO'S are aligned to ISLO	
Curriculum Map: Scaffolding indicates Foundational, Practice, and Capstone Assessments by course	
Assessment Cycle is three years or less to cover all PSLO and ISLO	
Actions taken by programs on assessment during each year of the cycle are specified	
During collection year, courses/assignments are specified that align to PSLO at FP&C levels	
Rubric: Criteria for grading the assignment is described (may include as an appendix)	
Sample: Number of samples reviewed is specified	
Accountability: Reviewer of the assignment are specified	
Assessment data is collected across all locations and modalities	

Performance Targets of acceptability are indicated	
Results include: Graduation, Retention, Persistence, DFWI, Post Grad Success, Equity Gaps, PSLO, ISLO	
Interpretation: Current results are compared against performance targets	
Interpretation: Current results are compared against previous years of data	
Interpretation: Current results are compared against some external comparator	
Action drivers: Items not meeting performance targets have actions planned	
Action drivers: Additional action plans for overall department improvement are indicated	
Action plans: Specifics of accountability and timelines are indicated	
Action plans: Actions are linked to identification of resources needed	
Faculty discuss trends in the data	
Faculty discuss previous action plan success given new data	
Faculty discuss the assessment process and make any improvements necessary	

Directions: Please provide comments on any item that is not graded as well developed.