MARISSA MASDEN

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EDUCATION

Ph.D., Mathematics (Applied Toplogy)   University of Oregon, Eugene, OR   *Expected June 2023*

- Dissertation: Topological, combinatorial and geometric properties of neural network functions (in progress).

- Advisor: Dev Sinha

Bachelor's of Science, Double Major in **Mathematics and Chemistry**   Walla Walla University, College Place WA   *June 2015*

- Honors humanities and general studies

- WA State teaching certification

RESEARCH CONTRIBUTIONS

- **Algorithmic Determination of the Combinatorial Structure of the Linear Regions of ReLU Neural Networks**. Marissa Masden (2022). Submitted. Available at https://arxiv.org/abs/2207.07696.

- **Local and global topological complexity measures of ReLU neural network functions.** J. Elisenda Grigsby, Kathryn Lindsey and Marissa Masden (2022). Submitted. Available at https://arxiv.org/abs/2204.06062.

- **Alloy rupture strength prediction using machine learning and microstructure analysis.** Ram Devanathan, Osman Mamun, Mohammad Taufique, William E. Frazier, Arun Sathanur, Keerti Kappagantula, Jing Wang, Marissa Masden, Madison Wenzlick, Kelly Rose. To appear, TMS 2023 Annual Meeting & Exhibition.

- **Linear discriminant intitialization for feedforward neural networks.** Marissa Masden and Dev Sinha (2019). Submitted. Available at arxiv.org/abs/2007.12782.

RESEARCH EXPERIENCE

University of Oregon Eugene, OR   *2017-present*
Graduate research   Advisor: Dev Sinha

- Discovered a combinatorial description of ReLU neural networks' linear regions which encodes the face poset of the canonical polyhedral complex of a ReLU neural network by recording sign sequence information about its vertices, and proved this description was valid for all but a measure-0 set of neural networks.

- Developed and optimized code in python to compute the face poset of the canonical polyhedral complex of fully-connected feedforward ReLU neural networks implemented in PyTorch, and implemented Sage scripts computing the homology groups of subcomplexes of the canonical polyhedral complex and measured topological invariants of the decision boundaries of neural networks.

Pacific Northwest National Laboratory Richland, WA (remote)   *Summer 2021*
NSF Math Sciences Graduate Intern (ORISE)   Ram Devanathan lab

- Proposed and implemented topological data analytic methods to improve neural network segmentation of SEM images of metal grains, including training a PyTorch model with modified topological loss function.

- Compared scikit-learn and other custom ridge detection algorithms' performance for post-processing deep neural network output with classical accuracy metrics.

Washington State University Pullman, WA   *Summers 2013-2014*
Undergraduate Research Intern   Aurora Clark lab

- Translated an R algorithm for finding polyhedral structure in molecular dynamics simulations into C, developed improvements, and incorporated it into preexisting ChemNetworks software (2014)

- Created utility software in R to visualize data output and optimize parameters for the C software (2014)

- Researched the Markov Clustering algorithm and helped the research group efficiently implement it by manipulating data structure (2013)

Loma Linda University Loma Linda, CA *Summer 2013*
Biomedical Undergraduate Research Program Intern Jonathan Neihdigh lab
- Investigated organic pathways for synthesizing selectively methylated amino acids for use in constructing artificially modified proteins.
- Performed and recorded possible synthetic pathways and evaluated success primarily using thin layer chromatography (TLC), high pressure liquid chromatography with UV/Vis and mass spectrometry (HPLC-UV/Vis, HPLC-MS), and nuclear magnetic resonance (NMR).

TEACHING EXPERIENCE

Mathematics Department, University of Oregon, Eugene OR *2017-present*
Instructor of Record for the following courses:
- Math 111 (College Algebra)
- Math 112 (Elementary Functions)
- Math 231 (Elements of Discrete Mathematics I)
- Math 243 (Intro. to Methods of Probability and Statistics)
- Math 251 (Calculus I)
- Math 281 (Multivariate Calculus I)

Teaching Assistant and Grader for the following courses:
- Math 243 (Intro. to Methods of Probability and Statistics)
    - Lead TA, Fall 2021
- Math 461 (Intro. to Mathematical Methods of Statistics I)
- Math 635-636 (Algebraic Topology)

Henrietta Lacks Health and Bioscience High School, Vancouver WA *2015-2017*
Certificated Teacher for the following courses:
- Geometry. Developed curriculum meeting state standards and balanced needs of diverse student population.
- AP Statistics. Developed post-exam interdisciplinary project with epidemiology class introducing advanced methods for statistical analysis.
Faculty sponsor of Math Club and supervisor of after-school tutoring

Walla Walla University, College Place, WA *2011-2015*
- Contract Instructor, Remedial Geometry *Fall 2013 and 2014*
- Teaching Assistant, Introductory Statistics Lab *Winter 2013-2015*
- Mathematics Tutor, Teaching Learning Center *2011-2015*

SELECT PRESENTATIONS

Research and Invited Talks
- Topological properties of ReLU network functions, at initialization and during training. To occur, invited talk at JMM 2023 Special Session *Mathematical Methods in Machine Learning and Optimization*.
- Precise computation of cellular topology of neural network functions. To occur, invited talk at JMM 2023 Special Session *Applied Topology: Theory and Implementation*.
- Geometric Duality, Neural Networks, and Decision Boundaries. To occur, invited talk at Cascade Topology Seminar, Portland State University, November 2022.
- Exact Combinatorial and Topological Data for ReLU Networks' Linear Regions. Northeastern University Topology Seminar, May 2022.

- Persistent Homology for Machine Learning in Microstructure Analysis. NSF Math Sciences Graduate Internship 2021 Summer Presentations, Summer 2021.

- Neural Networks at Initialization. Boston College Math and Machine Learning Seminar (remote), Boston College, Fall 2020.

Expository Talks and Posters

- Piecewise Linear Morse theory: An overview. Geometry-Topology Seminar, Oregon State University, Fall 2021.

- Understanding ReLU Activation Patterns through the Sign Sequence Cubical Complex. Poster at Applied Algebraic Topology Network Poster Session, Fall 2021.

- Persistent Homology for Machine Learning in Microstructure Analysis. NSF MSGI 2021 Summer Presentations, Summer 2021.

- Using Persistence Signatures in Machine Learning. Geometry-Topology Seminar, Oregon State University, Spring 2020.

- Understanding Neural Networks through Geometry. 1st Midwest Graduate Student Conference: Geometry and Topology Meet Data Analysis and Machine Learning, The Ohio State University, 2019

Leadership, Service and Outreach

Directed Reading Program Mentor, University of Oregon Mathematics Department   AY 2021-2022
- Lead an undergraduate through a 12-week directed reading on finite-state Markov chains and stochastic processes. Selected readings and appropriate problems, designed code exercises, and met 1-2 hours weekly.

- Guided the undergraduate through preparing a 10-minute academic mathematics talk about Markov chains and steady states to their peers.

Association for Women in Mathematics, UO Student Chapter
- President, 2020-2021 and 2022-2023

- Secretary, AY 2019-2020

- K-12 Outreach Committee, 2018-present; co-chair 2019-2022

American Mathematical Society, UO Student Chapter
- Departmental Liaison (elected position), 2021-2022

Graduate Affairs Committee, UO Mathematics Department
- Graduate student representative (nominated position), 2018-2020

- Graduate Student Peer Mentor, 2019-2022

Graduate Student Mathematics Teaching Seminar, UO Mathematics Department
- Co-organizer, 2019-present

Select Conferences and Workshops

- Joint Mathematics Meetings. Boston, Massachusetts, January 2023. *Invited Speaker at AMS Special Session on Mathematical Methods in Machine Learning and Optimization and AMS Special Session on Applied Topology: Theory and Implementation.*

- Cascade Topology Seminar. Fariborz Maseeh Department of Mathematics and Statistics, Portland State University, Portland OR, November 2022. *Invited Speaker.*

- Institute of Advanced Studies 2022 Women and Mathematics program: The Mathematics of Machine Learning. Princeton, NJ, May 2022.
  One of 50 attendees to a program focused on interpretable and distributed machine learning.

- Oxford Applied Topology School. University of Oxford, Oxford, UK, March 2020.
  Awarded travel funding. Cancelled due to COVID-19.

- Neural Information Processing Systems (NeurIPS). Vancouver, BC, Canada, December 2019.

- FRG Workshop on Discrete Shapes. University of California, Davis, 2019.
  Awarded travel funding.

- The 1st Midwest Graduate Student Conference: Geometry and Topology meet Data Science and Machine Learning.
  The Ohio State University, 2019. *Speaker, awarded travel funding.*

Honors and Awards

NSF Research Training Grant, UO Mathematics Department	Summer 2022
Johnson Fellowship, UO Mathematics Deparatment	Summer 2019
Dean's First Year Merit Award, UO Mathematics Department	AY 2017-2018
Schofield Memorial Scholarship, WWU Education Department	2015
Honors Program Scholarship, WWU Honors General Studies Program	2015
Schottlauer Math Scholarship, WWU Mathematics Department	2015
M&I Johnstone Scholarship, WWU Mathematics Department	2014-2015
President's Scholarship for National Merit Scholars, WWU	2010-2014
C&L Jones Chemistry Scholarship, WWU Chemistry Department	2010-2011
Boeing National Merit Scholarship	2010-2011

Professional Affiliations

American Mathematical Society (AMS) member 2021-present
Association for Women in Mathematics (AWM) member 2019-present

Technical Skills

Programming Languages:

- *Proficient* in Python, C/C++, SageMath, R, LaTeX, Git

- *Light experience* in HTML/CSS/JavaScript, Ruby/Jekyll, Bash, Fortran

Select Python Skills:

- Machine Learning: PyTorch and TensorFlow/Keras

- Topological Data Analysis: Ripser, GUDHI, scikit-tda

- Network Analysis: NetworkX, igraph

- Data Analysis: scikit-learn, scikit-image, scipy, numpy, pandas

- Environment Control: Anaconda, Jupyter, venv

Scientific Computing Experience:

- *Significant experience* scheduling jobs using SLURM workload management system

- *Light experience* performing molecular dynamics simulations using NWChem and Visual Molecular Dynamics (VMD)