

# NAREN VOHRA

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## EDUCATION

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**Ph.D.** candidate, Mathematics, *Oregon State University (OSU)*. 2018 – Present

Advisor: Prof. Malgorzata Peszynska. Expected 2023.

**Master of Science**, Mathematics, *OSU*. 2018 – 2020

**Master of Science**, Major in Mathematics, *Indian Institute of Science (IISc)*, Bangalore, India. 2017 – 2018

**Bachelor of Science**, Major in Mathematics, *IISc*. 2012 – 2017

## PUBLICATIONS

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- 1 L. Bigler, M. Peszynska, and N. Vohra, **Heterogeneous Stefan Problem and Permafrost Models with P0-P0 Finite Elements and Fully Implicit Monolithic Solver**, *Electronic Research Archive*, 2022, 30 (4), 1477–1531.
- 2 C. Shin, A. Alhammali, L. Bigler, N. Vohra, and M. Peszynska, **Coupled flow and biomass-nutrient growth at pore-scale with permeable biofilm, adaptive singularity and multiple species**. *Mathematical Biosciences and Engineering*, 2021, 18 (3), 2097-2149.
- 3 N. Vohra, K. Lipnikov, S. Tokareva, **Second-order accurate mimetic scheme for solute transport on polygonal meshes**. *manuscript submitted*, 2022
- 4 L. Bigler, M. Peszynska, N. Vohra, **Numerical Upscaling of the Heterogeneous Stefan Problem**. *manuscript in preparation*
- 5 E. Jafarov, M. Peszynska, B. Rogers, N. Vohra, **Estimating Permafrost Thaw Settlement Using Active Layer Depth Data**. *manuscript in preparation*

## AWARDS AND ACHIEVEMENTS

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**Lightning Talk Award** 2022

Awarded 2<sup>nd</sup> place at the 2022 Student Lightning Talks, Los Alamos National Laboratory, for talk *Well-balanced Discretizations of Shallow Water Systems on Arbitrary Polygonal Meshes*.

**Oregon Lottery Graduate Scholarship** 2022

Awarded by the Graduate School, OSU, for the academic year 2022 - 2023.

**Graduate Student Excellence Award** 2022

Department of Mathematics, OSU.

**Oberwolfach Leibniz Graduate Students** 2022

Received support from Mathematisches Forschungsinstitut Oberwolfach to attend an Oberwolfach workshop (Id: 2204) in person.

**NSF Mathematical Sciences Graduate Internship** 2021

Internship at Los Alamos National Laboratory funded by Oak Ridge National Laboratory during Summer 2021.

**Outstanding Performance in Coursework Award** 2019, 2021

Department of Mathematics, OSU.

**INSPIRE Fellow** 2012–2013, 2015–2016

Awarded the INSPIRE Fellowship from August 2012 - January 2013 and August 2015 - July 2016 after securing admission into IISc through the AIEEE.

Secured an All India Rank of 506 in the 2012 All India Engineering Entrance Examination, taken by approximately 1.1 million students across the country.

## EXPERIENCE

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### Research Interests

• Numerical analysis of parabolic and hyperbolic systems • Finite element methods • Mathematical and computational modeling of multiphysics multiscale phenomena.

**Graduate Research Assistant, OSU** *Su, Fa 2019, Sp, 2020, Fa 2021, Wi 2022, Fa 22, Wi 23*

• Currently working on the analysis and implementation of thermo-hydro-mechanical models to simulate energy, flow, and deformation in ice-rich porous media, such as permafrost • Implemented and analyzed numerical models for the degenerate parabolic (Stefan problem) and mixed elliptic-parabolic (Biot's poroelasticity) system.

Support from NSF Grant DMS-1522734 and DMS-1912138. PI: Prof. Malgorzata Peszynska.

### Los Alamos National Laboratory

*6/21–8/27/2021, 6/20–8/26/2022*

Worked under the guidance of Dr. Svetlana Tokareva and Dr. Konstantin Lipnikov in the Applied Mathematics and Plasma Physics group of Theoretical Division at Los Alamos National Laboratory (LANL), NM, US, as a NSF Mathematical Sciences Graduate Internship participant (2021) and as a LANL Graduate Student (2022).

• Studied well-balanced, depth-positivity preserving numerical schemes for the shallow water equations on unstructured polygonal meshes and worked on their implementation in the numerical framework *Amanzi* • Studied and implemented the coupling of surface flow with subsurface flow and solute transport.

### Woodwell Climate Research Center

*4/18–6/10/2022*

Worked under the guidance of Prof. Malgorzata Peszynska, Dr. Elchin Jafarov, and Dr. Brendan Rogers as an Arctic Subsidence Modeling intern at Woodwell Climate Research Center, MA, US.

• Analyzed the correlation between thaw settlement and the change in the active layer depth by using the void ratio and moisture content of the frozen soil as a random parameter.

### Technical University of Munich, Germany

*1/30–2/4/2022*

Visited Prof. Barbara Wohlmuth's group in the Department of Mathematics at Technical University of Munich.

• Worked on permafrost models and the challenges associated with their numerical implementation, with particular emphasis on introducing visco-elasticity to analyze deformation.

### Graduate Teaching Assistant, OSU

*2018–Present*

*2022*: Models and Methods of Applied Mathematics (*Sp*; Grader).

*2021*: Models and Methods of Applied Mathematics and Probability 2 (*Wi*; Grader), Advanced Calculus and Probability 3 (*Sp*; Grader),

*2020*: Calculus for Management and Social Science (*Wi*), Integral Calculus (*Su*; Instructor), Differential Calculus (*Fa*).

*2019*: Differential Calculus (*Wi*), Calculus for Management and Social Science (*Sp*).

*2018*: Differential Calculus (*Fa*).

### Project Trainee at CAOS, IISc

*2016–2018*

Project at Center for Atmospheric and Oceanic Sciences (CAOS) at IISc under the guidance of Prof. Venugopal V. and Dr. Fabrice Papa.

Worked on the analysis of the decadal cycle in Ganges river discharge and its relation to the Indian Monsoon by using time-frequency analysis, particularly the wavelet transform.

## PRESENTATIONS AND CONFERENCES/WORKSHOPS ATTENDED

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- 1 AMS Fall Central Sectional Meeting (oral, invited), *Mixed Finite Elements for Permafrost and Thermo-hydro-mechanical Models*, Naren Vohra, Malgorzata Peszynska, 9/18/2022.
- 2 LANL Lightning Talk (oral), *Well-balanced Discretizations of Shallow Water Systems on Arbitrary Polygonal Meshes*, Naren Vohra, Svetlana Tokareva, Konstantin Lipnikov, 8/9/2022.
- 3 Woodwell Climate Research Center (oral), *Modeling Subsidence Due To Permafrost Thaw*, Naren Vohra, Malgorzata Peszynska, Elchin Jafarov, Brendan Rogers, 6/2/2022.
- 4 SIAM PNW (oral, invited), *Mixed Finite Elements for the Permafrost Model and Steps Towards Thermo-hydro-mechanical Coupling*, Naren Vohra, Malgorzata Peszynska, 5/21/2022.
- 5 The Finite Element Circus, University of Florida, 4/8–4/9/2022
- 6 Applied Math and Computational Seminar, OSU (oral), *Mixed Finite Elements for the Heterogeneous Stefan Problem and Application to Multiscale Multiphysics Models of Permafrost*, Naren Vohra, Lisa Bigler, Malgorzata Peszynska, 3/11/2022.
- 7 Oberwolfach Workshop on “Multiscale Coupled Models for Complex Media: From Analysis to Simulation in Geophysics and Medicine” (Workshop Id: 2204), Mathematisches Forschungsinstitut Oberwolfach, 1/23–1/29/2022.
- 8 The Finite Element Circus, Penn State University, 11/5–11/6/2021.
- 9 NSF-MSGI Presentation (oral), *Well-balanced Discretizations of Shallow Water Systems on Arbitrary Polygonal Meshes*, Naren Vohra, Svetlana Tokareva, Konstantin Lipnikov, 8/12/2021.
- 10 SIAM GS21 (oral), *Accounting for Mass and Volume Conservation in a Coupled Flow-Deformation-Energy Model at Pore-Scale*, Naren Vohra, Malgorzata Peszynska, 6/21–6/24/2021.
- 11 SIAM CSE21 (oral), *Coupled Biot and Phase Transition Model at Pore-Scale*, Naren Vohra, Malgorzata Peszynska, 3/1–3/5/2021.
- 12 Joint Mathematics Meeting, 1/6–1/9/2021.
- 13 InterPore Short Course, *Multiphase Flow in Permeable Media: A Pore-Scale Perspective*, Professor Martin Blunt, Imperial College London, 12/7–12/10/2020.
- 14 Second Joint SIAM/ CAIMS Annual Meeting (poster), *Coupling of Flow and Deformation in Porous Media at the Network Scale*, Naren Vohra, Malgorzata Peszynska, 7/6–7/17/2020.
- 15 Applied Math and Computation Seminar, OSU (oral), *A Multiscale Study of the Biot System and the Stefan Problem*, Naren Vohra, Malgorzata Peszynska, 5/29/2020.
- 16 7<sup>th</sup> Annual Cascade RAIN Meeting (oral), *Coupling of Flow and Deformation in Porous Media at Network Scale*, Naren Vohra, Malgorzata Peszynska, 4/4/2020.
- 17 2<sup>nd</sup> Biennial Meeting of SIAM Pacific Northwest Section, Seattle University, 10/18–10/20/2019.
- 18 Mathematical Problems In Industry Workshop, New Jersey Institute of Technology, *Construction of the PDF of fiber size and distribution using finite samples* (project sponsored by Gore Technologies), 6/17–6/21/2019.
- 19 Graduate Student Mathematical Modeling Camp, University of Delaware, *Modeling flow and fouling in elastic membrane filters*, 6/12–6/15/2019.
- 20 OpenFOAM Workshop, OSU, 6/3–6/4/2019.
- 21 6<sup>th</sup> Annual Cascade RAIN Meeting, University of Washington, Bothell, 4/13/2019.

## SKILLS

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### Programming languages

MATLAB, C++, Python.

### Computing environments and frameworks

[Amanzi](https://github.com/amanzi/amanzi) (Contributor) [<https://github.com/amanzi/amanzi>], [deal.II](https://dealii.org) [<https://dealii.org>], ParaView, Git, Blender, OpenFOAM, OpenMP, MPI.

## SOFTWARE

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This is a list of the open source software that I have contributed to and used in my research.

### 1. Poroelasticity code capsule in MATLAB and Python

Developed one-dimensional poroelasticity solver to simulate flow and deformation in porous media using quasi-static Biot's system.

MATLAB implementation: <https://github.com/nvohra0016/Biot1D-MATLAB> (Documentation with examples included)

Python implementation: <https://github.com/nvohra0016/Biot1D-Python>

Developers: Naren Vohra, Prof. Malgorzata Peszynska. Implemented as part of MPOWER (<http://sites.science.oregonstate.edu/~mpesz/mpower/>)

### 2. Amanzi

Amanzi is a reactive flow and transport simulation framework: <https://github.com/amanzi/amanzi>

• Improved the shallow water equation solver to handle issues associated with surface flow over irregular dry beds, such as well-balancing and depth-positivity • Worked on the coupling of surface flow and subsurface flow, and surface flow and solute transport.

## TRAVEL AWARDS

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AMS Fall Central Sectional Meeting, travel award, 2022.

SIAM Pacific Northwest Section Annual Meeting (PNW21), travel award, 2022.

SIAM Conference on Mathematical & Computational Issues in the Geosciences (GS21), travel award, 2021.

SIAM Conference on Computational Science and Engineering (CSE21), travel award, 2021.

Graduate Student Professional Development Award (OSU) for Joint Mathematics Meeting, registration support, 2021.

Mathematical Problems in Industry, New Jersey Institute of Technology, full support, 2019.

Graduate Student Mathematical Modeling Camp, University of Delaware, full support, 2019.

Annual Cascade RAIN Meeting, University of Washington, travel support, 2019.

## SELECTED COURSEWORK

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### OSU (2018–Present)

Partial Differential Equations (PDE)  
Finite Elements for PDE  
Numerical Analysis  
Finite Volume and Discontinuous Galerkin Methods  
Structural Mechanics  
Uncertainty Quantification  
Computational Mathematics Foundations of Multiphysics

### IISc (2012–2018)

Functional Analysis  
Homogenization of PDE  
Fourier Analysis  
Digital Image Processing  
Linear and Nonlinear Optimization  
Probability Models

## SERVICE

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### OSU Student Chapter SIAM

2019 – Present

President (elected), 2021 – 2022.

Organized talks by alumni and programming language tutorials for chapter members.

Helped increase number of members by at least 10.

### Mathematics Ad Hoc Review Committee

2022 – Present

Member (invited) of the ad hoc committee to review the current PhD qualifying requirements in the department of mathematics.

### Mathematics Graduate Program Ambassador

2022 – Present

Involved in outreach to potential applicants.