Dohyun **Kim**

Finite Element Method · PDE-constrained Optimization · High-performance Computing

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Summary

Applied mathematician working on numerical PDEs, variational inequalities and constrained optimization. I develop and analyze finite element and first-order optimization methods that keep every iterate feasible, including the SiMPL method for topology optimization, and implement them for large-scale problems on GPUs in MFEM, where I am a developer and official code reviewer. Co-PI on a DOE ASCR grant (2026–2030).

Education

Yonsei University — *Seoul, S. Korea*

Ph.D. in Computational Science and Engineering — *Mar. 2015 - Feb. 2021*

- Thesis: "Non-conforming methods for 4th-order PDEs"
- Advisor: Prof. Eun-Jae Park
- Polytopal finite element methods, discontinuous Galerkin methods, a priori/a posteriori error analysis

Hanyang University — *Seoul, S. Korea*

B.S. in Mathematics — *Mar. 2011 - Feb. 2015*

- Coursework in functional analysis, linear algebra, numerical analysis, and graph theory.

Funding

Scalable, Mesh-Independent Algorithms for State Constraints via the Proximal Galerkin Method — *U.S. Department of Energy*

Co-PI (PI: Brendan Keith), $1,000,000 — *Aug. 2026 - Jul. 2030*

- DOE Office of Science, Advanced Scientific Computing Research, EPSCoR State/National Laboratory Partnerships (award DE-SC0026897)

Professional Experience

Brown University — *Providence, RI, USA*

Research Scientist — *Sep. 2025 - Present*

- PDE-constrained optimization
- A priori/a posteriori error analysis for variational inequalities

Brown University — *Providence, RI, USA*

Postdoctoral Research Associate — *Jan. 2023 - Aug. 2025*

- PDE-constrained optimization
- A priori/a posteriori error analysis for variational inequalities

Yonsei University — *Seoul, S. Korea*

Postdoc — *Sep. 2022 - Dec. 2022*

- Polytopal finite element methods

Hong Kong Centre for Cerebro-cardiovascular Health Engineering (COCHE) *Hong Kong, China*

Postdoc *Oct. 2021 - Oct. 2022*

- Pressure-robust numerical methods for Navier-Stokes equations
- Fluid-structure interaction problems

Yonsei University *Seoul, S. Korea*

Postdoc *Mar. 2021 - Oct. 2021*

- Polytopal finite element methods for Stokes equations

Teaching Experience

Numerical Solution of Partial Differential Equations II *Co-instructor - APMA2560*

Brown University *Spring 2026*

- Recitation instructor (variational inequalities, strongly monotone operators, serial and parallel implementation in MFEM)

Introduction to Computational Linear Algebra *Instructor - APMA1170*

Brown University *Fall 2024*

- Linear algebra (vector spaces, linear transformations, eigenvalues)
- Numerical linear algebra (LU decomposition, Krylov subspace methods, eigenvalue solvers)

Numerical Solution of Partial Differential Equations II *Teaching Assistant - APMA2560*

Brown University *Spring 2024*

- Recitation instructor (theory and C++ implementation of finite element methods)

Publications

Preprints

[1] **Remap for ALE hydrodynamics via direct interpolation and constraint optimization** *2026*

B. Keith, **D. Kim**, B. S. Lazarov, K. Mittal, C. Petra, M. R. Schmidt, and V. Z. Tomov

Submitted

[2] **The SiMPL Method for Multi-Material Topology Optimization** *2026*

P. Gangl, B. Keith, **D. Kim**, and T. M. Surowiec

arXiv:2605.11994 (revision submitted)

[3] **Proximal discontinuous Galerkin methods for variational inequalities** *2026*

A. Ern, B. Keith, **D. Kim**, R. Masri, and B. Rivière

arXiv:2604.19708 (submitted)

[4] **The proximal Galerkin method for non-symmetric variational inequalities** *2026*

G. Fu, B. Keith, **D. Kim**, R. Masri, and W. Pazner

arXiv:2602.14967

Journal Articles

[1] **Pressure-robust staggered DG methods for the Navier-Stokes equations on general meshes** *2026*

D. Kim, L. Zhao, E. T. Chung, and E.-J. Park

Journal of Scientific Computing, 109:45

[2] **Finite element approximation to the non-stationary quasi-geostrophic equation** *2025*

D. Kim, A. K. Pani, and E.-J. Park
ESAIM: Mathematical Modelling and Numerical Analysis, 59(4):1973–2003

[3] **Analysis of the SiMPL method for density-based topology optimization** *2025*

B. Keith, **D. Kim**, B. S. Lazarov, and T. M. Surowiec
SIAM Journal on Optimization, 35(2):1134–1164

[4] **A simple introduction to the SiMPL method for density-based topology optimization** *2025*

D. Kim, B. S. Lazarov, T. M. Surowiec, and B. Keith
Structural and Multidisciplinary Optimization, 68(4):1–17

[5] **High-performance finite elements with MFEM** *2024*

J. Andrej, N. Atallah, J.-P. Bäcker, J.-S. Camier, D. Copeland, V. Dobrev, Y. Dudouit, T. Duswald, B. Keith, **D. Kim**, T. Kolev, B. Lazarov, K. Mittal, W. Pazner, S. Petrides, S. Shiraiwa, M. Stowell, and V. Tomov
The International Journal of High Performance Computing Applications, 38(5)

[6] **DynAMO: Multi-agent reinforcement learning for dynamic anticipatory mesh optimization with applications to hyperbolic conservation laws** *2024*

T. Dzanic, K. Mittal, **D. Kim**, J. Yang, S. Petrides, B. Keith, and R. Anderson
Journal of Computational Physics, 506:112924

[7] **Staggered DG method with small edges for Darcy flows in fractured porous media** *2022*

L. Zhao, **D. Kim**, E.-J. Park, and E. T. Chung
Journal of Scientific Computing, 90(3):83

[8] **Morley finite element methods for the stationary quasi-geostrophic equation** *2021*

D. Kim, A. K. Pani, and E.-J. Park
Computer Methods in Applied Mechanics and Engineering, 375:113639

[9] **Review and implementation of staggered DG methods on polygonal meshes** *2021*

D. Kim, L. Zhao, and E.-J. Park
Journal of the Korean Society for Industrial and Applied Mathematics, 25(3)

[10] **Staggered DG methods for the pseudostress-velocity formulation of the Stokes equations on general meshes** *2020*

D. Kim, L. Zhao, and E.-J. Park
SIAM Journal on Scientific Computing, 42(4):A2537–A2560

[11] **Error estimates of B-spline based finite-element methods for the stationary quasi-geostrophic equations of the ocean** *2018*

D. Kim, T.-Y. Kim, E.-J. Park, and D.-W. Shin
Computer Methods in Applied Mechanics and Engineering, 335:255–272

Open source contributions

[1] **LeanNA: numerical analysis in Lean 4 (closed alpha)** *2026 - Present*

Lean 4 library on Mathlib
Formalization of the standard theory of finite element methods, variational inequalities and proximal Galerkin methods; more than 12,000 theorems

[2] **Official code reviewer** *2026 - Present*

MFEM (C++ library for FEM managed by LLNL)

Reviews and approves pull requests to the MFEM library

[3] **General hyperbolic class and refactored Ex18, Ex18p, with a preassembly option** *2024*

MFEM (C++ library for FEM managed by LLNL)

Flux evaluation for general hyperbolic PDEs, refactored compressible Euler examples, and preassembly of the nonlinear operator

[4] **Add `SetEssentialTDofs` to `(Par)BlockNonlinearForm`** *2025*

MFEM (C++ library for FEM managed by LLNL)

Added support for essential boundary conditions in nonlinear block systems

Presentation

Conference organized

Mini-symposium: Recent developments in mathematical analysis and numerics for incompressible flow and related problems *Pittsburgh, Pennsylvania, USA*

2022 SIAM Annual Meeting *July, 2022*

Special Session on Constrained Optimization and Optimal Control *Lawrence, Kansas, USA*

2025 Spring Central Sectional Meeting *April, 2025*

Mini-symposium: Numerical Methods for Constrained Variational Problems *Pittsburgh, Pennsylvania, USA*

2027 SIAM Conference on Computational Science and Engineering (CSE27) *February, 2027*

Mini-symposium: Physics and Structure-Preserving Numerical Methods for Variational Problems *Milano, Italy*

16th International Conference on Spectral and High Order Methods (ICOSAHOM 2027) *July, 2027*

Selected talks (among 20+ talks)

Multi-Material Topology Optimization with General Convex Polytopal Constraints *Munich, Germany*

17th World Congress on Computational Mechanics (WCCM-ECCOMAS 2026) *July, 2026*

A Projected Mirror Descent Method for Density-based Multi-material Topology Optimization *Atlanta, Georgia, USA*

INFORMS Optimization Society Conference *March, 2026*

SiMPL method for Topology Optimization *Fort Worth, Texas, USA*

SIAM Conference on Computational Science and Engineering *March, 2025*

SiMPL Method for Density Based Topology Optimization *Worcester, Massachusetts, USA*

Worcester Polytechnic Institute *October, 2024*

Dynamic anticipatory mesh optimization with reinforcement learning *Larnaca, Cyprus*

International Conference on High Order Finite Element and Isogeometric Methods *May, 2023*