

# Alp Dener

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## Research Interests

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**Optimization:** PDE-constrained Problems, Gradient-based Algorithms, Sensitivity Analysis, MDO Architectures

**Machine Learning:** Physics Informed Neural Networks, Constrained Training Methods, Supervised Learning

**Scientific Computing:** High Performance Computing for Optimization, Reusable Scientific Software

## Education

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**Rensselaer Polytechnic Institute** December 2017  
Aeronautical Engineering, Ph.D.

**University of Maryland, Baltimore County** May 2012  
Mechanical Engineering, B.S.

## Work Experience

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**Postdoctoral Appointee – Argonne National Laboratory** Feb 2018–Present  
*Mathematics and Computer Science Division* Supervisor: Todd Munson

- Principal developer on Toolkit for Advanced Optimization (TAO) and contributor to PETSc
- Research large-scale optimization algorithms with efficient treatment of nonlinear constraints
- Promote TAO, expand its user base, and provide software support for external researchers

**Graduate Research Assistant – Rensselaer Polytechnic Institute** Feb 2013–Dec 2017  
*Optimal Design Lab* Supervisor: Jason E. Hicken

- Investigate PDE-constrained multi-disciplinary design optimization problems
- Research gradient-based, reduced-space, matrix-free optimization algorithms
- Develop a parallel-agnostic optimization library tailored for large-scale engineering systems

**Undergraduate Research Assistant – University of Maryland, Baltimore County** Oct 2010–May 2011  
*Joint Center for Earth Systems Technology* Supervisor: Gergely Dolgos

- Construction of an optical aerosol measurement instrument
- Design and manufacture of high-precision optical component mounts
- Propose instrument mounting solutions for the NASA GSFC science fleet aircraft

## Teaching Experience

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**Guest Lecturer – Rensselaer Polytechnic Institute**  
*Mechanical, Aerospace and Nuclear Engineering Department*

- Design Optimization (MANE 4280/6963) Fall 2016, Fall 2017
- Aerospace Structures and Materials (MANE 4060) Fall 2012

**Teaching Assistant – Rensselaer Polytechnic Institute**  
*Mechanical, Aerospace and Nuclear Engineering Department*

- Design Optimization (MANE 4280/6963) Fall 2016, Fall 2017
- Strength of Materials (ENGR 2530) Summer 2017
- Aerospace Structures and Controls Laboratory (MANE 4920) Spring 2013
- Aerospace Structures and Materials (MANE 4060) Fall 2012
- Aerodynamics I (MANE 4070) Fall 2012

## Publications

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### Journal Articles

- Dener, Alp, et al. 2020. "Training neural networks under physical constraints using a stochastic augmented Lagrangian approach (submitted)". *Journal of Computational Physics*.
- Miller, M Andres, et al. 2020. "Encoder-decoder neural network for solving the nonlinear Fokker-Planck-Landau collision operator in XGC (accepted)". *Journal of Plasma Physics*.
- Mills, Richard Tran, et al. 2020. "Toward Performance-Portable PETSc for GPU-based Exascale Systems (submitted)". *IEEE Transactions on Parallel and Distributed Systems (Special Section on Innovative R&D toward the Exascale Era)*.
- Dener, Alp, and Jason E Hicken. 2017. "Matrix-free Algorithm for the Optimization of Multidisciplinary Systems". *Structural and Multidisciplinary Optimization, Springer*. doi:10.1007/s00158-017-1734-0.
- Hicken, Jason E, and Alp Dener. 2015. "A Flexible Iterative Solver for Nonconvex, Equality-constrained Quadratic Subproblems". *Journal on Scientific Computing, SIAM*. doi:10.1137/140994496.

### Refereed Proceedings

- Dener, Alp, Adam Denchfield, and Todd Munson. 2019. "Preconditioning nonlinear conjugate gradient with diagonalized quasi-Newton". In *Proceedings for the Platform for Advanced Scientific Computing Conference*. Zurich, Switzerland. doi:10.1145/3324989.3325712.
- Dener, Alp, and Todd Munson. 2019. "Accelerating Limited-Memory Quasi-Newton Convergence for Large-Scale Optimization". In *International Conference on Computational Science*. Faro, Portugal. doi:10.1007/978-3-030-22744-9\_39.
- Dener, Alp, et al. 2018. "Enabling Modular Aerostructural Optimization: Individual Discipline Feasible without the Jacobians". In *2018 Multidisciplinary Analysis and Optimization Conference, AIAA AVIATION Forum*. Atlanta, GA, USA. doi:10.2514/6.2018-3570.
- Dener, Alp, et al. 2016. "Kona: A Parallel Optimization Library for Engineering-Design Problems". In *57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, AIAA SciTech Forum*. San Diego, CA, USA. doi:10.2514/6.2016-1422.
- Dener, Alp, et al. 2015. "Comparison of Inexact- and Quasi-Newton Algorithms for Aerodynamic Shape Optimization". In *53rd AIAA Aerospace Sciences Meeting, AIAA SciTech Forum*. Kissimmee, FL, USA. doi:10.2514/6.2015-1945.
- Dener, Alp, and Jason E Hicken. 2014. "Revisiting Individual Discipline Feasible with matrix-free Inexact-Newton-Krylov". In *10th AIAA Multidisciplinary Design Optimization Conference, AIAA SciTech Forum*. National Harbor, MD, USA. doi:10.2514/6.2014-0110.

### Technical Reports

- Balay, Satish, et al. 2020. *PETSc Users Manual*. Tech. rep. ANL-95/11 - Revision 3.14. Argonne National Laboratory.
- Dener, Alp, et al. 2020. *TAO Users Manual*. Tech. rep. ANL/MCS-TM-322 - Revision 3.14. Argonne National Laboratory.

### Doctoral Thesis

- Dener, Alp. 2017. "A Modular Matrix-free Approach to Multidisciplinary Design Optimization". PhD thesis, Rensselaer Polytechnic Institute.

### Preprints / Working Papers

- Dener, Alp, et al. 2021. "Toward Constrained Optimization in Machine Learning: An Error-Tolerant Multisecant Method for Training PINNs (in preparation)". *arXiv preprint*.
- Dener, Alp, Adam Denchfield, and Todd Munson. 2021. "The TAO Nonlinear Conjugate Gradient and Quasi-Newton Laboratory (in preparation)". *arXiv preprint*.
- Hicken, Jason E, Pengfei Meng, and Alp Dener. 2017. "Error-tolerant multisecant method for nonlinearly constrained optimization". *arXiv preprint arXiv:1709.06985*.

## Presentations

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### Conference Presentations

- Dener, Alp, et al. 2021. *Toward Constrained Optimization in Machine Learning: An Error-Tolerant Multisecant Method for Training PINNs*. SIAM Conference on Computational Science and Engineering.
- Dener, Alp, et al. 2021. *A Stochastic Augmented Lagrangian for Physics-Constrained Neural Network Training Abstract*. SIAM Conference on Computational Science and Engineering.
- Dener, Alp. 2020. *Investigating Quasi-Newton Outer Product Representations on GPUs*. SIAM Conference on Parallel Processing for Scientific Computing.
- Dener, Alp, Adam Denchfield, and Todd Munson. 2019. *Accelerating Quasi-Newton and Conjugate Gradient Convergence for Large-Scale Optimization*. SIAM Conference on Computational Science and Engineering.
- Dener, Alp, et al. 2018. *Enabling Modular Aerostructural Optimization: Individual Discipline Feasible without the Jacobians*. 2018 Multidisciplinary Analysis and Optimization Conference, AIAA AVIATION Forum.
- Dener, Alp, et al. 2016. *Kona: A Parallel Optimization Library for Engineering-Design Problems*. 57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, AIAA SciTech Forum.
- Dener, Alp, et al. 2015. *Comparison of Inexact- and Quasi-Newton Algorithms for Aerodynamic Shape Optimization*. 53rd AIAA Aerospace Sciences Meeting, AIAA SciTech Forum.
- Dener, Alp, and Jason E Hicken. 2014. *Revisiting Individual Discipline Feasible with matrix-free Inexact-Newton-Krylov*. 10th AIAA Multidisciplinary Design Optimization Conference, AIAA SciTech Forum.

### Invited Talks/Lectures

- Dener, Alp. 2020. *Large-Scale Optimization Using PETSc/TAO*. Argonne Training Program for Extreme-Scale Computing.
- Dener, Alp. 2019. *PDE-constrained Optimization Using PETSc/TAO*. Argonne Training Program for Extreme-Scale Computing.

## Proposal Contributions

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- "Development of a Machine Learning Toolkit in PETSc", co-investigator, LDRD Prime - Future Computing, 2021-0177, 2021, funding: \$295K
- "Frameworks, Algorithms and Scalable Technologies for Mathematics (FASTMath) SciDAC Institute", numerical optimizations expert, DOE-ASCR, LAB 20-2223, 2020, funding: \$4.05M
- "Machine Learning and Artificial Intelligence for Simulation Acceleration and Real-Time Scientific Discovery of Fusion Science on Exascale Computers (MASS)", numerical optimization expert, DOE-FES, LAB 20-2224, 2020, not funded
- "Machine learning enhanced sampling methods for the stochastic multi-fidelity optimization of complex systems", numerical optimization expert, DOE-ASCR, LAB 20-2321, 2020, not funded

## Software Projects

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- TAO:** Toolkit for Advanced Optimization ANSI C / Fortran  
*Maintainer, Developer* Feb 2018–Present  
Principal maintainer and code reviewer for the library. Lead developer for constrained optimization methods. Supervisor for development of ADMM code by summer student. Point-of-contact for users and external contributors.
- PETSc:** Portable Extendable Toolkit for Scientific Computing ANSI C / Fortran  
*Developer* Feb 2018–Present  
Member of the core development team. Contributor and maintainer for various linear algebra tools and other functionality required by TAO solvers. Lead developer for the Jenkins CI/CD prototype.
- MADtorch:** Multisecant Accelerated Descent Optimizer for pyTorch Python3  
*Creator, Maintainer, Developer* Feb 2021–Present  
Lead architect of a novel pyTorch optimizer for mini-batch training under general nonlinear constraints. Currently used in research efforts to accelerate XGC fusion simulation using a physics-informed neural network.
- MACH:** MDO for Aircraft Configurations with High Fidelity Python3 / C++ / Fortran  
*External Contributor* Jun 2014–Dec 2017  
Software suite for aerodynamic and aero-structural shape optimization, developed and maintained by MDOLab @ UMich. Implemented a new MDO coupling architecture and related 2nd order adjoint-based matrix-free Hessian-vector products.
- Kona:** A Parallel Optimization Framework for Engineering-design Problems Python3  
*Creator* Jan 2013–Dec 2017  
Lead architect of the core optimization research library for Optimal Design Lab @ RPI. Designed parallel-agnostic implementations of SQP methods using vector algebra abstractions. Library still in use by current doctoral students.

## Honors & Awards

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- o AIAA Student Paper Competition - 1st Place 2018
  - Category: Multidisciplinary Analysis and Optimization

## Professional Activities and Service

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### Referee/Reviewer

- o Mathematics of Optimization Research (2018-)
- o SIAM Journal on Scientific Computing (2018-)
- o Optimization and Engineering (2018-)
- o AIAA Journal (2018-)
- o ATPESC Program Committee Member (2021)
- o DOE SBIR Phase I Review Panel (2019)

### Conference Service

- o Session Organizer: SIAM CSE19, SIAM CSE21

### Argonne Training Program for Extreme-Scale Computing

- o Lead Organizer, Numerical Software Track (2021-)
- o Organizer, Numerical Software Track (2020)

### National Science Bowl

- o Questions Judge, Illinois Regionals (2021)

### Societies

- o American Institute of Aeronautics and Astronautics (2012-)
- o Society of Industrial and Applied Mathematics (2012-)
- o Mathematical Optimization Society (2018-)
- o Institute for Operations Research and the Management Sciences (2018-)

### Supervised Students

- o Jamal Shabani, Louisiana State University (2021)
- o Han Sol Suh, Georgia Institute of Technology (2019)