Matthew J. Zahr

Assistant Professor
Aerospace and Mechanical Engineering
University of Notre Dame

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Research Interests

model reduction · finite element and discontinuous Galerkin methods · high-order discretizations · numerical methods for shocks and discontinuities · topology optimization · PDE-constrained optimization · multiphysics and multiscale problems · uncertainty quantification

Academic Positions

2021–pres	**Concur. Assistant Professor**, Applied and Computational Mathematics and Statistics, University of Notre Dame
2019–pres	**Assistant Professor**, Aerospace and Mechanical Engineering, University of Notre Dame
2016–2018	**Luis W. Alvarez Postdoctoral Fellow**, Mathematics, Lawrence Berkeley National Laboratory

Education

Sep 2016	**Ph.D., Computational and Mathematical Engineering, Stanford University**	*Stanford, CA*
	Advisor: Charbel Farhat ∘ Ph.D. minors: Mechanical Engineering, Aeronautics and Astronautics ∘ Funding: Department of Energy Computational Science Graduate Fellowship ∘ Dissertation: "Adaptive Model Reduction to Accelerate Optimization Problems Governed by Partial Differential Equations"	
Sep 2016	**M.S., Computational and Mathematical Engineering, Stanford University**	*Stanford, CA*
	Advisor: Charbel Farhat	
May 2011	**B.S., Civil and Environmental Engineering, University of California, Berkeley**	*Berkeley, CA*
	Advisor: Sanjay Govindjee ∘ Minor: Mathematics	

Honors & Awards

2020–2023	**Young Investigator Award**, Air Force Office of Scientific Research	
	3 year, $450k research grant	
Jun 2017	**Gene Golub Dissertation Award**, Stanford University	*Stanford, CA*
	Best ICME thesis in 2016-2017 academic year	
Feb 2017	**Early Career Travel Award**	
	SIAM Conference on Computational Science and Engineering (February 2017)	
2016–2018	**Luis W. Alvarez Postdoctoral Fellowship**, Lawrence Berkeley National Laboratory	*Berkeley, CA*
	2 year, independent research fellowship	
2016–2018	**Sydney Fernbach Postdoctoral Fellowship**, Lawrence Livermore National Laboratory	*Livermore, CA*
	2 year, independent research fellowship (declined)	
Apr 2015	**Robert J. Melosh Medal Finalist**, Duke University	*Durham, NC*
	Best student paper in finite element analysis	
2013–2016	**Student Travel Award**	
	International Meshing Roundtable (September 2016) ∘ SIAM Conference on Uncertainty Quantification (April 2016) ∘ World Congress on Computational Mechanics XI (July 2014) ∘ International Conference on Spectral and Higher-Order Methods (June 2014) ∘ SIAM Conference on Optimization (May 2014) ∘ San Diego Supercomputing Summer Institute, HPC Workshop (August 2013)	
2011–2015	**Department of Energy Computational Science Graduate Fellowship**	
	4 years - full tuition, stipend, and research allowance	

May 2011	**University Medal Finalist**, University of California, Berkeley	*Berkeley, CA*
	Campus-wide award to most distinguished graduating senior	
May 2011	**Civil Engineering Department Citation**, University of California, Berkeley	*Berkeley, CA*
	Department-wide award to most distinguished student	
Aug 2010	**Best Project Award, 2010 AHPCRC Summer Institute**, Stanford University	*Stanford, CA*
Apr 2010	**Structural Engineers Association of N. California (SEAONC) Scholarship**	
May 2009	**Louise Cooper Endowment**, University of California, Berkeley	*Berkeley, CA*
	Ranked 1st in CEE department	
Aug 2009	**Best Overall Project, 2009 Young Researchers Symposium**	

Publications

Thesis

[1] M. J. Zahr, *Adaptive Model Reduction to Accelerate Optimization Problems Governed by Partial Differential Equations*. PhD thesis, Stanford University, August 2016

Journal Articles (submitted)

[2] A. Shi, P.-O. Persson, and M. J. Zahr, "Implicit shock tracking for unsteady flows by the method of lines," *Journal of Computational Physics*, in review 2021

[3] T. Huang and M. J. Zahr, "A robust, high-order implicit shock tracking method for simulation of complex, high-speed flows," *Journal of Computational Physics*, in review 2021

Journal Articles (in press)

[4] A. Schein, K. T. Carlberg, and M. J. Zahr, "Preserving general physical properties in model reduction of dynamical systems via constrained-optimization projection," *International Journal for Numerical Methods in Engineering*, accepted 2021

Journal Articles (published)

[5] M. J. Zahr and J. M. Powers, "High-order resolution of multidimensional compressible reactive flow using implicit shock tracking," *AIAA Journal*, vol. 59, no. 1, pp. 150–164, 2021

[6] M. Yano, T. Huang, and M. J. Zahr, "A globally convergent method to accelerate topology optimization using on-the-fly model reduction," *Computer Methods in Applied Mechanics and Engineering*, vol. 375, p. 113635, 2021

[7] M. J. Zahr, A. Shi, and P.-O. Persson, "Implicit shock tracking using an optimization-based high-order discontinuous Galerkin method," *Journal of Computational Physics*, vol. 410, p. 109385, 2020

[8] D. Z. Huang, W. Pazner, P.-O. Persson, and M. J. Zahr, "High-order partitioned spectral deferred correction solvers for multiphysics problems," *Journal of Computational Physics*, vol. 412, p. 109441, 2020

[9] H. Gao, J.-X. Wang, and M. J. Zahr, "Non-intrusive model reduction of large-scale, nonlinear dynamical systems using deep learning," *Physica D: Nonlinear Phenomena*, vol. 412, p. 132614, 2020

[10] J. Töger, M. J. Zahr, N. Aristokleous, K. Markenroth Bloch, M. Carlsson, and P.-O. Persson, "Blood flow imaging by optimal matching of computational fluid dynamics to 4D flow data," *Magnetic Resonance in Medicine*, vol. 84, no. 4, pp. 2231–2245, 2020

[11] M. J. Zahr, K. Carlberg, and D. P. Kouri, "An efficient, globally convergent method for optimization under uncertainty using adaptive model reduction and sparse grids," *SIAM/ASA Journal on Uncertainty Quantification*, vol. 7, no. 3, pp. 877–912, 2019

[12] D. Z. Huang, P.-O. Persson, and M. J. Zahr, "High-order, linearly stable, partitioned solvers for general multiphysics problems based on implicit-explicit Runge-Kutta schemes," *Computer Methods in Applied Mechanics and Engineering*, vol. 346, pp. 674 – 706, 2018

[13] M. J. Zahr and P.-O. Persson, "An optimization-based approach for high-order accurate discretization of conservation laws with discontinuous solutions," *Journal of Computational Physics*, vol. 365, pp. 105 – 134, 2018

[14] M. J. Zahr, P. Avery, and C. Farhat, "A multilevel projection-based model order reduction framework for nonlinear dynamic multiscale problems in structural and solid mechanics," *International Journal for Numerical Methods in Engineering*, vol. 112, no. 8, pp. 855–881, 2017

[15] M. J. Zahr and P.-O. Persson, "An adjoint method for a high-order discretization of deforming domain conservation laws for optimization of flow problems," *Journal of Computational Physics*, vol. 326, pp. 516 – 543, 2016

[16] M. J. Zahr, P.-O. Persson, and J. Wilkening, "A fully discrete adjoint method for optimization of flow problems on deforming domains with time-periodicity constraints," *Computers & Fluids*, vol. 139, pp. 130 – 147, 2016

[17] M. J. Zahr and C. Farhat, "Progressive construction of a parametric reduced-order model for PDE-constrained optimization," *International Journal for Numerical Methods in Engineering*, vol. 102, no. 5, pp. 1111–1135, 2015

[18] D. Amsallem, M. J. Zahr, and K. Washabaugh, "Fast local reduced basis updates for the efficient reduction of nonlinear systems with hyper-reduction," *Advances in Computational Mathematics*, pp. 1–44, 2015

[19] D. Amsallem, M. J. Zahr, Y. Choi, and C. Farhat, "Design optimization using hyper-reduced-order models," *Structural and Multidisciplinary Optimization*, pp. 1–22, 2014

[20] D. Amsallem, M. J. Zahr, and C. Farhat, "Nonlinear model order reduction based on local reduced-order bases," *International Journal for Numerical Methods in Engineering*, vol. 92, no. 10, pp. 891–916, 2012

Book Chapters (Invited)

[21] A. Shi, P.-O. Persson, and M. J. Zahr, "High-order implicit shock tracking (HOIST)," in *SEMA-SIMA, In Honor of Oubay Hassan's 60th Birthday*, Springer, 2021

[22] M. J. Zahr and P.-O. Persson, "Energetically optimal flapping wing motions via adjoint-based optimization and high-order discretizations," in *Frontiers in PDE-Constrained Optimization*, Springer, 2018

Conference Papers (Refereed)

[23] M. Mirhoseini and M. J. Zahr, "An optimization approach to solve parametrized conservation laws based on reduced order models," in *Proc. of the AIAA Aviation Forum and Exposition (Aviation 2021)*, (Washington, D.C.), American Institute of Aeronautics and Astronautics, 6/7/2021 – 6/11/2021

[24] C. Naudet and M. J. Zahr, "High-order implicit shock tracking using entropy variables and radial basis functions," in *Proc. of the AIAA Aviation Forum and Exposition (Aviation 2021)*, (Washington, D.C.), American Institute of Aeronautics and Astronautics, 6/7/2021 – 6/11/2021

[25] A. Shi, P.-O. Persson, and M. J. Zahr, "Implicit shock tracking and the method of lines for shock-dominated, unsteady flows," in *Proc. of the AIAA Aviation Forum and Exposition (Aviation 2021)*, (Washington, D.C.), American Institute of Aeronautics and Astronautics, 6/7/2021 – 6/11/2021

[26] T. Huang and M. J. Zahr, "High-order implicit shock tracking for three-dimensional high-speed flows," in *Proc. of the AIAA Aviation Forum and Exposition (Aviation 2021)*, (Washington, D.C.), American Institute of Aeronautics and Astronautics, 6/7/2021 – 6/11/2021

[27] M. J. Zahr and P.-O. Persson, "An r-adaptive, high-order discontinuous Galerkin method for flows with attached shocks," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech2020)*, (Orlando, Florida), American Institute of Aeronautics and Astronautics, 1/6/2020 – 1/10/2020

[28] M. Franco, P.-O. Persson, W. Pazner, and M. J. Zahr, "An adjoint method using fully implicit Runge-Kutta schemes for optimization of flow problems," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech2019)*, (San Diego, California), American Institute of Aeronautics and Astronautics, 1/7/2019 – 1/11/2019

[29] A. Shi, P.-O. Persson, and M. J. Zahr, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking with guaranteed mesh quality," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech2019)*, (San Diego, California), American Institute of Aeronautics and Astronautics, 1/7/2019 – 1/11/2019

[30] D. Z. Huang, P.-O. Persson, and M. J. Zahr, "A high-order partitioned solver for general multiphysics problems and its applications in optimization," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech2019)*, (San Diego, California), American Institute of Aeronautics and Astronautics, 1/7/2019 – 1/11/2019

[31] M. J. Zahr and P.-O. Persson, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech2018)*, (Kissimmee, Florida), American Institute of Aeronautics and Astronautics, 1/8/2018 – 1/12/2018

[32] J. Wang, M. J. Zahr, and P.-O. Persson, "Energetically optimal flapping flight based on a fully discrete adjoint method with explicit treatment of flapping frequency," in *Proc. of the 23rd AIAA Computational Fluid Dynamics Conference*, (Denver, Colorado), American Institute of Aeronautics and Astronautics, 6/5/2017 – 6/9/2017

[33] K. Washabaugh, M. J. Zahr, and C. Farhat, "On the use of discrete nonlinear reduced-order models for the prediction of steady-state flows past parametrically deformed complex geometries," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech 2016)*, (San Diego, California), 1/4/2016 – 1/8/2016

[34] D. De Santis, M. J. Zahr, and C. Farhat, "Gradient-based aerodynamic shape optimization using the FIVER embedded boundary method," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech 2016)*, (San Diego, California), 1/4/2016 – 1/8/2016

[35] M. J. Zahr and P.-O. Persson, "High-order, time-dependent aerodynamic optimization using a discontinuous Galerkin discretization of the Navier-Stokes equations," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech 2016)*, (San Diego, California), 1/4/2016 – 1/8/2016

[36] M. J. Zahr and P.-O. Persson, "Performance tuning of Newton-GMRES methods for discontinuous Galerkin discretizations of the Navier-Stokes equations," in *Proc. of the 21st AIAA Computational Fluid Dynamics Conference*, vol. AIAA-2013-2685, American Institute of Aeronautics and Astronautics, 6/24/2013 – 6/27/2013

[37] M. J. Zahr, D. Amsallem, and C. Farhat, "Construction of parametrically-robust CFD-based reduced-order models for PDE-constrained optimization," in *Proc. of the 21st AIAA Computational Fluid Dynamics Conference*, vol. AIAA-2013-2685, American Institute of Aeronautics and Astronautics, 6/24/2013 – 6/27/2013

[38] K. Washabaugh, D. Amsallem, M. J. Zahr, and C. Farhat, "Nonlinear model reduction for CFD problems using local reduced-order bases," in *Proc. of the 42nd AIAA Fluid Dynamics Conference and Exhibit, Fluid Dynamics and Co-located Conferences*, vol. 2686, 6/25/2012 – 6/28/2012

[39] K. Carlberg, J. Cortial, D. Amsallem, M. J. Zahr, and C. Farhat, "The GNAT nonlinear model reduction method and its application to fluid dynamics problems," in *AIAA Paper 2011-3112, 6th AIAA Theoretical Fluid Mechanics Conference*, (Honolulu, Hawaii), 6/27/2011 – 6/30/2011

[40] D. Amsallem, M. J. Zahr, and C. Farhat, "On the robustness of residual minimization for constructing POD-based reduced-order CFD models," in *Proc. of the 43rd AIAA Fluid Dynamics Conference and Exhibit*, (San Diego, California), 6/27/2011 – 6/30/2011

Technical Reports

[41] M. J. Zahr and S. Govindjee, "Theoretical and numerical foundations for the use of microcolumns as angular motion sensors," tech. rep., University of California, Berkeley, 2011

[42] M. J. Zahr, K. Carlberg, D. Amsallem, and C. Farhat, "Comparison of model reduction techniques on high-fidelity linear and nonlinear electrical, mechanical, and biological systems," tech. rep., University of California, Berkeley, 2010

[43] M. J. Zahr, N. Luco, and H. Ryu, "Mitigation of seismic risk pertaining to non-ductile reinforced concrete buildings using seismic risk maps," tech. rep., United States Geologic Survey (USGS), 2009

Talks

Seminar Presentations (Invited)

○ M. J. Zahr, "Integrating computational physics and numerical optimization to address challenges in computational science, engineering, and medicine," in *Applied and Computational Mathematics and Statistics Seminar, University of Notre Dame (Host: Alan Lindsay)*, (Notre Dame, Indiana), University of Notre Dame, 4/8/2021

○ M. J. Zahr, "Integrating computational physics and numerical optimization to address challenges in computational science, engineering, and medicine," in *Data Sciences Seminar, Johns Hopkins University (Host: Fei Lu)*, (Baltimore, Maryland), Johns Hopkins University, 12/4/2019

○ M. J. Zahr, "Integrated computational physics and numerical optimization," in *Center for Informatics and Computational Science Seminar, Univerity of Notre Dame (Host: Nicholas Zabaras)*, (Notre Dame, Indiana), University of Notre Dame, 3/6/2019

○ M. J. Zahr, "Integrated computational physics and numerical optimization," in *Program in Applied Mathematics Colloquium, University of Arizona (Host: Matthias Morzfeld)*, (Tuscon, Arizona), University of Arizona, 9/21/2018

○ M. J. Zahr, "Integrated computational physics and numerical optimization," in *Applied Mathematics Seminar, UC Berkeley (Host: Per-Olof Persson)*, (Berkeley, California), University of California, Berkeley, 9/6/2018

○ M. J. Zahr, "Optimization-based computational physics and high-order methods: from optimized analysis to design and data assimilation," in *Aerospace and Ocean Engineering Seminar, Virginia Tech (Host: Kevin Wang)*, (Blacksburg, Virginia), Virginia Polytechnic Institute and State University, 4/2/2018

○ M. J. Zahr, "Gradient-based optimization of flow problems using the adjoint method and high-order numerical discretizations," in *Applied, Computational, and Industrial Math Seminar Series*, (San Jose, California), San Jose State University, 5/8/2017

○ M. J. Zahr and P.-O. Persson, "Optimization of CFD simulations, with MRI applications," in *TESLA Seminar (Host: Johannes Töger)*, (Lund, Sweden), Lund University, 3/31/2017

○ M. J. Zahr, "Adaptive model reduction to accelerate optimization problems governed by partial differential equations," in *Farhat Research Group Seminar*, (Stanford, California), Stanford University, 1/10/2017

○ M. J. Zahr, "Adaptive model reduction to accelerate optimization problems governed by partial differential equations," in *LBNL Postdoc Seminar Series*, (Berkeley, California), Lawrence Berkeley National Laboratory, 1/9/2017

- M. J. Zahr, "Efficient PDE-constrained optimization under uncertainty using adaptive model reduction and sparse grids," in *CME 500 Seminar*, (Stanford, California), Stanford University, 4/11/2016

- M. J. Zahr, "Accelerating PDE-constrained optimization problems using adaptive reduced-order models," in *University of Notre Dame Aerospace and Mechanical Engineering Seminar (Host: Gretar Tryggvason)*, (South Bend, Indiana), University of Notre Dame, 3/3/2016 – 3/4/2016

- M. J. Zahr, "Accelerating PDE-constrained optimization problems using adaptive reduced-order models," in *University of Southern California Aerospace and Mechanical Engineering Seminar (Host: Geoff Spedding)*, (Los Angeles, California), University of Southern California, 2/25/2016 – 2/26/2017

- M. J. Zahr, "Accelerating PDE-constrained optimization problems using adaptive reduced-order models," in *Luis W. Alvarez Fellowship Seminar (Host: Jonathan Carter)*, (Berkeley, California), Lawrence Berkeley National Laboratory, 2/9/2016

- M. J. Zahr, "Accelerating PDE-constrained optimization problems using adaptive reduced-order models," in *J. H. Wilkinson Fellowship Seminar (Host: Sven Leyffer)*, (Argonne, Illinois), Argonne National Laboratory, 1/15/2016

- M. J. Zahr, "Accelerating PDE-constrained optimization problems using adaptive reduced-order models," in *John von Neumann Postdoctoral Fellowship Seminar (Host: Denis Ridzal)*, (Albuquerque, New Mexico), Sandia National Laboratories, 1/11/2016

- M. J. Zahr and P.-O. Persson, "High-order methods for optimization and control of conservation laws on deforming domains," in *Dean Seminar at Sandia National Laboratories (Host: Kevin Carlberg)*, (Livermore, California), 12/14/2015

- M. J. Zahr, "Accelerating PDE-constrained optimization problems using adaptive reduced-order models," in *Sidney Fernbach Postdoctoral Fellowship Seminar (Host: Jeffrey A. F. Hittinger)*, (Livermore, California), Lawrence Livermore National Laboratory, 12/9/2015

- M. J. Zahr, "High-order methods for optimization and control of conservation laws on deforming domains," in *Farhat Research Group Seminar*, (Stanford, California), Stanford University, 12/8/2015

- M. J. Zahr and P.-O. Persson, "High-order methods for optimization and control of conservation laws on deforming domains," in *Applied Mathematics Seminar at UC Berkeley (Host: Per-Olof Persson)*, (Berkeley, California), 9/30/2015

- M. J. Zahr and C. Farhat, "Accelerating PDE-constrained optimization using adaptive reduced-order models," in *Seminar at Sandia National Laboratories (Host: Drew Kouri)*, (Albuquerque, New Mexico), 7/8/2015

- M. J. Zahr, "Accelerating PDE-constrained optimization using adaptive reduced-order models: application to topology optimization," in *Robert J. Melosh Medal Competition*, (Durham, North Carolina), Duke University, 4/24/2015

Workshop Presentations (Invited)

- M. J. Zahr, "Efficient PDE-constrained optimization under uncertainty using adaptive model reduction and sparse grids," in *2017 West Coast ROM Workshop*, (Berkeley, California), Lawrence Berkeley National Laboratory, 11/17/2017

- M. J. Zahr, "Efficient PDE-constrained optimization under uncertainty using adaptive model reduction and sparse grids," in *BIRS Workshop: Data-Driven Methods for ROMs and Stochastic PDEs*, (Banff, Alberta, Canada), Banff International Reseach Station, 1/30/2017 – 2/3/2017

- M. J. Zahr and C. Farhat, "A nonlinear trust-region framework for PDE-constrained optimization using adaptive model reduction," in *West Coast ROM Workshop*, (Livermore, California), Sandia National Laboratories, 11/19/2015

- M. J. Zahr and C. Farhat, "Accelerating PDE-constrained optimization using progressively constructed reduced-order models," in *Bay Area ROM Workshop*, (Livermore, California), Sandia National Laboratories, 8/8/2014

Conference Presentations and Other Talks (Invited)

- M. Mirhoseini and M. J. Zahr, "Model reduction of convection-dominated flows using implicit tracking," in *SIAM Conference on Computational Science and Engineering*, (Fort Worth, Texas), 3/1/2021 – 3/5/2021

- D. Z. Huang, P.-O. Persson, and M. J. Zahr, "High-order partitioned spectral deferred correction solvers for multiphysics problems," in *SIAM Conference on Computational Science and Engineering*, (Fort Worth, Texas), 3/1/2021 – 3/5/2021

- T. Wen and M. J. Zahr, "A globally convergent method to accelerate PDE-constrained optimization using on-the-fly model reduction," in *SIAM Conference on Computational Science and Engineering*, (Fort Worth, Texas), 3/1/2021 – 3/5/2021

- A. Shi, P.-O. Persson, and M. J. Zahr, "Implicit shock tracking and the method of lines for shock-dominated, unsteady flows," in *SIAM Conference on Computational Science and Engineering*, (Fort Worth, Texas), 3/1/2021 – 3/5/2021

- T. Huang, C. Naudet, and M. J. Zahr, "Robust high-order implicit shock tracking solver for complex high-speed flows," in *SIAM Conference on Computational Science and Engineering*, (Fort Worth, Texas), 3/1/2021 – 3/5/2021

- M. J. Zahr, "High-resolution visualization of in vivo blood flow from low-resolution 4D flow MRI scans using computational fluid dynamics and optimization," in *SIAM Conference on Parallel Processing for Scientific Computing (PP20)*, (Seattle, Washington), 2/12/2020 – 2/15/2020

- M. J. Zahr and P.-O. Persson, "An optimization-based discontinuous Galerkin approach for high-order shock tracking," in *SIAM Conference on Computational Science and Engineering*, (Spokane, Washington), 2/25/2019 – 3/1/2019

- R. Baraldi, M. Morzfeld, and M. J. Zahr, "An acceleration framework for parameter estimation using implicit sampling and adaptive reduced-order models," in *SIAM Conference on Computational Science and Engineering*, (Spokane, Washington), 2/25/2019 – 3/1/2019

- M. J. Zahr, K. Carlberg, and D. P. Kouri, "Efficient PDE-constrained optimization under uncertainty using adaptive model reduction and sparse grids," in *SIAM Conference on Computational Science and Engineering*, (Spokane, Washington), 2/25/2019 – 3/1/2019

- M. J. Zahr, K. Carlberg, and D. P. Kouri, "Efficient PDE-constrained optimization under uncertainty using adaptive model reduction and sparse grids," in *SIAM Conference on Uncertainty Quantification*, (Garden Grove, California), 4/16/2018 – 4/19/2018

- M. J. Zahr, K. Carlberg, and D. P. Kouri, "Efficient PDE-constrained optimization under uncertainty using adaptive model reduction and sparse grids," in *SIAM Conference on Computational Science and Engineering*, (Atlanta, Georgia), 2/27/2017 – 3/3/2017

- M. J. Zahr, K. Carlberg, and D. P. Kouri, "Efficient PDE-constrained optimization under uncertainty using adaptive model reduction and sparse grids," in *SIAM Annual Meeting*, (Boston, Massachusetts), 7/11/2016 – 7/15/2016

- M. J. Zahr, K. Carlberg, and D. P. Kouri, "Adaptive stochastic collocation for PDE-constrained optimization under uncertainty using sparse grids and model reduction," in *SIAM Conference on Uncertainty Quantification*, (Lausanne, Switzerland), Ecole Polytechnique Federale de Lausanne, 4/5/2016 – 4/8/2016

- M. J. Zahr, "High-order, time-dependent PDE-constrained optimization using discontinuous Galerkin methods," in *Department of Energy Computational Science Graduate Fellowship Program Review*, (Washington D.C.), 7/27/2015 – 7/30/2015

- M. J. Zahr and C. Farhat, "A nonlinear trust-region framework for PDE-constrained optimization using progressively constructed reduced-order models," in *2015 SIAM Conference on Computational Science and Engineering (CSE15)*, (Salt Lake City, Utah), 3/14/2015 – 3/18/2015

- M. J. Zahr, K. Washabaugh, and C. Farhat, "Robust reduced-order models via fast, low-rank basis updates," in *2014 SIAM Annual Meeting*, (Chicago, Illinois), 7/7/2014 – 7/11/2014

- M. J. Zahr and C. Farhat, "Efficient, parametrically robust nonlinear model reduction using local reduced-order bases," in *2013 SIAM Conference on Computational Science and Engineering (CSE13)*, (Boston, Massachusetts), 2/25/2013 – 3/1/2013

- D. Amsallem, K. Washabaugh, M. J. Zahr, and C. Farhat, "Efficient nonlinear model reduction approach using local reduced bases and hyper-reduction," in *2013 SIAM Conference on Computational Science and Engineering (CSE13)*, (Boston, Massachusetts), 2/25/2013 – 3/1/2013

Seminar Presentations (Contributed)
- M. J. Zahr, "Optimization-based computational physics and high-order methods: from optimized analysis to design and data assimilation," in *LBNL CRD Postdoc Seminar Series*, (Berkeley, California), Lawrence Berkeley National Laboratory, 9/18/2017

Workshop Presentations (Contributed)
- M. J. Zahr and P.-O. Persson, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking," in *5th International Workshop on High-Order CFD Methods*, (Kissimmee, Florida), 1/8/2018 – 1/12/2018

Conference Presentations and Other Talks (Contributed)
- A. Schein, K. Carlberg, M. J. Zahr, and M. W. Gee, "An optimization-based formulation for equality and inequality constrained reduced-order modeling," in *World Congress on Computational Mechanics XIV (WCCM XIV) and European Community on Computational Methods in Applied Sciences (ECCOMAS) Congress 2020*, (Paris, France), 1/11/2021 – 1/15/2021

- M. J. Zahr and P.-O. Persson, "An r-adaptive, high-order discontinuous Galerkin method for flows with attached shocks," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech2020)*, (Orlando, Florida), American Institute of Aeronautics and Astronautics, 1/6/2020 – 1/10/2020

- M. J. Zahr, "An optimization-based approach for the reduction of conservation laws with parametrized discontinuities," in *15th U.S. National Congress on Computational Mechanics (USNCCM15)*, (Austin, Texas), 7/28/2019 – 8/2/2019

- M. J. Zahr and P.-O. Persson, "An optimization-based approach for high-order accurate discretization of conservation laws with discontinuous solutions," in *15th U.S. National Congress on Computational Mechanics (USNCCM15)*, (Austin, Texas), 7/28/2019 – 8/2/2019

- P.-O. Persson, D. Z. Huang, and M. J. Zahr, "High-order partitioned solvers and fully discrete adjoints for multiphysics problems," in *15th U.S. National Congress on Computational Mechanics (USNCCM15)*, (Austin, Texas), 7/28/2019 – 8/2/2019

- M. J. Zahr and P.-O. Persson, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking," in *North American High Order Methods Conference (NAHOMCon)*, (San Diego, California), 6/2/2019 – 6/5/2019

- M. J. Zahr and P.-O. Persson, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking," in *Finite Elements in Fluids*, (Chicago, Illinois), 3/31/2019 – 4/3/2019

- M. Franco, P.-O. Persson, W. Pazner, and M. J. Zahr, "An adjoint method using fully implicit Runge-Kutta schemes for optimization of flow problems," in *AIAA Science and Technology Forum and Exposition (SciTech2019)*, (San Diego, California), 1/7/2019 – 1/11/2019

- A. Shi, P.-O. Persson, and M. J. Zahr, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking with guaranteed mesh quality," in *Proc. of the AIAA Science and Technology Forum and Exposition (SciTech2019)*, (San Diego, California), American Institute of Aeronautics and Astronautics, 1/7/2019 – 1/11/2019

- D. Z. Huang, P.-O. Persson, and M. J. Zahr, "A high-order partitioned solver for general multiphysics problems and its applications in optimization," in *AIAA Science and Technology Forum and Exposition (SciTech2019)*, (San Diego, California), 1/7/2019 – 1/11/2019

- M. J. Zahr and P.-O. Persson, "An optimization-based discontinuous galerkin approach for high-order accurate shock tracking," in *6th European Conference on Computational Mechanics (ECCM 6) and 7th European Conference on Computational Fluid Dynamics (ECFD 7)*, (Glasgow, Scotland, United Kingdom), 6/11/2018 – 6/15/2018

- M. J. Zahr and P.-O. Persson, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking," in *AIAA Science and Technology Forum and Exposition (SciTech2018)*, (Kissimmee, Florida), American Institute of Aeronautics and Astronautics, 1/8/2018 – 1/12/2018

- M. J. Zahr and P.-O. Persson, "Adjoint-based optimization of time-dependent fluid-structure systems using a high-order discontinuous Galerkin discretization," in *14th U.S. National Congress on Computational Mechanics (USNCCM14)*, (Montreal, Quebec, Canada), 7/17/2017 – 7/20/2017

- M. J. Zahr and P.-O. Persson, "Adjoint-based optimization of time-dependent fluid-structure systems using a high-order discontinuous Galerkin discretization," in *VII International Conference on Coupled Problems in Science and Engineering*, (Rhodes Island, Greece), 6/12/2017 – 6/14/2017

- J. Wang, M. J. Zahr, and P.-O. Persson, "Energetically optimal flapping flight based on a fully discrete adjoint method with explicit treatment of flapping frequency," in *23rd AIAA Computational Fluid Dynamics Conference*, (Denver, Colorado), 6/5/2017 – 6/9/2017

- M. J. Zahr, "Adjoint-based PDE-constrained optimization using globally high-order numerical discretizations," in *2017 Berkeley/Stanford Computational Mechanics Festival (CompFest)*, (Berkeley, California), University of California, Berkeley, 5/8/2017

- M. J. Zahr and P.-O. Persson, "Adjoint-based optimization of time-dependent fluid-structure systems using a high-order discontinuous Galerkin discretization," in *IACM 19th International Conference on Finite Element in Flow Problems (FEF)*, (Rome, Italy), 4/5/2017 – 4/7/2017

- M. J. Zahr and P.-O. Persson, "Adjoint-based optimization of time-dependent fluid-structure systems using a high-order discontinuous Galerkin discretization," in *European Workshop on High Order Nonlinear Numerical Methods for Evolutionary PDEs: Theory and Applications*, (Stuttgart, Germany), University of Stuttgart, 3/27/2017 – 3/31/2017

- M. J. Zahr, "Adaptive model reduction to accelerate optimization problems governed by partial differential equations," in *Thesis Defense*, (Stanford, California), Stanford University, 8/3/2016

- M. J. Zahr and P.-O. Persson, "High-order, time-dependent aerodynamic optimization using a discontinuous Galerkin discretization of the Navier-Stokes equations," in *AIAA Science and Technology Forum and Exposition (SciTech 2016)*, (San Diego, California), 1/4/2016 – 1/8/2016

- K. Washabaugh, M. J. Zahr, and C. Farhat, "On the use of discrete nonlinear reduced-order models for the prediction of steady-state flows past parametrically deformed complex geometries," in *AIAA Science and Technology Forum and Exposition (SciTech 2016)*, (San Diego, California), 1/4/2016 – 1/8/2016

- D. De Santis, M. J. Zahr, and C. Farhat, "Gradient-based aerodynamic shape optimization using the FIVER embedded boundary method," in *AIAA Science and Technology Forum and Exposition (SciTech 2016)*, (San Diego, California), 1/4/2016 – 1/8/2016

- M. J. Zahr and P.-O. Persson, "Unsteady CFD optimization using high-order discontinuous Galerkin finite element methods," in *13th U.S. National Congress on Computational Mechanics (USNCCM13)*, (San Diego, California), 7/26/2015 – 7/30/2015

- M. J. Zahr and C. Farhat, "PDE-constrained optimization using progressively constructed reduced-order models," in *World Congress on Computational Mechanics XI (WCCM XI)*, (Barcelona, Spain), 7/20/2014 – 7/25/2014

- M. J. Zahr and P.-O. Persson, "Hyperreduced models for discontinuous Galerkin finite element methods," in *International Conference on Spectral and High Order Methods (ICOSAHOM)*, (Salt Lake City, Utah), 6/23/2014 – 6/27/2014

- M. J. Zahr and C. Farhat, "Rapid nonlinear topology optimization using precomputed reduced-order models," in *17th US National Congress on Theoretical and Applied Mechanics (USNCTAM)*, (East Lansing, Michigan), 6/15/2014 – 6/20/2014

- M. J. Zahr and C. Farhat, "PDE-constrained optimization using hyper-reduced models," in *SIAM Conference on Optimization*, (San Diego, California), 5/19/2014 – 5/22/2014

- M. J. Zahr, "Rapid topology optimization using reduced-order models," in *2013 Berkeley/Stanford Computational Mechanics Festival (CompFest)*, (Berkeley, California), University of California, Berkeley, 10/19/2013

- M. J. Zahr and C. Farhat, "Rapid nonlinear topology optimization using reduced-order models," in *12th U.S. National Congress on Computational Mechanics (USNCCM12)*, (Raleigh, North Carolina), 7/22/2013 – 7/25/2013

- M. J. Zahr, D. Amsallem, and C. Farhat, "Construction of parametrically robust CFD-based reduced-order models for PDE-constrained optimization," in *43rd AIAA Fluid Dynamics Conference and Exhibit*, (San Diego, California), 6/24/2013 – 6/27/2013

- M. J. Zahr and P.-O. Persson, "Performance tuning of Newton-GMRES methods for discontinuous Galerkin discretizations of the Navier-Stokes equations," in *43rd AIAA Fluid Dynamics Conference and Exhibit*, (San Diego, California), 6/24/2013 – 6/27/2013

- M. J. Zahr and C. Farhat, "Construction of parametrically robust reduced-order models for PDE-constrained optimization," in *10th World Congress on Structural and Multidisciplinary Optimization (WCSMO10)*, (Orlando, Florida), 3/19/2013 – 3/24/2013

- D. Amsallem, M. J. Zahr, Y. Choi, and C. Farhat, "Design optimization using hyper-reduced order models," in *10th World Congress on Structural and Multidisciplinary Optimization (WCSMO10)*, (Orlando, Florida), 3/19/2013 – 3/24/2013

- D. Amsallem, M. J. Zahr, and C. Farhat, "Nonlinear model order reduction with local reduced-order bases for hyper-reduction," in *Proceedings of the 2012 European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS)*, (Vienna, Austria), 9/10/2012 – 9/14/2012

- D. Amsallem, C. Farhat, and M. J. Zahr, "Real-time CFD-based fluid-structure predictions using a database of parameterized reduced-order models," in *10th World Congress on Computational Mechanics (WCCM X)*, (Sao Paolo, Brazil), 7/8/2012 – 7/13/2012

Poster Presentations

- T. Huang, C. Naudet, and M. J. Zahr, "High-order implicit shock tracking for high-speed flows," in *SIAM Conference on Computational Science and Engineering*, (Fort Worth, Texas), 3/1/2021 – 3/5/2021

- J. Wang and M. J. Zahr, "A topology optimization method with high order level-set based boundary tracking mesh," in *Topology Optimization Roundtable*, (Albuquerque, New Mexico), 3/10/2019 – 3/13/2019

- A. Kiran, M. J. Zahr, and P.-O. Persson, "An optimization-based discontinuous Galerkin approach for high-order accurate shock tracking," in *LBNL Summer Student Program Poster Session*, (Berkeley, California), 8/2/2018

- M. J. Zahr and P.-O. Persson, "Adjoint-based optimization, uncertainty quantification, and data assimilation of multiphysics systems using high-order numerical discretizations," in *DOE ASCR Applied Mathematics PI Meeting*, (Washington D.C.), 9/11/2017 – 9/12/2017

- M. J. Zahr, "Efficient PDE-constrained optimization using adaptive model reduction," in *Institute for Mathematics and its Applications: Frontiers in PDE-Constrained Optimization*, (Minneapolis, Minnesota), 6/6/2016 – 6/10/2016

- M. J. Zahr, "Efficient PDE-constrained optimization using adaptive model reduction," in *2016 Stanford Computational Mathematics and Engineering Affiliates Meeting*, (Stanford, California), 5/1/2016

- M. J. Zahr, "Efficient PDE-constrained optimization using adaptive model reduction," in *2016 Stanford Aerospace and Astronautics Affiliates Meeting*, (Stanford, California), 4/26/2016

- M. J. Zahr and C. Farhat, "Accelerating PDE-constrained optimization using adaptive reduced-order models," in *Army High Performance Computing Research Center (AHPCRC) Review Meeting*, (Santa Cruz, California), 1/18/2016 – 1/20/2016

- M. J. Zahr, P. Avery, and C. Farhat, "A hyperreduced FE^2 method for real-time multiscale simulations," in *Army High Performance Computing Research Center (AHPCRC) Review Meeting*, (Santa Cruz, California), 1/18/2016 – 1/20/2016

- M. J. Zahr and C. Farhat, "Accelerating PDE-constrained optimization using progressively-constructed reduced-order models," in *Army High Performance Computing Research Center (AHPCRC) Review Meeting*, (Santa Cruz, California), 8/10/2015 – 8/12/2016

- M. J. Zahr and P.-O. Persson, "Unsteady PDE-constrained optimization using high-order DG-FEM," in *13th U.S. National Congress on Computational Mechanics (USNCCM13)*, (San Diego, California), 7/26/2015 – 7/30/2015

- M. J. Zahr and C. Farhat, "Progressive construction of a parametric reduced-order model for PDE-constrained optimization," in *2014 DOE CSGF Annual Program Review*, (Washington D.C.), 7/14/2014 – 7/17/2014

- M. J. Zahr, "PDE-constrained optimization using progressively constructed reduced-order models," in *2014 Stanford Aerospace and Astronautics Affiliates Meeting*, (Stanford, California), 4/28/2014

- M. J. Zahr and C. Farhat, "Rapid topology optimization using reduced-order models," in *2013 DOE CSGF Annual Program Review*, (Washington D.C.), 7/25/2013 – 7/27/2013

- M. J. Zahr and C. Farhat, "Rapid structural shape optimization using progressively constructed reduced-order models," in *12th U.S. National Congress on Computational Mechanics (USNCCM12)*, (Raleigh, North Carolina), 7/22/2013 – 7/25/2013

- M. J. Zahr and C. Farhat, "Design of fluid mechanical systems using reduced-order models," in *2012 DOE CSGF Annual Program Review*, (Washington D.C.), 7/26/2012 – 7/28/2012

Grants & Funding

Active Research Grants

2021–2026 *A robust multi-disciplinary design analysis and optimization framework for hypersonic systems grounded in model hyperreduction*, Multidisciplinary University Research Initiative, Air Force Office of Scientific Research, Co-Principal Investigator (with C. Farhat (PI), Stanford University; J. Alonso, Stanford University; G. Candler, University of Minnesota; M. Hemati, University of Minnesota; M. Heinkenschloss, Rice University), $7.5M (ND: $750k), 5 years

2020–2023 *Adaptive, data-driven model reduction and machine learning to enable high-fidelity, many-query computational physics*, FA9550-20-1-0236, Young Investigator Program, Air Force Office of Scientific Research, Principal Investigator, $450k, 3 years

Completed Research Grants

2016–2018 *Enabling Extreme-Scale Many-Query Computational Physics: An adaptive framework for optimization and uncertainty quantification of multiphysics applications*, Laboratory Directed Research and Development, Lawrence Berkeley National Laboratory, Principal Investigator, $232.5k, 2 years

Completed Education Grants

2016–2017 *Advanced MATLAB programming for scientific computing*, Development of Massively Open Online Course (MOOC), MathWorks, Principal Investigator (with N. Henderson, Stanford University), $40k, 1 year

Research Mentoring

Ph.D. Students Supervised (Formal Advisees)

Students formally (co-)advised and funded by MJZ

2021–pres **Victor Zucatti da Silva**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project: Model reduction of convection-dominated flows using implicit tracking.

2021–pres **Ashish Nair**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project: Solid-fuel ramjet combustion submodel development and validation.

2020–pres **Charles Naudet**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project: High-order implicit shock tracking.

2019–pres **Tianci Huang**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project 1: A globally convergent method to accelerate topology optimization using on-the-fly model reduction. Project 2: Robust implicit shock tracking solvers based on pseudo-transient continuation and vanishing viscosity.

| 2019–pres | **Tianshu Wen**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project: Adaptive model reduction to accelerate optimization problems governed by partial differential equations. |
| 2018–pres | **Marzieh Mirhoseini**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project: Model reduction of convection-dominated flows using implicit tracking. |

Ph.D. Students Supervised (Informal Advisees)

Students that work closely with MJZ (attend group meetings, weekly one-on-one meetings, first-author publications)

2021–pres	**Luning Sun**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project: High-order implicit shock tracking.
2019–pres	**Han Gao**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project 1: Non-intrusive nonlinear model reduction using deep neural networks. Project 2: Finite element-based discretizations with global and local basis functions.
2018–pres	**Andrew Shi**, *Mathematics, University of California, Berkeley*. Project: Implicit shock tracking and the method of lines for shock-dominated, unsteady flows.
2017–2019	**Jingyi Wang**, *Mechanical Engineering, University of California, Berkeley*. Project 1: Energetically optimal flapping flight based on a fully discrete adjoint method with explicit treatment of flapping frequency. Project 2: High-order topology optimization.

Other Graduate Students

2020–pres	**Fritiof Hegardt**, *Engineering, Lund University*. Project: Simulation-based imaging: blood flow imaging by optimally matching CFD to 4D flow data.
2019–pres	**Alexander Schein**, *Mechanics & High Performance Computing, Technische Universität Müchen*. Project: An optimization-based formulation for constrained model reduction.
2018–2019	**Robert Baraldi**, *Applied Mathematics, University of Washington*. Department of Energy Computational Science Graduate Fellowship (DOE CSGF) Practicum. Project: Efficient Bayesian inversion using adaptive model reduction and sparse grids.
2017–2019	**Daniel Zhengyu Huang**, *Computational and Mathematical Engineering, Stanford University*. Project: A high-order partitioned solver for general multiphysics problems.
Smr 2018	**Aditya Kiran**, *Mathematics, University of South Carolina*. National Science Foundation Mathematical Sciences Graduate Internship (NSF-MSGI). Project: High-order implicit shock tracking.
Aut 2018	**Anran Lu**, *Computational and Mathematical Engineering, Stanford University*. Project: An optimization-based formulation for constrained model reduction.
Aut 2018	**Yiwen Guo**, *Computational and Mathematical Engineering, Stanford University*. Project: An optimization-based formulation for constrained model reduction.
Smr 2018	**Michael Franco**, *Mathematics, University of California, Berkeley*. Project: Fully discrete adjoint method for fully implicit, stage-parallel Runge-Kutta schemes.
Spr 2018	**Kexin Yu**, *Computational and Mathematical Engineering, Stanford University*. Project: Implementation and study of hyperreduction methods for nonlinear model reduction with pyMORTestbed.
2018	**Remmelt Ammerlaan**, *Computational and Mathematical Engineering, Stanford University*. Project 1: Implementation and study of hyperreduction methods for nonlinear model reduction with pyMORTestbed. Project 2: An optimization-based formulation for constrained model reduction.
Spr 2016	**Gabriele Boncoraglio**, *Aeronautics and Astronautics, Stanford University*. Project: Accelerating PDE-constrained optimization with partially converged solutions and model reduction.
Aut 2015	**Christina White**, *Mechanical Engineering, Stanford University*. Project: Machine learning algorithms in model order reduction.

Undergraduate Students

2019–2020	**Charles Naudet**, *Aerospace and Mechanical Engineering, University of Notre Dame*. Project: Simulation-based imaging: blood flow imaging by optimally matching CFD to 4D flow data.
Smr 2019	**Tung Nguyen**, *Mathematics, Wabash College*. Project: Design optimization of cardiovascular stents.
Smr 2015	**Fredrick Earnest**, *Mechanical and Aerospace Engineering, New Mexico State University*. Undergraduate Research Intern, Army High Performance Computing Research Center, Stanford University. Project: Projection-based model order reduction for nonlinearly constrained contact.
Smr 2014	**Joseph Graff**, *Mechanical and Aerospace Engineering, New Mexico State University*. Undergraduate Research Intern, Army High Performance Computing Research Center, Stanford University. Project: Automated mesh generation and validation for CFD analysis and shape optimization.

Smr 2014	**Zach Nevills**, *Mechanical Engineering, Stanford University*. Undergraduate Research Intern, Army High Performance Computing Research Center, Stanford University. Project: Automated mesh generation and validation for CFD analysis and shape optimization.
Smr 2014	**Harry Pham**, *Mechanical Engineering, Stanford University*. Undergraduate Research Intern, Army High Performance Computing Research Center, Stanford University. Project: Implementation of an aeroelastic shape optimization driver. *Award*: 2nd Place, Best Project Award.

Candidacy Exam Committee Member

2021	**Zhuogang Peng**, *Aerospace and Mechanical Engineering, University of Notre Dame*.
2020	**Michael Vander Wal**, *Aerospace and Mechanical Engineering, University of Notre Dame*.
2020	**Navid Shervani-Tabar**, *Aerospace and Mechanical Engineering, University of Notre Dame*.
2019	**Di Zhou**, *Aerospace and Mechanical Engineering, University of Notre Dame*.

Masters Thesis Committee Member

2021	**Andrew Volchko**, *Aerospace and Mechanical Engineering, University of Notre Dame*.

Teaching

Legend: †course designed or substantially renovated

University of Notre Dame

Aut 2020	†**Advanced Numerical Methods (AME 60714)**, University of Notre Dame
	Theory and implementation of advanced numerical methods to solve and optimize linear and nonlinear partial differential equations (PDEs) with particular emphasis on hyperbolic PDEs and (compressible) computational fluid dynamics. Topcs include: hyperbolic PDE theory, discontinuous Galerkin methods, Arbitrary Lagrangian-Eulerian (ALE) formulation for PDEs on moving domains, PDE-constrained optimization, and model reduction. ○ *Enrollment*: 12 (Aut 2020)

Spr 2020	†**Finite Element Methods (AME 40541/60541)**, University of Notre Dame
Spr 2021	An introduction to the fundamental concepts of linear and nonlinear finite element methods with applications to structural analysis, heat flow, fluid mechanics, and multiphysics problems. This is a combined undergraduate (AME40541) and graduate (AME60541) course (formerly AME50541). ○ *Enrollment*: 27 (Spr 2020), 29 (Spr 2021) ○ *Course website*: http://mjzahr.github.io/teach-nd-ame40541-spr21.html

Spr 2019	†**Finite Element Methods (AME 50541)**, University of Notre Dame
	An introduction to the fundamental concepts of linear and nonlinear finite element methods with applications to structural analysis, heat flow, fluid mechanics, and multiphysics problems. ○ *Enrollment*: 17 (Spr 2019) ○ *Course website*: http://mjzahr.github.io/teach-nd-ame50541-spr19.html

Stanford University

Spr 2017	**Model Reduction (CME 345)**, Stanford University
	Basic mathematical theory for projection-based model reduction. Topics include: linear dynamical systems; projection-based model reduction; error analysis; proper orthogonal decomposition; balanced truncation; moment matching methods based on Krylov subspaces; nonlinear model reduction. ○ *Enrollment*: 17 (Spr 2017) ○ *Course website*: http://mjzahr.github.io/teach-stanford-cme345-spr17.html

Spr 2014	†**Advanced MATLAB for Scientific Computing (CME 292)**, Stanford University
Aut 2014	(1 unit, half term) Advanced MATLAB programming: advanced syntax, publication-quality graphics, numerical lin-
Spr 2015	ear algebra and optimization, object-oriented programming, file manipulation and system interaction, C/MATLAB interface through MEX, MATLAB Coder, toolboxes (symbolic, parallel, PDE). ○ *Enrollment*: 11 (Spr 2014), 6 (Aut 2014), 16 (Spr 2015) ○ *Award*: Received $40k grant from MathWorks to convert course into MOOC ○ *Course website*: http://mjzahr.github.io/teach-stanford-cme292-spr15.html

Smr 2013	**Classical Solutions to Partial Differential Equations (CME 001)**, Stanford University
	Refresher course intended to prepare first year ICME for upcoming coursework and qualifying exams ○ *Enrollment*: 30 (Smr 2013) ○ *Course website*: http://mjzahr.github.io/teach-stanford-cme001-smr13.html

Professional Activities

Workshop Organization

2017 West Coast ROM Workshop, *Lawrence Berkeley National Laboratory*. Organizers: K. Carlberg, M.J. Zahr. November 17, 2017. http://math.lbl.gov/~mjzahr/wcrw2017/.

6th International Workshop on High Order CFD Methods - Test Cases with Shocks, *American Institute of Aeronautics and Astronautics Science and Technology Forum and Exposition 2022 (AIAA Scitech 2022)*. Organizers: T. Fisher, A. Corrigan, M.J. Zahr, C. Kim. January 02, 2022.

Minisymposium Organization

W. Pazner, P. Persson, M.J. Zahr, "MS26: Fluid applications of high-order finite element methods," International Conference on Spectral and High Order Methods (ICOSAHOM) 2021, Vienna, Austria, July 6 – July 10, 2021

Y. Choi, M. Yano, M.J. Zahr, "MS311: Model reduction for computational physics," 16th U.S. National Congress on Computational Mechanics, Chicago, Illinois, July 25 – 29, 2021

M.J. Zahr, A. Corrigan, A. Kercher, "MS33: Advances in high-order methods for high-speed flows," SIAM Conference on Computational Science and Engineering, Fort Worth, Texas, March 1 – 5, 2021

M.J. Zahr, W. Pazner, P. Persson, "MS365: High-order discontinuous Galerkin and finite element methods for CFD," SIAM Conference on Computational Science and Engineering, Spokane, Washington, February 25 – March 1, 2019

Y. Choi, M. Yano, M.J. Zahr, "MS1001: Model order reduction for computational continuum mechanics," 15th U.S. National Congress on Computational Mechanics, Austin, Texas, July 28 – August 1, 2019

F. Chinesta, E. Cueto, C. Farhat, M.J. Zahr, "Model reduction, big data, and dynamic data-driven systems," World Congress on Computational Mechanics XIII (WCCM XIII), New York City, New York, July 22 – 27, 2018

F. Chinesta, E. Cueto, C. Farhat, M.J. Zahr, "Model reduction, big data, and dynamic data-driven systems," 6th European Conference on Computational Mechanics, 7th European Conference on Computational Fluid Dynamics, Glasgow, Scotland, United Kingdom, June 11 – 15, 2018

A. Manzoni, M.J. Zahr, "MS145: Reduced order modeling techniques in large scale and data-driven PDE problems," SIAM Conference on Computational Science and Engineering, Atlanta, Georgia, February 27 – March 3, 2017

Seminar Organization

Applied Mathematics Seminar, *Lawrence Berkeley National Laboratory, University of California, Berkeley*. Organizers: M.J. Zahr, L. Lin, P. Persson. Aut 2017, Spr 2018, Aut 2018. http://math.lbl.gov/ams.

Journal and Book Chapter Referee

Aerospace Science and Technology (AESTE) · American Institute of Astronautics and Aeronautics Journal (AIAAJ) · Annual Reviews in Control (ARC) · Communications in Applied Mathematics and Computational Science (CAMCS) · Communications in Computational Physics (CiCP) · Computational Mechanics (CM) · Computer Methods in Applied Mechanics and Engineering (CMAME) · Computers & Fluids (CAF) · International Journal for Numerical Methods in Engineering (IJNME) · International Journal for Numerical Methods in Fluids (IJNMF) · International Journal of Mathematics and Mathematical Sciences (IJMMS) · Journal of Aerospace Engineering (JAE) · Journal of Computational Physics (JCP) · Journal of Computational Science (JCS) · Journal of Computational and Applied Mathematics (JCAM) · Journal of Scientific Computing (JSC) · Optimization and Engineering (OPTE) · Proceedings of the National Academy of Sciences of the United States of America (PNAS) · SIAM Journal on Scientific Computing (SISC) · SIAM Journal on Uncertainty Quantification (JUQ) · Smart Science (SS) · SoftwareX (SOFT-X) · Springer Nature Applied Sciences (SNAS) · Institute for Mathematics and its Applications (IMA)

Professional Memberships

American Society of Mechanical Engineers. Since 2019

American Institute of Aeronautics and Astronautics. Lifetime Membership. Since 2019

United States Association for Computational Mechanics. Since 2019

Society for Industrial and Applied Mathematics. Since 2016

Service & Outreach

Departmental Service

AY20/21   **Ad-Hoc Committee on Computing**, Aerospace and Mechanical Engineering, University of Notre Dame

Served on ad-hoc committee for the Department of Aerspace and Mechanical Engineering tasked with modernizing the computational aspects of the undergraduate curricula. Committee was in charge of 1) determining the computing and data science needs for the AME program, 2) determining the computing prerequisite needs in the AME curriculum, 3) determining how to integrate computing throughout the curriculum, and 4) developing a proposal to the faculty to address each.

AY19/20   **Faculty Search Committee**, Aerospace and Mechanical Engineering, University of Notre Dame

Served on Department of Aerspace and Mechanical Engineering search committee. Reviewed 228 applications (out of 501), participated in 11 teleconference interviews (out of 19), and conducted one-on-one interview with all 6 on-campus interviewees.

2019–pres   **Qualify Exam Committees**, Aerospace and Mechanical Engineering, University of Notre Dame

Served on qualifying exam committee for 8 students to date: 4 (2019), 2 (2020), 2 (2021)

Community Outreach

Feb 2020   **Northern Indiana Regional Science & Engineering Fair**   *Notre Dame, IN*
Feb 2021   Science fair competition in northern Indiana for grades K-12 ∘ Project judge

Feb 2020   **St. Joseph Valley Mathcounts competition**   *Notre Dame, IN*

Math competition in St. Joseph County for grades 6-8 ∘ Assisted with organization and grading

Mar 2016   **Central Catholic High School Career Day**   *Modesto, CA*
Mar 2017
Mar 2018   Presentation: Computational methods to solve next-generation science and engineering grand challenge problems ∘ A workshop intended to demonstrate the real-world impact of CSE, convey my excitement and passion for the field, and hopefully motivate a diverse group of students to consider a CSE career ∘ A question and answer session followed the workshop, including a discussion of my personal career path