Ken Kamrin

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Cambridge, MA 02139, USA
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Education

2003-2008 *Massachusetts Institute of Technology* *Ph.D. Applied Mathematics*

Thesis: Stochastic and Deterministic Models for Dense Granular Flow
Doctorate awarded June 2008 supervised by Prof. Martin Z. Bazant. (GPA: 5.000 / 5.000)

1998-2003 *University of California, Berkeley* *B.S. Engineering Physics, Mathematics minor*

Graduated with Highest Honors. (GPA: 4.000 / 4.000)

Appointments

2022-present *Massachusetts Institute of Technology* *Professor, Mechanical Engineering*

2022-present *Massachusetts Institute of Technology* *Professor, Applied Mathematics*

2016-2022 *Massachusetts Institute of Technology* *Associate Professor, Mechanical Engineering*

2011-2014 *Massachusetts Institute of Technology* *Class of '56 Career Development Chair*

2011-2016 *Massachusetts Institute of Technology* *Assistant Professor, Mechanical Engineering*

2008-2011 *Harvard University* *Applied Mathematics Lecturer and NSF Postdoctoral Research Fellow (Sponsors: J. W. Hutchinson and L. Mahadevan)*

Publications

Textbook

[1] L. Anand, K. Kamrin, and S. Govindjee, *Introduction to Mechanics of Solid Materials*, Oxford University Press (2022).

Journal

[61] S. Agarwal†, D. I. Goldman, K. Kamrin. Mechanistic framework for reduced-order models in soft materials: Application to three-dimensional granular intrusion. *PNAS*, (In press).

[60] E. Deal, J. G. Venditti, S. J. Benavides, R. Bradley, Q. Zhang†, K. Kamrin, J. T. Perron. Grain shape effects in bed load sediment transport, *Nature*, (In press).

[59] Q. Zhang†, E. Deal, J. T. Perron, J. G. Venditti, S. J. Benavides, M. Rushlow, and K. Kamrin. Fluid-driven transport of round sediment particles: From discrete simulations to continuum modeling, *JGR: Earth Surface*, **127**:7, e2021JF006504, (2022).

[58] S. Dunatunga† and K. Kamrin. Modelling silo clogging with non-local granular rheology, *J. Fluid Mech.*, 940 (2022).

[57] S. J. Benavides, E. Deal, M. Rushlow, J. G. Venditti, Q. Zhang†, K. Kamrin, and J. T. Perron. The impact of intermittency on bed load sediment transport. *Geophys. Res. Lett.* **49**:5 e2021GL096088 (2022).

[56] X. Wang†, K. Kamrin, and C. H. Rycroft. An incompressible Eulerian method for fluid-structure interaction with mixed soft and rigid solids, *Phys. Fluids* **34**:3 033604 (2022).

[55] W. Hu, Z. Zhou, S. Chandler, D. Apostolopoulos, K. Kamrin, R. Serban, D. Negrut. Traction control design for off-road mobility using an SPH-DAE cosimulation framework, *Multibody System Dynamics*, 1-24 (2022).

[54] S. Mowlavi† and K. Kamrin. Interplay between hysteresis and nonlocality during onset and arrest of flow in granular materials, *Soft Matter*, **17**, 7359-7375 (2021).

[53] S. Agarwal†, A. Karsai, D. I. Goldman, and K. Kamrin. Surprising simplicity in the modeling of dynamic granular intrusion. *Science Advances*, **7**:17, eabe0631 (2021).

[52] W. Hu, M. Rakhsha, L. Yang, K. Kamrin, and D. Negrut. Modeling granular material dynamics and its two-way coupling with moving solid bodies using a continuum representation and the SPH method *CMAME*, **385**, 114022 (2021).

[51] A. Baumgarten†, B. Couchman, and K. Kamrin. A coupled finite volume and material point method for two-phase simulation of liquidsediment and gassediment flows, *CMAME*, **384**, 113940 (2021).

[50] S. Agarwal†, A. Karsai, D. Goldman, and K Kamrin. Efficacy of simple continuum models for diverse granular intrusions, *Soft Matter*, **17**, 7196-7209 (2021).

† Is/was a member of the Kamrin Group at MIT

[49] P. Y. Chen, M, Chantharayukhonthorn†, Y. Yue, E. Grinspun, K. Kamrin. Hybrid Discrete-Continuum Modeling of Shear Localization in Granular Media, *J. Mech. Phys. Solids*, **153**, 104404 (2021).

[48] S. Mowlavi† and K. Kamrin. Contact model for elastically anisotropic bodies and efficient implementation into the discrete element method. *Gran. Mat.*, **23**(2), 1-29 (2021).

[47] Q. Zhang†, S. Townsend†, and K. Kamrin. Expanded Scaling Relations for Locomotion in Sloped or Cohesive Granular Beds. *Phys. Rev. Fluids*, **5**, 114301 (2020).

[46] S. Kim† and K. Kamrin. Power-Law Scaling in Granular Rheology across Flow Geometries. *Phys. Rev. Lett.* (Editor's Suggestion), **125**, 088002 (2020).

[45] C. Rycroft, C. Wu, Y. Yu, and K. Kamrin. Reference map technique for incompressible fluid-structure interaction. *J. Fluid Mech.*, **898**, A9 (2020).

[44] P.E. Schiebel, H.C. Astley, J.M. Rieser, S. Agarwal†, C. Hubicki, A.M. Hubbard, K. Diaz, J.R. Mendelson III, K. Kamrin, and D.I. Goldman. Mitigating memory effects during undulatory locomotion on hysteretic materials. *Elife*, 9 (2020).

[43] A. Baumgarten† and K. Kamrin. Modeling Stress Relaxation in Dense, Fine-Particle Suspensions. *J. Rheol.*, **64**:2, 367-377 (2020).

[42] S. Jain, K. Kamrin, and A. Mani. A Conservative and Non-Dissipative Eulerian Formulation for the Simulation of Soft Solids in Fluids. *J. Comput. Phys.*, **399**, 108922 (2019).

[41] A. Baumgarten† and K. Kamrin. A General Constitutive Model for Dense, Fine Particle Suspensions Validated in Many Geometries. *PNAS*, **116**:42 , 20828-20836 (2019).

[40] E. Rojas† and K. Kamrin. Capturing Transient Granular Rheology with Extended Fabric Tensor Relations. *Gran. Mat.*, **21**, 89 (2019).

[39] S. Agarwal†, C. Senatore, T. Zhang, M. Kingsbury, K. Iagnemma, D. I. Goldman, K. Kamrin. Modeling the Interaction of Rigid Wheels with Dry Granular Media. *J. Terramechanics*, **85**, 1-14 (2019).

[38] K. Kamrin. Non-locality in Granular Flow: Phenomenology and Modeling Approaches. *Front. Phys.*, **7**:116 (2019).

[37] J. Goddard and K. Kamrin. Dissipation Potentials from Elastic Collapse. *Proc. Roy. Soc. A.*, **475**, 20190144 (2019).

[36] J. Slocum, K. Kamrin, A. Slocum. A Buckling Flexure-Based Force-Limiting Mechanism. *J. Mechanisms Robotics.*, **11**, 041004 (2019).

[35] A. Baumgarten† and K. Kamrin. A General Fluid-Sediment Mixture Model and Constitutive Theory Validated in Many Flow Regimes. *J. Fluid Mech.*, **861**, 721-764, (2019).

[34] Y. Yue, B. Smith, P. Chen, M. Chantharayukhonthorn†, K. Kamrin, E. Grinspun. Hybrid Grains: Adaptive Coupling of Discrete and Continuum Simulations of Granular Media. *ACM TOG*, **37**:6, 283 (2018).

[33] T. Olsen† and K. Kamrin. Resolving Force Indeterminacy in Contact Dynamics Using Compatibility Conditions. *Gran. Mat.*, **20**, 69 (2018).

[32] P. Mutabaruka† and K. Kamrin. Simulation Technique for Slurries Interacting with Moving Parts and Deformable Solids with Applications. *Comp. Part. Mech.*, **2**, 239-267, (2018).

[31] K. Kamrin. A Hierarchy of Granular Continuum Models: Why Flowing Grains are Both Simple and Complex. *Proceedings of the 8th International Congress on Micromechanics of Granular Media, EPJ Web of Conferences*. **140**, 01007 (2017).

[30] Q. Zhang† and K. Kamrin. A Microscopic Description of the Granular Fluidity Field in Nonlocal Flow Modeling. *Phys. Rev. Lett.*, **118**, 058001 (2017).

[29] S. Dunatunga† and K. Kamrin. Continuum Modeling of Projectile Impact and Penetration in Dry Granular Media. *J. Mech. Phys. Solids*, **100**, 45-60 (2017).

[28] J. Slonaker†, D. C. Motley†, Q. Zhang†, S. Townsend†, C. Senatore, K. Iagnemma, and K. Kamrin. General Scaling Relations for Locomotion in Granular Media. *Phys. Rev. E*, **95**, 052901 (2017).

[27] H. Askari† and K. Kamrin. Intrusion in Rheology in Grains and Other Flowable Materials. *Nature Materials*, **15**, 1274-1279 (2016).

[26] T. Olsen†, A. Helal, G. McKinley, and K. Kamrin. Coupled Dynamics of Flow, Microstructure, and Conductivity in Sheared Suspensions. *Soft Matter*, **12**, 7688-7697, (2016).

[25] S. Kumar, D. M. Parks, and K. Kamrin. Mechanistic Origin of the Large Adhesion at Graphene/a-SiO_2 interface: Contributions Beyond van der Waals, and Their Origins. *ACS Nano*, **10**(7), 6552-6562, (2016).

[24] W. Lu, M. D. Thouless, Z. Hu, H. Wang, R. Ghelichi†, C.-H. Wu†, K Kamrin, D. M. Parks. CASL Structural Mechanics Modeling of Grid to Rod Fetting. *JOM*, **68**(11), 2922-2929, (2016).

[23] D. Henann† and K. Kamrin. A Finite-Element Implementation of the Nonlocal Granular Rheology. *Int. J. Numer. Meth. Engin.*, **108**, 273-302, (2016).

[22] R. Ghelichi† and K. Kamrin. Modelling Growth Paths of Interacting Crack Pairs in Elastic Media. *Soft Matter*, **11**, 7995-8012 (2015)

[21] S. Dunatunga† and K. Kamrin. Continuum Modeling and Simulation of Granular Flows Through Their Many Phases. *J. Fluid Mech.*, **779**, 483-513 (2015)

[20] T. Olsen† and K. Kamrin. Modeling of Anisotropic Conductivity in Suspension Networks. *Soft Matter*, **11**, 3875-3883 (2015)

[19] B. Valkov†, C. H. Rycroft, and K. Kamrin. Eulerian Method for Multiphase Interactions of Soft Solid Bodies in Fluids. *J. Appl. Mech.*, (Winner, 2016 JAM Award), **82**:4, 041011 (2015)

[18] K. Kamrin and D. Henann†. Nonlocal Modeling of Granular Flows Down Inclines. *Soft Matter*, **11**:1, 179-185, (2015)

[17] K. Kamrin and E. Bouchbinder. Two-Temperature Continuum Thermomechanics of Deforming Amorphous Solids, *J. Mech. Phys. Solids*, **73**, 269-288 (2014)

[16] K. Kamrin and J. Goddard. Symmetry Relations in Viscoplastic Drag Laws, *Proc. R. Soc. A*, **470**:2171, 20140434, (2014)

[15] D. Henann† and K. Kamrin. Continuum Modeling of Secondary Rheology in Dense Granular Materials. *Phys. Rev. Lett.*, **113**, 178001, (2014).

[14] K. Kamrin and G. Koval. Effect of Particle Surface Friction on Nonlocal Constitutive Behavior of Flowing Granular Media. *Comp. Part. Mech.*, **1**:2, 169-176, (2014).

[13] D. Henann† and K. Kamrin. Continuum Thermomechanics of the Nonlocal Granular Rheology. *Int. J. Plasticity*, **60**, 145-162, (2014).

[12] D. Henann†, J. Valenza, D. L. Johnson, K. Kamrin. Small-Amplitude Acoustics in Bulk Granular Media. *Phys. Rev. E.*, **88**, 042205, (2013).

[11] D. Henann† and K. Kamrin. A Predictive, Size-Dependent Continuum Model for Dense Granular Flows. *PNAS*, **110**:17, 6730-6735, (2013).

[10] P. Six† and K. Kamrin. Some exact properties of the effective slip over surfaces with hydrophobic patternings. *Phys. Fluids*, **25**, 021703, (2013).

[9] K. Kamrin and G. Koval, Nonlocal constitutive relation for steady granular flow, *Phys. Rev. Lett.*, **108**, 178301 (2012).

[8] K. Kamrin, C. H. Rycroft, and J.-C. Nave. Reference Map Technique for Finite-Strain Elasticity and Fluid-Structure Interaction, *J. Mech. Phys. Solids* **60**, 1952-1969 (2012).

[7] K. Kamrin and L. Mahadevan. Soft Catenaries. *J. Fluid Mech.*, **691**, 165-177 (2012).

[6] K. Kamrin and H. A. Stone. The Symmetry of Mobility Laws for Viscous Flow Along Arbitrarily Patterned Surfaces. *Phys. Fluids*, **23**, 031701 (2011).

[5] K. Kamrin, M. Z. Bazant, and H. A. Stone. Effective Slip Boundary Conditions for Arbitrary Periodic Surfaces: The Surface Mobility Tensor. *J. Fluid Mech.*, **658**, 409-437 (2010).

[4] K. Kamrin. Nonlinear Elasto-Plastic Model for Dense Granular Flow, *Int. J. Plasticity*, **26**, 167-188 (2010).

[3] C. H. Rycroft, K. Kamrin, and M. Z. Bazant. Assessing Continuum Postulates in Simulations of Granular Flow. *J. Mech. Phys. Solids*, **57**:5 828-839 (2009).

[2] K. Kamrin, C. H. Rycroft, and M. Z. Bazant. The Stochastic Flow Rule: A Multi-Scale Model for Granular Plasticity. *Modelling Simul. Mater. Sci. Eng.*, **15**, S449-S464 (2007).

[1] K. Kamrin and M. Z. Bazant. Stochastic Flow Rule for Granular Materials. *Phys. Rev. E*, **75**, 041301 (2007).

Book Chapter

[2] K. Kamrin, Quantitative Rheological Model for Granular Materials: The Importance of Particle Size, *Handbook of Materials Modeling*, Vol 2, Editors: W. Andreoni, S. Yip, Springer (2020).

[1] K. Kamrin, Foreword to *Packings and Flows: The science of granular matter*, by E. Guyon, J.Y. Delenne, and F. Radjai, MIT Press (2020).

Other

[4] K. Kamrin, Elastic Sheets: Cracks by Design, *Nature Materials*, News and Views, **16**(1), 8-9, (2017).

[3] K. Kamrin, Foreword on the Special Issue: From Discrete Particles to Continuum Models of Granular Mechanics, *Comp. Part. Mech.*, **4**:4, 371 (2017).

[2] K. Kamrin, Predicting Granular Flows: A New Size-Dependent Constitutive Model, iMechanica Journal Club Theme, imechanica.org/node/14929, (2013).

[1] K. Kamrin, Steady Granular Flows, iMechanica Journal Club Theme, imechanica.org/node/7028, (2009).

Students and Postdocs

Postdocs

David Henann (2011-2013, now faculty at Brown), Zakia Sultana (2012-2014, now at IBM), Ramin Ghellichi (2013-2016, now faculty at Polytechnico Milano), Hesam Askari (2014-2016, now faculty at U Rochester), Chen-Hung Wu (2014-2016, now at AirBnB), Patrick Mutabaruka (2014-2016), Eduardo Rojas (2017-current, now faculty at U Antofagasta, Chile), Xiaolin Wang (2017-2022, now at Oracle).

Graduate students

Sachith Dunatunga (MS 2014, PhD 2017, now at Lyft), Boris Valkov (MS 2014, now at Schlumberger), Tyler Olsen (MS 2015, PhD 2018, now at Renaissance Tehcnologies), Sabrina Ball (MS 2015, co-advised), James Slonaker (MS 2016, now at Oracle), Aaron Baumgarten (MS 2018, PhD 2021, now postdoc at Johns Hopkins), Seongmin Kim (PhD 2021, now postdoc at HKUST), Qiong Zhang (MS 2017, PhD 2022, now postdoc at MIT), Shashank Agarwal (MS 2018, PhD 2022, now at Exponent), Saviz Mawlavi (PhD 2022, now at Mitsubishi Electric Research), Maytee Chantharayukhonthorn (MS 2019, PhD expected 2023), Will Zunker (MS expected 2023).

Undergraduate researchers

Pierre Six (2011-2012), Amy Guyomard (2012-2013, now grad student at Oxford), James Slonaker (2013-2015, now at Schlumberger), David Carrington Motley (2014-2016, now grad student at Stanford), Stephen Townsend (2016-2018, now consultant at Novantas), Nicholas Klugman (2018-2020), Fidel Cano-Renteria (2019-2020, now grad student at Caltech).

Selected Honors

MacVicar Faculty Fellowship (2022) [a]

Annual Speaker, Danish Center for Applied Mathematics and Mechanics (2018)

ASME Journal of Applied Mechanics Award (2016) [b]

Ruth and Joel Spira Award for Excellence in Teaching (2016) [c]

Eshelby Mechanics Award for Young Faculty (2015) [d]

NSF Early Faculty Career Development (CAREER) Award (2012)

APS Nicholas Metropolis Award (2010) [e]

NSF Mathematical Sciences Postdoctoral Research Fellowship (2009)

Harvard University Certificate of Distinction in Teaching (2009)

National Defense Science and Engineering Graduate Fellowship (2005)

NSF Graduate Research Fellowship (2005)

Hertz Fellowship (2003)

MIT Presidential Fellowship (2003)

University Medal Finalist (2003) [f]

UC Berkeley Engineering Science Departmental Citation (2003) [g]

[a] MIT's highest honor for undergraduate teaching and education.
[b] Awarded by the Applied Mechanics Division for best paper of the preceding two years. For JAM, Vol 82, 041011 (2015).
[c] Awarded by MIT School of Engineering..
[d] Presented by ASME to a "rapidly emerging junior faculty who exemplifies the creative use and development of mechanics."
[e] Awarded by APS and J Comput Phys for "outstanding doctoral thesis work in computational physics."
[f] One of four finalists for UC Berkeley's top student honor.
[g] Awarded to the top student in engineering science.

Selected Service Roles

MIT

Undergraduate Director and Chair of the Undergraduate Programs Committee, Department of Mechanical Engineering (2021-current).

Member, Ad Hoc Committee on Leveraging Best Practices from Remote Teaching for On-Campus Education, RIC-16, TaskForce 2021 (2021-current)

Communications and Media Faculty Advisor, Department of Mechanical Engineering (2019-current).

Member, Education Strategy Committee, Department of Mechanical Engineering (2019-current)

Member, Mechanics Curriculum Committee (2014-2015)

UROP Co-Coordinator, Department of Mechanical Engineering (2013-2020)

Co-Organizer, Seminar on Mechanics, Modeling, Experimentation, and Computation, Department of Mechanical Engineering (2010-2019)

Non-MIT

Board of Directors, Society of Engineering Science (2019-2022)

Editorial Board, *International Journal of Solids and Structures*, Elsevier (2022-current)

Associate Editor, *Granular Matter*, Springer (2019-current)

Associate Editor, *Computational Particle Mechanics*, Springer (2013-current)

Co-Founder and Co-Organizer, New England Workshop on the Mechanics of Materials and Structures (NEW.Mech) (2010-2022)

Scientific Committee, USNC/TAM (2022)

Scientific Committee, USNCCM-16 (2022)

Co-Organizer, Symposium on Multiscale Mechanics of Particulate Media, Society of Engineering Science (2013-2019)

Co-Organizer, Focus Session on Continuum Descriptions of Particulate Media, APS March Meeting (2011-2019)

Co-Organizer, Symposium on Micromechanics of Granular Media, Engineering Mechanics Institute Conference (2018)

Co-Organizer, Symposium on Granular Media Modeling and Simulation, World Congress on Computational Mechanics (2018)

Co-Organizer, Symposium on Constitutive Modeling of Amorphous and Particulate Systems, US National Congress for Theoretical and Applied Mechanics (2018)

Guest Editor, *Computational Particle Mechanics*, Special Issue: From Discrete Particles to Continuum Models of Granular Mechanics (2017)

Co-Organizer, Army Research Office Workshop: Characterizing the Dynamics of Geo-Surface Materials (2016)

Co-Organizer, Symposium on Inelastic Flow of Granular Media and Geomaterials, International Conference on Plasticity (2016).

Scientific Committee and Co-Organizer, International Conference of Particle-Based Methods (2015 and 2017)

Co-Organizer, International Conference, *Modeling Granular Media Across Scales*, Montpellier, France (2014)

iMechanica Journal Club, Discussion and Theme Leader (Nov 2009, June 2013)

Member, Committee on Special Scholarships, UC Berkeley Academic Senate (2002-2003)

Member, Committee on Teaching, UC Berkeley Academic Senate (2001-2002)

Expert work and Consulting

Engineering Consultant, Corning (2019-present)

Expert Witness and Patent Consultant, Telebrands (2013-2018)

Expert Witness, Yannetti Criminal Law Firm (2015)

DOE National Energy Technology Laboratory, Invited Expert (2013)

Invited Talks

Seminars

Some new continuum approaches for dry and wet particle flow problems, Mechanical Engineering Departmental Seminar, MIT, October 2021.

From Granular Continuum Modeling to Simplified Locomotion Models, Mechanical Engineering Departmental Seminar, Johns Hopkins University, (virtual) September 2021.

Some New Continuum Approaches for Dry and Wet Particles Flows, Chemical Engineering Departmental Seminar, Columbia University, New York, (virtual) September 2020.

Toward Reduced-Order Models for Flowing Grains: Surprising Complexity Meets Surprising Simplicity, Applied Math Seminar, UC Berkeley, (virtual) April 2020.

Toward Reduced-Order Models for Granular Materials, Geomechanics Seminar, UC Berkeley, Berkeley, CA, March 2020.

Continuum-inspired Methods for Modeling Flowing Grains, Fluid Mechanics Seminar, UC Berkeley, Berkeley, CA, February 2020.

Some New Modeling Approaches for Flows of Wet and Dry Granular Media, Applied Mechanics Colloquium, Harvard University, Cambridge, MA, November 2019.

Some New Continuum-Based Approaches for Particle Flow Modeling, Institute for Mechanical Systems Seminar, ETH, Zurich, Switzerland, November 2019.

Some New Directions in Particle Flow Modeling, IGM Colloquium, EPFL, Lausanne, Switzerland, November 2019.

Some New Continuum-Based Approaches for Particle Flow Modeling, Mechanical Engineering Seminar, UCSB, Santa Barbara, CA, October 2019

Rapid Simulation Tools for Highly Deforming Granular Media, Army Research Lab, Aberdeen Proving Ground, MD, March 2019.

Continuum Modeling of Flowing Grains, Annual Lecture of the Danish Center for Applied Mathematics and Mechanics, Danish Technical University, December 2018.

Continuum Modeling of Flowing Grains, Annual Lecture of the Danish Center for Applied Mathematics and Mechanics, Aarhus University, December 2018.

Continuum Modeling of Flowing Grains, Worcester Polytechnic Institute, Department of Civil Engineering, November 2018.

Modeling Flowing Granular Material as a Continuum: Surprising complexity meets surprising simplicity, UC Berkeley, Department of Mechanical Engineering, August 2018.

When Granular Materials are Easy and When They Are Not, Formlabs Technical Seminar, August 2018.

Granular Materials are Complex But Also Simple, MIT, Department of Mathematics, Physical Mathematics Seminar, May 2018.

Modeling Flowing Granular Material as a Continuum: Surprising complexity meets surprising simplicity, New York University, Courant Institute of Mathematical Sciences, Applied Math Laboratory Seminar, April 2018.

Modeling Flowing Granular Material as a Continuum: Surprising complexity meets surprising simplicity, University of Chicago, Department of Physics, Computations in Science Seminar, March 2018.

When Granular Flow Modeling is Simple and When It Isnt, University of Rochester, Department of Mechanical Engineering, March 2018.

When Granular Flow Modeling is Simple and When It Isnt, University of Sydney, School of Civil Engineering, January 2018.

A Hierarchy of Continuum Models for Granular Flow, Duke University, Applied Math and Analysis Seminar, December 2017.

Modeling Granular Materials from Fundamentals to Applications: Surprising complexity meets surprising simplicity, Northeastern University, Mechanics Seminar, November 2017.

Granular Flow Continuum Modeling from Fundamentals to Applications, Brandeis University, IGERT Seminar, November 2017.

Modeling Granular Materials from Fundamentals to Applications: Surprising complexity meets surprising simplicity, MIT, Department of Mechanical Engineering Colloquium, October 2017.

Continuum Modeling of Flowing Grains, Princeton University, Department of Mechanical and Aerospace Engineering Seminar, September 2017.

Simulating Solids Like Fluids: A Fully Eulerian Approach to Fluid-Structure Interaction, Center for Turbulence Research Seminar, Stanford University, May 2017.

The Simplicity and Complexity of Granular Flow Modeling, Carnegie Mellon University, Mechanics Materials and Computing Seminar, April 2017.

Continuum Modeling of Granular Flows: A Hierarchy of Models, Northwestern University, Colloquium in Theoretical and Applied Mechanics, December 2016.

Continuum Modeling of Granular Flows, University of Illinois Urbana-Champaign, Department of Mechanical Science and Engineering, November 2016.

Simulating Joint Fluid and Solid Behaviors: Exploiting the Eulerian Frame, Duke University, Department of Civil and Environmental Engineering, November 2016.

Mechanics with Two Temperatures?, University of Pennsylvania, Department of Mechanical Engineering and Applied Mechanics, September 2016.

A Hierarchy of Granular Continuum Models: From flow fields to impact and traction applications, Clark University, Department of Physics, April 2016.

Granular Continuum Modeling: From flow fields to traction and intrusion models, Tank Automotive Research, Development and Engineering Center (TARDEC), Detroit, Michigan, April 2016.

Continuum Modeling of Particle Flows, University of Texas at Austin, Institute for Computational Engineering and Sciences Seminar, April 2016.

Continuum Modeling of Flowing Grains, University of Wisconsin at Madison, Applied Mathematics Seminar, December 2015.

Constitutive Modeling of Particle Flows, Eshelby Lecture, University of Houston, Department of Mechanical Engineering, August 2015.

Quantitatively Predictive Continuum Modeling of Granular Flows, Colloquium of the Center for Nonlinear Studies, Los Alamos National Laboratory, June 2015.

A Predictive Rheology for Flowing Granular Media, Fluid Mechanics Seminar, Department of Mechanical Engineering, Stanford University, June 2015.

Nonlocal Continuum Modeling of Granular Flows, Warren Lecture, Department of Civil, Environmental, and Geo-Engineering, University of Minnesota, April 2015.

Continuum Modeling of Granular Flows: Theory, Computation, and Experiment, Department of Mechanical and Aerospace Engineering, UC San Diego, April 2015.

A Predictive Nonlocal Continuum Model for Granular Flows, School of Engineering and Applied Science, Yale University, April 2015.

What are the Navier-Stokes equations of sand flow? Some challenges in theoretical and computational continuum mechanics, Department of Mathematics, UC Berkeley, February 2015.

Nonlocal Continuum Modeling of Granular Flows, Department of Mechanical Engineering, UC Santa Barbara, March 2015.

Modeling the nonlocal oddities of granular flows, Granular Forum, University of Sydney, January 2015.

Modeling the oddities of granular flow using size-dependent plasticity, School of Engineering and Applied Science, Brown University, December 2014.

Size-dependent continuum modeling of flowing granular media, Physical Mathematics Seminar, Department of Mathematics, MIT, October 2014.

Continuum Modeling of Granular Flow, Applied and Interdisciplinary Mathematics Seminar, Department of Mathematics, Northeastern University, October 2014.

Nonlocal Modeling of Granular Flows, Department of Mechanical Engineering, Politechnico di Milano, July 2014.

Modeling the Strange Flow Behaviors of Granular Media, Squishy Physics Seminar, Harvard University, April 2014.

Toward a Quantitatively Predictive Model for Granular Flow, Applied Mathematics and Computational Science Seminar, University of Pennsylvania, April 2014.

Continuum Modeling of Granular Flow, National Energy Technology Laboratories, Morgantown, West Virginia, March 2014.

Continuum Modeling of Granular Flow, Levich Institute, City College of New York, February 2013.

Continuum Modeling of Flowing Granular Media, Mechanical Engineering Seminar, Columbia University, November 2013.

Wet and Dry Granular Flows, Schlumberger-Doll Research Center, Cambridge, November 2013.

Continuum Modeling of Flowing Granular Media, Mechanical and Aerospace Engineering, Syracuse University, November 2013.

Size-dependent Continuum Modeling of Flowing Granular Media, Mechanics and Materials Seminar, UC San Diego, October 2013.

Size-dependent Continuum Modeling of Flowing Granular Media, GALCIT Colloquium, Caltech, October 2013.

Size-dependent Continuum Modeling of Flowing Granular Media, Seminar Series of ExxonMobil Research, ExxonMobil Laboratories Newark, October 2013

Size-dependent Continuum Modeling of Flowing Granular Media, Applied Mechanics Colloquium, Harvard University, October 2013.

Constructing and Verifying a Three-Dimensional Nonlocal Granular Rheology (2 Lectures), Yukawa Institute for Theoretical Physics, University of Kyoto, June 2013.

Reference Map Technique for Simulating Deformable Solids, Laboratory of Mechanics and Civil Engineering, Université de Montpellier II, June 2013.

A Size-Dependent Continuum Model for Dense Granular Flows, Institut Universitaire des Systèmes Thermiques Industriels, Polytech Marseille, June 2013.

Continuum Modeling of Granular Flow, Department of Chemical Physics, Weitzmann Institute of Science, April 2013.

Continuum Modeling of Granular Flow, Department of Physics, Rochester Institute of Technology, April 2013.

Understanding and Modeling Granular Material Flows at the Continuum Scale, Department of Physics, University of South Florida, February 2013.

Toward a Predictive Continuum Model for Dense Granular Flows, Center for Nonlinear and Complex Systems Seminar, Duke University, October 2012.

Toward a Predictive Continuum Model for Dense Granular Flows, Soft Matter Seminar, Georgia Tech, October 2012.

Toward a General Constitutive Relation for Steady Granular Flow, Laboratory of Mechanics and Civil Engineering, Université de Montpellier II, June 2012.

Steady Granular Flow: Local and Nonlocal Constitutive Approaches, Materials Science Seminar, Johns Hopkins Materials Science, Februrary 2012.

Constitutive Modeling of Granular Flow, and New Perspectives on Continuum Flow Simulation, Mechanical Engineering Seminar, UC Berkeley Mechanical Engineering, December 2011.

Mobility Laws for Fluid Flow over Arbitrarily Patterned Surfaces, Physical Applied Math Seminar, MIT Applied Mathematics, December 2011.

Granular Flow and FSI: Simultaneous Fluid-like and Solid-like Behaviors, Materials Processing Center Advisory Board, MIT, October 2011.

Continuum Modeling and Computational Aspects of Flowing Granular Media, Seminar of the Applied Mathematics Laboratory, Courant Institute, NYU, April 2011.

Constitutive Modeling and Computational Aspects of Flowing Granular Media, Joint Materials/Solid Mechanics Seminar, Brown University, April 2011.

Modeling Sand Flow, Applied Mathematics Seminar, Southern Methodist University, March 2011.

Reference Map Algorithm for the Simulation of Deformable Solids, Applied Mathematics Seminar, McGill University, March 2011.

Steady Granular Flow, Applied Math Seminar, University of Delaware, October 2010.

A Novel Finite-Difference Method for Large Deformation Solid Mechanics, Numerical Methods for Partial Differential Equations Seminar, MIT Department of Mathematics, May 2010.

Steady Granular Flow: Continuum Theory, Simulation, and Computational Challenges, MMEC Seminar, MIT Department of Mechanical Engineering, March 2010.

A Continuum Model for Dense Granular Flow, Caltech, GALCIT, March 2010.

Shear Flow over Arbitrary Periodic Surfaces, Squishy Physics Seminar, Harvard SEAS, February 2010.

A Continuum Model for Dense Granular Flow, Applied Mechanics Colloquium, Harvard SEAS, December 2009.

A Continuum Model for Dense Granular Flow, MMEC Seminar, MIT Department of Mechanical Engineering, November 2009.

General Continuum Law for Dense Granular Flow, Sandia National Laboratory, July 2009.

General Continuum Law for Dense Granular Flow, Brandeis University Department of Physics, June 2009.

A Continuum Model for the Deformation of Granular Materials, Clark University, Physics Colloquium, February 2009.

A New Continuum Model for Dense Granular Deformations, University of California, Santa Barbara, Kavli Institute for Theoretical Physics, March 2008.

A New Continuum Model for Dense Granular Deformations, Solid Earth Physics Seminar, Harvard School of Engineering and Applied Sciences, February 2008.

An Elasto-Plastic Model for Dense Granular Flow, Brown University Department of Mechanical Engineering, February 2008.

An Elasto-Plastic Model for Dense Granular Flow, Yale University Departments of Physics and Mechanical Engineering (joint seminar), February 2008.

An Elasto-Plastic Model for Dense Granular Flow, Institut Universitaire des Systèmes Thermiques Industriels, Polytech Marseille, January 2008.

An Elasto-Plastic Model for Dense Granular Flow, Institut Navier, École Nationale des Ponts et Chaussées, January 2008.

An Elasto-Plastic Model for Dense Granular Flow, Theoretical Chemical-Physics, École Supérieure de Physique et de Chimie Industrielles, January 2008.

An Elasto-Plastic Model for Dense Granular Flow, Physics and Mechanics of Heterogeneous Media, École Supérieure de Physique et de Chimie Industrielles, January 2008.

Detailed Story of the Stochastic Flow Rule, Clark University Department of Physics, October 2006.

Flow Rules in Granular Plasticity, Brown Bag Seminar Series, MIT Applied Mathematics, March 2005.

Conference talks

Concurrent multi-scale approach for granular flow problems, 10th Multiscale Mechanics of Materials Conference, Baltimore, MD, October 2022.

Modelling Robot-Ground Interaction Systems, ALERT Geomechanics Conference, Aussois, France, September 2022.

Three-Dimensional Resistive Force Theory in Granular Media, Machine-Ground Interaction Consortium, (virtual) September 2022.

Material point method for dry and wet media: From soil mechanics to industrial applications , International Workshop on Virtual Laboratory Testing and Micromechanics, Norwegian Geotechnical Institute, Oslo, Norway, September 2022.

Some New Continuum-Based Approaches for Particle Flow Modeling, Gordon Research Conference: Granular Matter, Eastman, MA, June 2022.

A Primer on Granular Continuum Mechanics, Gordon Research Seminar: Granular Matter, Eastman, MA, June 2022.

To The Continuum and Beyond!, Webinar of the Journal *Granular Matter*, (virtual) November 2020.

Modeling Stress-Relaxation in Dense, Fine-Particle Suspensions, Physics of Dense Suspensions Workshop, (virtual) July 2020.

Exploiting Simple Soil Models: Deducing Locomotive Scaling Laws for Use Beyond Earth, ICRA 2020 Space Robotics Workshop, (virtual) June 2020.

Some Extended Continuum-based Approaches for Particle Flow Modeling, Institute for Advanced Study Workshop on Emerging Scales in Granular Media, Hong Kong University of Science and Technology, Hong Kong, January 2020.

Extended Continuum Methods for Dry and Wet Granular Flow Modeling, 3rd IMA Conference on Dense Granular Flows, Centre for Mathematical Sciences, Cambridge, UK, July 2019.

Some New Directions in the Modeling of Granular Flows, Engineering Mechanics Institute Conference, Keynote Lecture, Caltech, Pasadena, CA June 2019.

Extended Continuum Methods for Dry and Wet Granular Flow Modeling, 60th Birthday Conference for Michael Shelley, University of Michigan, Ann Arbor, MI, June 2019.

Hybridizing Continuum and Discrete Methods of Granular flow, 4th International Workshop on Packing Problems, Yale, CT, June 2019.

Fun with New Methods for Particle Flow Problems, 16th Annual Conference on Frontiers in Applied and Computational Mathematics, NJIT, Newark, NJ, May 2019.

Toward General Rheological Models of Dry and Fluid-Saturated Granular Media, APS March Meeting, Boston, MA, March 2019.

Hybridizing Discrete and Continuum Approaches To Granular Materials Simulation, MIT Center for Computational Engineering Symposium, Cambridge, MA, March 2019.

Continuum modeling of wet and dry granular flows, Southern Granular Materials Workshop, Puerto Varas, Chile, December 2018.

Toward a General Mixture Theory and Numerical Method for Fluid-Saturated Granular Media, Society of Engineering Sciences Symposium in honor of Lallit Anand, Madrid, Spain, October 2018.

When Granular Materials are Easy, European Solid Mechanics Conference, Bologna, Italy, July 2018. *A*

Hierarchy of Continuum Models for Granular Flow, Powders and Grains, Keynote Lecture, Montpellier, France, July 2017.

An Eulerian Technique for Simulating Fluids Laden with Arbitrarily-Shaped Deformable Particles, IUTAM Symposium: Computational Mechanics of Particle-Functionalized Fluid and Solid Materials for Additive Manufacturing and 3D Printing Processes, Berkeley, May 2017

Advancing mathematical models for deforming materials, Workshop on Interdisciplinary Mathematics, Pennsylvania State University, University Park, May 2017.

Rheological Modeling of Granular Flows, American Institute of Chemical Engineers Annual Meeting, Plenary Session: Complex Particle Flows, San Francisco, November 2016.

Toward Continuum Models of Granular Materials, Army Research Office Workshop: Characterizing the Dynamics of Geo-Surface Materials, Chicago, August 2016.

Numerical Modeling of Wet Particulate Media In Various Limits, US Army Engineer Research and Development Center, Fluid-Structure Interaction Workshop, Vicksburg, Mississippi, April 2016.

Incorporating Cooperativity in Continuum Modeling of Granular Flows, IUTAM Multi-phase Continuum Modeling of Particulate Flows, Gainesville, Florida, December 2015.

Advances in the Continuum Representations of Granular Material Dynamics, Machine-Ground Interaction Consortium, Madison, Wisconsin, December 2015.

Continuum Modeling and Continuum Simulation Tools for Granular Materials Through Their Various Regimes of Behavior, Conference on Particle Simulations, Erlangen, Germany, September 2015.

Nonlocal Modeling of Granular Flows, KITP Conference: Complexity in Mechanics, Kavli Institute for Theoretical Physics, UC Santa Barbara, October 2014.

Nonlocal Continuum Modeling of Dry Granular Flow, 13th Continuum Models Discrete Systems Conference, Salt lake City, July 2014.

Modeling the Nonlocal Oddities of Granular Flow, 12th Northeastern Granular Materials Workshop, Brown University, April 2014.

A Predictive Model for Dense Granular Flow, 57th New England Workshop on Complex Fluids, Northeastern University, December 2013

Constitutive Modeling of Dense Granular Flow, Non-Newtonian Multiphase Slurry Workshop, DOE National Energy Technology Laboratory, Morgantown, WV, August 2013

A Size-Dependent Continuum Model for Predicting Dense Granular Flows, 7th MIT Conference on Computational Fluid and Solid Mechanics, June 2013

Steady Granular Flow: Local and Nonlocal Approaches, International Congress of Theoretical and Applied Mechanics, Beijing, August 2012.

Steady Granular Flow: Local and Nonlocal Approaches, Gordon Research Conference: Granular and Granular-Fluid Flow, Davidson, July 2012.

Local and nonlocal continuum modeling for dense granular flow, European Solid Mechanics Conference, Graz, June 2012.

Local and Nonlocal Approaches to Steady Granular Flow, International Union on Theoretical and Applied Mechanics Symposium on Mobile Particulate Systems, Bangalore, January 2012.

A Plasticity Model for Steady Flowing Granular Materials, 17th International Symposium on Plasticity, Puerto Vallarta, January 2011.

A Continuum Model for Steady Granular Flow, 16th US National Congress of Theoretical and Applied Mechanics, State College, June 2010.

Steady Granular Flow: Continuum Theory and Simulation, Northeastern Granular Material Workshop, Cambridge, June 2010.

Elasto-Plastic Modeling of Steady Granular Flow, APS March Meeting, Portland, March 2010.

The Stochastic Flow Rule: A Multi-scale Model for Granular Plasticity, 7th World Congress of Computational Mechanics, Los Angeles, July 2006.

Teaching

Courses Class Lecturer in the Mechanical Engineering department at MIT.

Class	*Description*	*Date*
2.002	Mechanics and Materials II	Spring 2022
2.002	Mechanics and Materials II	Spring 2021
2.002	Mechanics and Materials II	Spring 2020
2.002	Mechanics and Materials II	Spring 2019
2.002	Mechanics and Materials II	Spring 2018
2.002	Mechanics and Materials II	Spring 2017
2.002	Mechanics and Materials II	Spring 2016
2.001	Mechanics and Materials I	Fall 2015
2.001	Mechanics and Materials I	Spring 2014
2.001	Mechanics and Materials I	Fall 2013
2.002	Mechanics and Materials II	Spring 2013
2.002	Mechanics and Materials II	Spring 2012

Section and Laboratory Instructor in the Mechanical Engineering department at MIT.

Class	*Description*	*Date*
2.001	Mechanics and Materials I	Fall 2022
2.001	Mechanics and Materials I	Fall 2021
2.001	Mechanics and Materials I	Fall 2020
2.001	Mechanics and Materials I	Fall 2018
2.001	Mechanics and Materials I	Fall 2017
2.001	Mechanics and Materials I	Fall 2014
2.001	Mechanics and Materials I	Fall 2012
2.002	Mechanics and Materials II	Spring 2012
2.002	Mechanics and Materials II	Fall 2011
2.002	Mechanics and Materials II	Spring 2011

Applied Mathematics Lecturer at Harvard University. Headed classes of $\sim$20-40 students in a lead instructor role.

Class	*Description*	*Date*
Applied Mathematics 105A	Complex and Fourier Analysis	Fall 2009
Applied Mathematics 147	Nonlinear Dynamical Systems	Spring 2009
Applied Mathematics 105A	Complex and Fourier Analysis	Fall 2008

Teaching Assistant in the MIT mathematics department. Taught bi-weekly recitations, graded homework and exams, and assigned final course grades for $\sim$20 students.

Class	*Description*	*Date*
18.03	Differential Equations	Spring 2005
18.02A	Calculus 2 & start of Multivariable Calculus	Fall 2004

Taught undergraduate mathematics under two official titles at the UC Berkeley Student Learning Center: Group Instructor (GI) and Adjunct Course Instructor (ACI). As GI, led a bi-weekly review discussion for ∼20 students. As ACI, instructed a supplemental course for credit including exams. Two lectures per week, ∼25 students.

Class	*Description*	*Date*	*Position*
Math 1B	Calculus 2	Spring 2003	GI
Math 54	Linear Algebra & Differential Equations	Fall 2002	GI
Math 53	Multivariable Calculus	Fall 2001, Spring 2002	GI
Math 1B	Calculus 2	Spring 2001	ACI
Math 55	Discrete Math	Spring 2000, Fall 2000	GI

Teaching Reviews

Student-averaged teaching score at MIT is 6.5/7.0. Teaching evaluations available upon request.