James Roggeveen, Ph.D.

j.v.roggeveen@gmail.com | (508) 280-2536 | jamesroggeveen.com | LinkedIn | Google Scholar

Scientific AI | Applied Mathematics | Physical Modeling

RESEARCH PROFILE

Researcher and applied mathematician working across scientific AI, differentiable computing, and physical modeling. Builds evaluations and infrastructure for frontier AI systems in technical domains; advances numerical methods for inverse problems and physical-model discovery; and combines mathematical analysis, simulation, and experiments to study complex physical systems.

APPOINTMENTS AND RESEARCH EXPERIENCE

Google DeepMind 2025–Present
Visiting Faculty Researcher Cambridge, MA

- Created scalable domain-specific engineering tasks and associated programmatic graders; analyzed agent trajectories to distinguish capability failures from task and grader failures and guide revisions.
- Reviewed agentic tasks and environments for scientific and engineering domains with domain experts, assessing their realism, difficulty, and validity as capability evaluations.
- Publicly credited by Google DeepMind for foundational support to the Gemini Deep Think team.

Harvard University 2024–Present
Postdoctoral Fellow in Applied Mathematics | Advisor: Michael P. Brenner Cambridge, MA

- Built reusable expert-facing infrastructure for model execution, collaborative testing, programmatic grading, and symbolic verification, allowing domain experts to focus on authoring and refining authentic scientific problems.
- Co-led **HARDMath2**, a 211-problem NeurIPS 2025 benchmark, and built its collaborative authoring and testing infrastructure, enabling 40+ graduate students to write and peer-review original applied-mathematics problems.
- Owned the evaluation infrastructure for **CMT-Benchmark**, enabling condensed-matter theorists to collect, test, refine, and evaluate 50 original research-level problems across 17 frontier language models.
- Invented a meshless, differentiable spectral-basis method for PDE inverse problems on irregular geometries and paired coding agents with independent numerical verifiers to extend the solver to new scientific applications.
- Designed a differentiable framework for identifying tensor-valued constitutive laws from sparse, partial flow measurements; manuscript under review at *Nature Communications*.

Princeton University 2019–2024
Doctoral Researcher, Mechanical and Aerospace Engineering | Advisor: Howard A. Stone Princeton, NJ

- Built a calibration-free nonlinear model of micropipette aspiration and an automated inference pipeline to extract multiple rheological properties from one-dimensional experimental time series; validated the method on known fluids and applied it to protein condensates.
- Derived an analytical classification of the long-time motions available to asymmetric rigid particles in two-dimensional shear flow and connected the transition between motion classes to particle shape.
- Formulated and numerically validated an asymptotic theory for passive-scalar transport through channels with rough or topographically patterned surfaces, quantifying effects on drift and dispersion.
- Mapped the dynamics and drift of elastic hinges in oscillatory shear flow using Poincaré maps, automated fixed-point identification, and long-time numerical simulations.

EDUCATION

Princeton University — Princeton, NJ
Ph.D., Mechanical Engineering, 2024 | M.A., Mechanical Engineering, 2021
Dissertation: "Asymmetric and rough boundary surface effects on fluid flows"

University of Cambridge — Cambridge, UK
Master of Advanced Study, Applied Mathematics, 2019 | Distinction
Part III essay: "Gravity currents passing over cavities"

Massachusetts Institute of Technology — Cambridge, MA
B.S., Mechanical Engineering, 2018 | GPA: 5.0/5.0
Thesis: "Self-propulsion of floating objects"

PUBLICATIONS AND PREPRINTS

Preprints

E. Y. Wang, S. Motwani, **J. V. Roggeveen**, *et al.* "HorizonMath: Measuring AI progress toward mathematical discovery with automatic verification." arXiv:2603.15617, 2026. *3rd AI for Math Workshop at ICML 2026*.

J. V. Roggeveen and M. P. Brenner. "Meshless solutions of PDE inverse problems on irregular geometries." arXiv:2510.25752, 2025.

A. M. Sunol*, **J. V. Roggeveen***, M. G. Alhashim, H. S. Bae, and M. P. Brenner. "Learning constitutive models and rheology from partial flow measurements using automatic differentiation." Under review at *Nature Communications*. arXiv:2510.24673, 2025. **Equal contribution.*

Peer-reviewed publications

1. H. Pan, **J. V. Roggeveen**, *et al.* "CMT-Benchmark: A benchmark for condensed matter theory built by expert researchers." *International Conference on Learning Representations (ICLR)*, 2026. arXiv:2510.05228.
2. **J. V. Roggeveen***, E. Y. Wang*, *et al.* "HARDMath2: A benchmark for applied mathematics built by students as part of a graduate class." *NeurIPS Datasets & Benchmarks*, 2025. arXiv:2505.11774. **Equal contribution.*
3. H. H. Cheng, **J. V. Roggeveen**, H. Wang, H. A. Stone, Z. Shi, and C. P. Brangwynne. "Micropipette aspiration reveals differential RNA-dependent viscoelasticity of nucleolar subcompartments." *Proceedings of the National Academy of Sciences*, 2025. DOI:10.1073/pnas.2407423122.
4. **J. V. Roggeveen** and H. A. Stone. "Drift of elastic hinges in quasi-two-dimensional oscillating shear flows." *Physical Review Fluids*, 2025. DOI:10.1103/PhysRevFluids.10.034401.
5. **J. V. Roggeveen**, H. Wang, Z. Shi, and H. A. Stone. "A calibration-free model of micropipette aspiration for measuring properties of protein condensates." *Biophysical Journal*, 2023. DOI:10.1016/j.bpj.2023.09.018.
6. **J. V. Roggeveen**, H. A. Stone, and C. Kurzthaler. "Transport of a passive scalar in wide channels with surface topography: An asymptotic theory." *Journal of Physics: Condensed Matter*, 2023. DOI:10.1088/1361-648X/acc8ad.
7. **J. V. Roggeveen** and H. A. Stone. "Motion of asymmetric bodies in two-dimensional shear flow." *Journal of Fluid Mechanics*, 2022. DOI:10.1017/jfm.2022.203.
8. **J. V. Roggeveen**, A. Stoica, and M. Dolci. "Analysis of alternative energy harvesting methods to power atmospheric robotic explorers on Jupiter." *IEEE Aerospace Conference*, 2017. DOI:10.1109/AERO.2017.7943715.

INVITED TALKS

2025 **Beyond the rheometer: Integrative approaches to modeling and characterizing complex fluids**
Invited Seminar, Nanyang Technological University, Singapore

2025 **Geometry-driven drift of passive particles in flows**
Soft, Fluid, Living Matter Coffee Hour, Yale University; Physical Mathematics Seminar, MIT; Modeling and Simulation Group Meeting, NYU Courant Institute

2025 **Shear-driven drift of passive, asymmetric and deformable particles**
Mechanics Joint Group Meeting, Boston University

2023 **Multiphase flows at low Reynolds numbers: From condensate rheology to fluid-structure interactions**
Center for Computational Biology, Flatiron Institute

2023 **Measuring condensate rheology with micropipette aspiration and fluid-structure interactions at low Reynolds number**
LadHyX Seminar, Ècole Polytechnique

2022 **Material characterization of condensates using micropipette aspiration**
Phase Group Seminar, Princeton University

2021 **Motion of asymmetric bodies in shear flow**
Soft Materials Coffee Hour, Princeton University

CONFERENCE PRESENTATIONS

2025 **HARDMath2: A benchmark for applied mathematics built by students as part of a graduate class**
Poster, NeurIPS Datasets & Benchmarks, San Diego

2025 **Fitting three-dimensional constitutive models to low-dimensional data using differentiable rheometry**
Interact: Non-Newtonian Flows, 78th Annual Meeting of the APS Division of Fluid Dynamics, Houston

2025 **Fitting tensorial constitutive models to experimental rheology using automatic differentiation**
Oral presentation, APS Global Physics Summit, Anaheim

2024 **Drift of elastic hinges in oscillating shear flows**
77th Annual Meeting of the APS Division of Fluid Dynamics, Salt Lake City

2023 **Purcell's elastic swimmer: Drift of elastic hinges in oscillatory shear flows**
76th Annual Meeting of the APS Division of Fluid Dynamics, Washington, DC

2023 **Modeling micropipette aspiration for use in material characterization of biological condensates**
XIXth International Congress on Rheology, Athens

2022 **Transport of a passive scalar in wide channels with surface topography**
75th Annual Meeting of the APS Division of Fluid Dynamics, Indianapolis

2021 **Motion of asymmetric bodies in shear flow**
74th Annual Meeting of the APS Division of Fluid Dynamics, Phoenix

TEACHING EXPERIENCE

Harvard University Fall 2025 and Fall 2026
Lecturer, AM 201: Physical Mathematics I. Sole instructor responsible for all lectures, problem sets, and exams; leads a class-wide project in which students create, peer-review, and test mathematical problems for AI evaluation.

Harvard University Spring 2025
Teaching Assistant, AM 201: Physical Mathematics I.

Princeton University 2021–2023
Assistant in Instruction: Mathematics in Engineering I (2023); Viscous Flows and Boundary Layers (2023); Mathematical Methods of Engineering Analysis I (2022); Instabilities in Fluids (2022); Multivariable Calculus (2021).

Massachusetts Institute of Technology 2015–2017
Teaching Assistant / Undergraduate Assistant: Thermodynamics (2017); Thermal-Fluids Engineering I (2017); Design and Manufacturing I (2017); Introductory Biology tutor (2015).

International Teaching and Outreach 2015, 2018
MIT Global Teaching Labs South Korea, instructor (2018); China Education and Technology Initiative, instructor (2015).

EARLIER RESEARCH AND ENGINEERING EXPERIENCE

University of Cambridge, Fluid Dynamics Laboratory 2019
Part III Researcher | Advisor: Stuart Dalziel Cambridge, UK

- Formulated a theory predicting how a gravity current passing overhead removes dense fluid trapped in a cavity, based on the density ratios of the current, cavity, and background fluids.
- Designed and conducted laboratory experiments to test the theoretical predictions.

Samsung Electronics 2018
Global Technology Center Intern Suwon, South Korea

- Automated manufacturing quality-control tasks by building C and Python tools to measure curved-glass surface roughness, locate microLEDs, and identify missing or misaligned components.
- Worked with external contractors to deploy the software in prototype robotic inspection systems.

Massachusetts Institute of Technology, Applied Mathematics Laboratory 2018
Undergraduate Thesis Researcher | Advisor: John Bush Cambridge, MA

- Studied symmetry breaking and spontaneous self-propulsion of floating fluid lenses driven by Faraday waves; mapped lens shapes and motions across forcing frequency and volume.
- Demonstrated how the phenomenon could generate translation of floating objects or rotary motion of gears.

SpaceX 2017
Vehicle Engineering Intern Hawthorne, CA

- Authored and implemented standardized procedures for resolving recurring Falcon 9 assembly defects in collaboration with avionics, propulsion, and structures stakeholders.
- Reduced work-order overhead while preserving engineering review, saving more than 40 engineering hours per booster.

Massachusetts Institute of Technology, Bourouiba Group 2016–2017
Undergraduate Researcher | Advisor: Lydia Bourouiba Cambridge, MA

- Built and calibrated a benchtop method for measuring viscoelastic relaxation time, comparing results with capillary-breakup extensional rheometry.
- Investigated changes in the rheological properties of human saliva after removal from the body and evaluated preservation protocols.

NASA Jet Propulsion Laboratory 2016
Summer Undergraduate Research Fellow | Advisor: Adrian Stoica Pasadena, CA

- Prepared a NASA Innovative Advanced Concepts proposal for WindBots, autonomous robotic explorers of Jupiter's atmosphere, and compared in-situ power-generation approaches.
- Led construction of a benchtop wind tunnel for testing candidate robotic architectures.

MIT 2.009 Product Engineering Process 2017
Firmware Lead, Yellow Team Cambridge, MA

- Led firmware development for a three-tier search-and-rescue tracking prototype integrating GPS, radio communications, onboard tracking, and display functions.
- Designed the system API governing data exchange among hardware modules and over the radio link.

FELLOWSHIPS, AWARDS, AND HONORS

GradFutures Professional Development Grant, Princeton University, 2023.

SEAS Travel Grant and Dean's Fund for Scholarly Travel, Princeton University, 2023.

Graduate School Teaching Award, Princeton University, 2022.

Guggenheim Second Year Fellowship and Sayre Award for Academic Excellence, Princeton University, 2020.

Upton Fellowship, Princeton University, 2019.

Trinity College External Research Studentship, University of Cambridge, 2018.

Phi Beta Kappa, 2018; Whitelaw Award for Originality of Design, MIT, 2016.

PROFESSIONAL SERVICE AND LEADERSHIP

Session Chair, "Fluids I," APS Global Physics Summit, 2025.

Reviewer, *Physical Review Fluids*, American Physical Society.

Graduate Student Council, Princeton Mechanical and Aerospace Engineering 2019–2024
Chair. Represented graduate students in faculty discussions of departmental policy and degree requirements; organized Research Day and annual visits for approximately 30 admitted students.

MIT Engineering Advisory Board 2019–2023
Senior Reviewer. Evaluated approximately 50 engineering portfolios per year for technical skill, creativity, and potential impact; conducted second-round reviews to calibrate new reviewers.

MIT Asian Dance Team 2014–2018
Captain and Director of Logistics. Helped lead a 270-member organization, overseeing finances, space, production logistics, and choreographer recruitment for semester showcases.

Mathey College, Princeton University 2021–2022
Resident Graduate Student. Advised, mentored, and provided live-in support for 50 first-year undergraduates.

TECHNICAL EXPERTISE

AI evaluation: Agentic task and environment design, expert-driven benchmark development, programmatic grading, symbolic and numerical verification, trajectory analysis, collaborative evaluation workflows.

Scientific computing: Automatic differentiation, inverse problems, numerical PDEs, asymptotic methods, optimization, dynamical systems, statistical inference, mathematical modeling.

Fluid mechanics and soft matter: Low-Reynolds-number flows, rheology, fluid-structure interactions, transport and dispersion, experimental data analysis.

Programming and tools: Python, JAX, SymPy, Mathematica, MATLAB, C, Git.

REFERENCES

Michael P. Brenner, Harvard University | brenner@seas.harvard.edu
Howard A. Stone, Princeton University | hastone@princeton.edu
Luc Deike, Princeton University | ldeike@princeton.edu
Pierre-Thomas Brun, KU Leuven | pierre-thomas.brun@kuleuven.be