Nicholas G. Chisholm, Ph.D.

Assistant Research Professor
Worcester Polytechnic Institute, Department of Mathematical Sciences
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Education

Carnegie Mellon University Pittsburgh, PA
Ph.D., Chemical Engineering (QPA: 3.85/4.00) May 2017
Dissertation: *Locomotion and Drift in Viscous Flows: Numerical and Asymptotic Predictions*

University of Rochester Rochester, NY
B.S., Chemical Engineering, *Magna cum laude* (GPA: 3.95/4.00) May 2012
Honor Societies: Phi Beta Kappa, Tau Beta Pi

Research and Professional Experience

Academic Research

Worcester Polytechnic Institute, Dept. of Mathematical Sciences Worcester, MA
Assistant Research Professor (Advisor: Prof. Sarah D. Olson) Sept. 2020–Present

- Improved the accuracy and efficiency of the method of regularized Stokeslets (MRS), a computational method for low-Reynolds-number and porous-media flows
- Discovered new fundamental theoretical results that apply to Stokes flows, Brinkman flows, and electrostatics problems
- Currently modeling the mechanics of cell division using the MRS
- Collaborating with biologists to inform models and compare results to *in vitro* experiments

Univ. of Pennsylvania, Dept. of Chemical & Biomolecular Engineering Philadelphia, PA
Postdoctoral Researcher (Advisor: Prof. Kathleen J. Stebe) Aug. 2017–July 2020

- Developed theoretical predictions of fluid flows generated by passively diffusing and actively self-propelled colloids at fluid-fluid interfaces with different physiochemical properties
- Closely collaborated with experimentalists to validate model predictions and inform future experiments
- Mentored graduate students in the Stebe group in developing theoretical models related to bacterial swimming, cargo capture by microrobots, and colloid self-assembly

Carnegie Mellon University, Dept. of Chemical Engineering Pittsburgh, PA
Ph.D. Candidate (Advisor: Prof. Aditya S. Khair) Aug. 2012–May 2017

- Quantified the contribution of intermediate-Reynolds-number particles and swimmers to large-scale fluid mixing via asymptotic analysis of induced fluid "drift"
- Characterized the effect of fluid inertia on the locomotion of a model intermediate-Reynolds-number swimmer, focusing on swimming speed, efficiency, and the transition to turbulent flow
- Developed a flexible, Python-based hp-finite element library for direct numerical simulation of mass and momentum transport phenomena, currently in active use by the Khair research group

University of South Carolina Dept. of Chemical Engineering Columbia, SC
NSF Research Experience for Undergraduates June–Aug. 2010

- Experimentally quantified the kinetic and thermodynamic characteristics of a silica-based solid amine CO_2 sorbent for carbon capture applications to assess performance and stability
- Compared experimental results with analytical predictions of kinetic and thermodynamic models

Advising and mentoring

Worcester Polytechnic Institute, Dept. of Mathematical Sciences Worcester, MA
Project Advisor, *Early Research Experience in E-Term* Jun.–Aug. 2022

- Directly advised an undergraduate researcher on independent summer research project regarding estimation of enhanced diffusion by active colloids at fluid interfaces
- Guided a undergraduate through a first experience in the research process: establishing background knowledge, applying it to solve an open-ended problem, and communicating results at weekly meetings and in a final poster presentation

Worcester Polytechnic Institute, Dept. of Mathematical Sciences Worcester, MA
Program Mentor, *Research Experience for Undergraduates (REU)* Jun.–Aug. 2021

- Mentored three REU students working in independent research projects
- Offered feedback and help to students during weekly research updates and office hours

Non-academic roles

NASA Glenn Research Center Cleveland, OH
Undergraduate Student Research Program June–Aug. 2011

- Investigated use of packed bed reactors for energy efficient CO_2 scrubbing on manned spacecraft
- Developed a preliminary CFD model to quantify the fluid flow within a packed bed under microgravity using ANSYS Fluent

Brookfield Engineering Laboratories Middleborough, MA
Intern June–Aug. 2012

- Designed a prototype device to profile the viscosity of coatings components as a function of temperature for a client company
- Presented designs to superiors and procured feedback from other engineers in order to revise my design and produce a final prototype for assessment by the client

Publications

Chisholm, **N. G.** and S. D. Olson. "A framework for generating radial and surface-oriented regularized Stokeslets". Accepted for publication in *MDPI Fluids*. 2022.

Chisholm, **N. G.** and S. D. Olson. "A generalized Lorentz reflection theorem". In preparation. 2022.

Deng, J., M. Molaei, **N. G. Chisholm**, and K. J. Stebe. *Interfacial flow around a pusher bacterium*. Under consideration for publication in the *Journal of Fluid Mechanics*. 2022. arXiv: 2204.02300.

Deng, J., M. Molaei, N. G. Chisholm, T. Yao, A. Read, and K. J. Stebe. "Active colloids on fluid interfaces". *Current Opinion in Colloid & Interface Science* (2022), p. 101629.

Chisholm, **N. G.** and K. J. Stebe. "Driven and active colloids at fluid interfaces". *Journal of Fluid Mechanics* 914 (2021).

Molaei, M., **N. G. Chisholm**, J. Deng, J. C. Crocker, and K. J. Stebe. "Interfacial flow around Brownian colloids". *Phys. Rev. Lett.* 126.22 (2021), p. 228003.

Deng, J., M. Molaei, **N. G. Chisholm**, and K. J. Stebe. "Motile bacteria at oil–water interfaces: *Pseudomonas aeruginosa*". *Langmuir* 36.25 (2020), pp. 6888–6902.

Yao, T., **N. G. Chisholm**, E. B. Steager, and K. J. Stebe. "Directed Assembly and Micro-Manipulation of Passive Particles at Fluid Interfaces via Capillarity Using a Magnetic Micro-Robot". *Appl. Phys. Lett.* 116.4 (2020), p. 043702.

Chisholm, **N. G.** and A. S. Khair. "Partial drift volume due to a self-propelled swimmer". *Physical Review Fluids* 3.1 (2018).

Khair, A. S. and **N. G. Chisholm**. "A higher-order slender-body theory for axisymmetric flow past a particle at moderate Reynolds Number". *Journal of Fluid Mechanics* 855 (2018), pp. 421–444.

Chisholm, **N. G.** and A. S. Khair. "Drift volume in viscous flows". *Physical Review Fluids* 2.6 (2017).

Chisholm, **N. G.**, D. Legendre, E. Lauga, and A. S. Khair. "A squirmer across Reynolds numbers". *Journal of Fluid Mechanics* 796 (2016), pp. 233–256.

Khair, A. S. and **N. G. Chisholm**. "Expansions at small Reynolds numbers for the locomotion of a spherical squirmer". *Physics of Fluids* 26.1 (2014), p. 011902.

Ebner, A. D., M. L. Gray, **N. G. Chisholm**, Q. T. Black, D. D. Mumford, M. A. Nicholson, and J. A. Ritter. "Suitability of a solid amine sorbent for CO2 capture by pressure swing adsorption". *Ind. Eng. Chem. Res.* 50.9 (2011), pp. 5634–5641.

Seminars

Chisholm, **N. G.** "A Novel Approach to Regularizing Stokeslets via Smoothed Vector Potentials". Seminar. Department of Mathematical Sciences Colloquium (Worcester Polytechnic Institute, Worcester, MA). 2021.

Chisholm, **N. G.** "Hydrodynamics of Driven and Active Colloids at Fluid Interfaces". Seminar. Complex Fluids Seminar (Carnegie Mellon University, Pittsburgh, PA). 2021.

Contributed Conference Presentations (by topic)

Computational Fluid Dynamics: Method of Regularized Stokeslets

Chisholm, **N. G.** and S. D. Olson. SIAM Conference on the Life Sciences. Oral presentation. 2022.

Chisholm, **N. G.** and S. D. Olson. Society of Mathematical Biology Annual Meeting (Virtual). Oral presentation. 2021.

Chisholm, **N. G.** and S. D. Olson. 74th Annnual Meeting of the APS Division of Fluid Dynamics. Oral presentation. 2021.

Hydrodynamics of Colloids at Fluid Interfaces

Chisholm, **N. G.** and K. J. Stebe. AIChE Annual Meeting. Oral presentation. 2020.

Chisholm, **N. G.** and K. J. Stebe. 73nd Annnual Meeting of the APS Division of Fluid Dynamics. Oral presentation. 2020.

Chisholm, **N. G.** and K. J. Stebe. 72nd Annnual Meeting of the APS Division of Fluid Dynamics. Oral presentation. 2019.

Chisholm, **N. G.** and K. J. Stebe. 16th Conference on Frontiers in Applied and Computational Mathematics jointly with 11th Northeastern Complex Fluids & Soft Matter Workshop. Oral presentation. 2019.

Chisholm, **N. G.** and K. J. Stebe. AIChE Annual Meeting. Oral presentation. 2019.

Chisholm, **N. G.** and K. J. Stebe. Gulf of Mexico Oil Spill & Ecosystem Conference. Poster. 2019.

Chisholm, **N. G.**, M. Molaei, J. Deng, R. L. Leheny, and K. J. Stebe. AIChE Annual Meeting. Oral presentation. 2018.

Chisholm, **N. G.**, M. Molaei, J. Deng, R. L. Leheny, and K. J. Stebe. 71st Annual Meeting of the APS Division of Fluid Dynamics. Oral presentation. 2018.

Chisholm, **N. G.**, L. Vaccari, M. Molaei, R. L. Leheny, and K. J. Stebe. Gulf of Mexico Oil Spill & Ecosystem Conference. Oral presentation. 2018.

Finite-Reynolds-Number Swimmers: Locomotion and Biogenic Mixing

Chisholm, **N. G.** and A. S. Khair. 88th Annual Meeting of The Society of Rheology. Oral presentation. 2017.
Chisholm, **N. G.** and A. S. Khair. AIChE Annual Meeting. Oral presentation. 2016.
Chisholm, **N. G.**, D. Legendre, E. Lauga, and A. S. Khair. AIChE Annual Meeting. Oral presentation. 2015.
Chisholm, **N. G.** and A. S. Khair. 17th U. S. National Congress on Theoretical and Applied Mechanics. Oral presentation. 2014.
Chisholm, **N. G.** and A. S. Khair. 66th Annual APS Division of Fluid Dynamics Meeting. Oral presentation. 2013.

Teaching Experience

Worcester Polytechnic Institute Worcester, MA
Instructor Aug. 2021–Jun. 2022

Courses: Integral Calculus (A-Term 2021), Multivariable Calculus (E1-Term 2022)

- Taught full 7-week courses in in-person and online settings for sections of 20–40 students
- Managed student workers responsible for leading weekly class discussion sections and grading
- Created lecture notes, homeworks, quizzes, and exams to achieve course learning objectives

Carnegie Mellon University Pittsburgh, PA
Teaching Assistant Sept. 2012–Dec. 2013

Courses: Heat and Mass Transfer, Math Techniques in Chemical Engineering, Adv. Fluid Dynamics

- Lead weekly office hours, graded and offered feedback on assignments and tests, and delivered lectures when needed as a substitute instructor (1–2 times per semester)

University of Rochester Rochester, NY
Study Group Leader — Electricity & Magnetism Sept.–Dec. 2011

- Provided guidance to small groups of 8–12 students seeking supplementary help on homework sets and for test preparation
- Applied teaching techniques and strategies discussed in weekly seminars for study group leaders

University of Rochester Rochester, NY
Workshop Leader — Organic Chemistry I, II Sept. 2010–May 2011

- Lead small workshop groups through challenging, mandatory problem sets meant to develop critical analytical skills
- Applied pedagogical strategies discussed and practiced in weekly workshop-leader meetings

Skills

Domain specific expertise: Fluid dynamics, colloidal suspensions, interfacial mechanics, soft matter, perturbation methods, mass transport, partial differential equations

Numerical methods: finite element analysis, regularized singularity methods, boundary integral methods

Programming languages: extensive experience with Julia, Python and MATLAB; some experience with C and Haskell

Software: Mathematica, ANSYS Fluent, Gmsh (FEM/FVM mesh generator), Git

Honors & Awards

Claire and John Bertucci Fellowship. Carnegie Institute of Technology. Accomplishment as a doctoral student. 2014.

Gary Powers Poster Award. Carnegie Mellon ChEGSA Symposium. Best Research Poster. 2013.

Shelby A. Miller Prize. University of Rochester. Best senior design project in chemical engineering. 2012.

Robert L. Wells Prize University of Rochester. Achievement in engineering and the humanities. 2012.