Arshia Fazeli

Toronto, ON | fazeliarshia@gmail.com | +1 (647) 781-4875
arshia-fazeli | arfazeli.github.io | arfazeli | 0009-0005-5384-9336

SUMMARY

PhD candidate in Chemical Engineering with 5 years of experience developing high-fidelity computational models and numerical solvers for multiphysics problems. Proven ability to design, implement, and verify complex software systems in Python (NGSolve, PETSc) and apply advanced numerical methods — discontinuous Galerkin FEM, finite-volume methods, adaptive mesh refinement — to real engineering problems. Published researcher with strong skills in scientific software engineering, data analysis, and machine learning pipelines.

EDUCATION

University of Waterloo *Sept 2021 – Sept 2026 (Expected)*
PhD in Chemical Engineering, Waterloo, ON, Canada

- GPA: 92.67/100
- Dissertation: *Well-Posed Two-Fluid Model with Improved Physical Fidelity for the Simulation of Dispersed Flows* (Advisor: Nasser M. Abukhdeir)
- Key courses: Computational Fluid Dynamics, Multiphase Flow Dynamics, Advanced Engineering Mathematics, Transport Phenomena

University College London *Sept 2018 – June 2021*
BEng in Chemical Engineering, London, UK

- First Class Honours
- Key courses: Computational Modelling and Analysis, Reaction Engineering, Process Dynamics and Control, Particulate Systems and Separation Processes

SKILLS

Programming Languages: Python, MATLAB, C++
Scientific Computing: NGSolve, PETSc, OpenFOAM, Ansys CFX, ParaView, GMSH, NETGEN
Python Libraries: NumPy, Numba, scikit-learn, pandas, Matplotlib, SymPy, unittest, pytest
Tools & Workflow: Git, LaTeX, Linux, LAMMPS, PLUMED

RESEARCH EXPERIENCE

University of Waterloo *Sept 2021 – Present*
Computational Multiphysics Researcher, Waterloo, ON, Canada

- Developed a two-fluid model for dispersed multiphase flows that fixes a long-standing instability in the standard formulation, using mathematical analysis to identify the physics missing from conventional models and calibrating a replacement against published experimental data.
- Built the supporting simulation software from scratch in Python/NGSolve — a discontinuous Galerkin finite element solver with mixed function spaces, adaptive implicit time stepping, and a coupled turbulence model — and verified its numerical accuracy using the method of manufactured solutions.
- Validated the model against three independent experimental datasets spanning gas–liquid and liquid–liquid systems, using quantitative model-selection criteria to rank it against previously published alternatives.
- Ran large-scale 3D transient simulations on national HPC clusters, reproducing measured flow structure and unsteady dynamics that competing models capture only with additional turbulence modelling.

OpenCMP — Open-Source Multiphysics FEM Framework *Apr 2026 – Present*
Developer, github.com/uw-comphys/opencmp

- Contributed an Euler–Euler two-fluid model solver for dispersed two-phase pipe flow — four coupled equations (phase velocities in HDiv/BDM, pressure and volume fraction in L^2) discretized with DG and resolved by Picard iteration, with drag, lift, and laminar dispersion closures.
- Contributed a standard high-Reynolds-number k–ε RANS model layered on the framework's existing INS solver: wall functions, automatic wall-distance computation, realizability and production limiters, correlation-based default inlet conditions, and a validated backward-facing-step tutorial, backed by 900+ lines of new unit and full-system tests.
- Implemented DG bound-preserving limiters (vertex-based P1 scaling and Bernstein–Bézier bounds) to keep volume fractions and turbulence quantities physically admissible.
- Set up GitHub Actions CI for the pytest suite and hardened it against native NGSolve crashes using process-forked test isolation; fixed the pre-existing failures it exposed (NumPy 2.0 incompatibilities, tolerance-sensitive adaptive time-stepping tests).

- Added restart-from-checkpoint support and refactored nonlinear mixing schemes out of the base solver into a standalone module.
- *Tools: Python, NGSolve, pytest, GitHub Actions, Git*

University College London *Aug 2020 – Dec 2020*
Research Associate, London, UK

- Conducted molecular dynamics simulations using LAMMPS and PLUMED to investigate nucleation pathways in colloidal suspensions.

TEACHING EXPERIENCE

University of Waterloo *Sept 2021 – Present*
Teaching Assistant, Waterloo, ON, Canada

- Led tutorials and office hours for graduate and undergraduate courses: Theory and Application of Transport Phenomena (CHE601), Introduction to Computational Methods (NE113), Continuum Mechanics (NE318), Computer Literacy & Programming (NE111/CHE120).
- Engineered a randomized Python `unittest` autograder for a programming course — freshly generated test inputs each run prevent hardcoded solutions; weighted scoring, safe execution via `runpy`, and per-student filtered error feedback.

SELECT PROJECTS

LLM-Generated Code Detector

- Built an end-to-end ML pipeline detecting AI-generated student code: engineered 18 AST-based and stylistic features (Halstead metrics, Shannon entropy, comment semantics, call nesting depth) and trained a Random Forest classifier via 5-fold stratified cross-validation with `RandomizedSearchCV`, achieving ROC-AUC of 0.95.
- Implemented a TF-IDF cosine similarity plagiarism checker to flag near-identical submission pairs across a student cohort.
- *Tools: Python, scikit-learn, pandas, NumPy*

DG Solver for Cahn–Hilliard Navier–Stokes System github.com/arfazeli/CHNS_DG_solver

- Implemented a monolithic DG solver for the coupled Cahn–Hilliard Navier–Stokes system, simulating the evolution of two immiscible incompressible fluids separated by a diffuse interface.
- *Tools: Python, NGSolve*

DG Solver for Cahn–Hilliard Equation github.com/arfazeli/CH_DG_solver

- DG solver for the Cahn–Hilliard phase-field equation capturing spinodal decomposition dynamics of binary fluid systems.
- Implemented adaptive mesh refinement driven by a Zienkiewicz–Zhu gradient-recovery error estimator on ∇c, enabling targeted refinement at the diffuse interface.
- *Tools: Python, NGSolve, NETGEN, GMSH, ParaView*

Steady Incompressible Navier–Stokes Solvers with Scalar Transport and Reaction SIMPLE, SCGS

- Implemented FVM solvers for the 2D incompressible Navier–Stokes equations using SIMPLE and SCGS velocity–pressure coupling; extended the SIMPLE solver to include scalar transport and reaction source terms.
- Implemented multiple convection and diffusion discretization schemes; leveraged Numba JIT compilation for significant runtime speedups.
- *Tools: Python, NumPy, Numba, Matplotlib, SymPy*

Euler Equations Solver Using Flux Vector Splitting github.com/arfazeli/1D_Euler_FVS

- Implemented a finite-volume solver for the 1D compressible Euler equations using Steger–Warming, Van Leer, and AUSM+ flux splitting schemes; the AUSM+ scheme uses an advection/pressure operator-split formulation for improved accuracy on contact discontinuities and shocks.
- *Tools: Python, NumPy, SymPy, Matplotlib*

Ebullated-Bed Reactor with Recycle-Cup Separation and Population Balance

- Recreated a three-dimensional pilot-scale ebullated-bed reactor to assess recycle-cup gas–liquid separation relevant to bitumen hydroprocessing, including gas hold-up and entrainment in the internal recycle line.
- Implemented feedback-controlled recycle-outlet boundary conditions to maintain target outlet flow and extended the Euler–Euler model with a population balance to predict bubble-size distributions and their effects on interphase momentum exchange and hydrodynamics.
- *Tools: OpenFOAM, Euler–Euler multiphase modelling, population balance modelling, feedback control, ParaView*

CFD of an Industrial-Scale Aerated Stirred-Tank Bioreactor

- Modelled dispersed air–liquid flow in a 2.08 m diameter, 7.55 m tall stirred-tank bioreactor with four six-blade impellers

and four wall baffles.
- Applied an Euler–Euler/PIMPLE formulation with k–ε and bubble-induced turbulence and multiple reference frames at 120 rpm; evaluated liquid circulation and gas-volume-fraction distributions throughout the vessel.
- *Tools: OpenFOAM, multiphaseEulerFoam, PIMPLE, MRF, ParaView*

CFD Simulation of a Side-Dump Combustor with Variable Inlet Angles

- Performed CFD simulations of turbulent airflow in a side-dump combustor; validated against experimental velocity and turbulence data and investigated the impact of side-inlet angle on fuel–air mixing.
- Conducted mesh refinement and error analysis to quantify discretization and modelling errors.
- *Tools: Ansys CFX*

LEADERSHIP AND SERVICE

Chemical Engineering Graduate Student Association (CEGSA), University of Waterloo *Jan 2022 – Jan 2023*
VP Academic

UCL Technology Society *Aug 2020 – July 2021*
Welfare Officer

Engineers Without Borders *Oct 2019 – Apr 2020*
Outreach Volunteer

UCL Project Impactive *Oct 2019 – Jan 2020*
Engineer

PUBLICATIONS

[2] **A. Fazeli**, S. Rhebergen, N. M. Abukhdeir. "Canonical formulation of two-fluid model with enhanced physical fidelity." *Chemical Engineering Science* (Under Review, 2026). Preprint

[1] **A. Fazeli**, S. Rhebergen, N. M. Abukhdeir. "Laminar dispersion force effects on two-fluid modelling and simulation of bubble column hydrodynamics." *International Journal of Multiphase Flow*, 2026. DOI

AWARDS

CSChE 2024 Best Poster Award Nov 2024

Garry L. Rempel Memorial Graduate Scholarship, University of Waterloo May 2022

Best Final Design Project Team Award, University College London June 2021