

Akshat Sachin Valse

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*Stochastic analysis for machine learning: Langevin sampling and its discretization,
large deviations and rare-event simulation, and the stability of learned PDE solvers.*

EDUCATION

Iowa State University, Honors Program

Expected May 2028

B.S. Statistics · B.S. Mathematics · B.A. Computer Science · B.S. Data Science

Cumulative GPA 3.85 / 4.00.

In progress, Fall 2026 (all five at the PhD level, 6000-series). Foundations of Probability Theory, measure-theoretic (STAT 6541); High-Dimensional Probability and Linear Algebra for Machine Learning (MATH 6230); Advanced Topics in Machine Learning (COM S 6730); Advanced Topics in Artificial Intelligence (COM S 6720); Advanced Topics in High-Performance Computing (COM S 6250).

Planned, Spring 2027. Advanced Probability Theory; Advanced Stochastic Processes.

Graduate and advanced coursework, completed.

Probability and statistics: Theory of Probability and Statistics (STAT 5430); Stochastic Process Models (STAT 5540); Empirical Methods for the Computational Sciences (STAT 5830); Multivariate Analysis (STAT 5750); Categorical Data Analysis (STAT 5770); Statistical Computing (STAT 5860).

Mathematics: Numerical Methods for Differential Equations (MATH 5810); Analysis I (MATH 4140); Introduction to Mathematical Logic (MATH 4430X); Partial Differential Equations (MATH 3850); Theory of Linear Algebra, honors (MATH 3170).

Computing and machine learning: Concepts and Applications of Machine Learning, honors (DS 3030); Design and Analysis of Algorithms (COM S 3110); Software Development Practices (COM S 3090).

RESEARCH EXPERIENCE

Langevin Sampling and Diffusion Estimation for Molecular Systems

May 2026 – present

Research Collaborator, Department of Mathematics, Iowa State University. Advisor: Prof. David Herzog. Funded by NSF award DMS-2246491.

- Built an end-to-end Python simulation pipeline implementing MALA and projected Euler–Maruyama samplers for overdamped Langevin dynamics, staged from a one-dimensional periodic potential to a solvated ion in a three-dimensional Lennard-Jones bath; estimated self-diffusion and mobility coefficients from long-run trajectory data.
- Derived the closed-form Lifson–Jackson diffusivity $D = 1/I_0(1)^2 \approx 0.62386$ as an exact benchmark and validated the estimators against it before scaling to three dimensions, where the pipeline reproduces published solvated-ion results.
- Author weekly technical reports, including a companion note supporting the group’s CLT-based error analysis.

Large Deviation Theory for Rare-Event Analysis in Queueing Systems

Nov. 2024 – present

Undergraduate Research Fellow, Department of Mathematics, Iowa State University. Advisor: Prof. Ruoyu Wu. Dean’s High Impact Undergraduate Research Award.

- Developed the first importance-sampling methodology for rare-event estimation in the mean-field join-the-shortest-queue model, deriving state-dependent exponential tilting from the Budhiraja–Friedlander–Wu (2021) large-deviation rate function; stated a logarithmic-efficiency conjecture with a proof sketch via the Dupuis–Wang subsolution framework.

- Built a reproducible, performance-tuned Python simulation framework (Xoshiro256** with deterministic seeding) and validated it across 27 configurations ($n \leq 100$, $\rho \in \{0.7, 0.9, 0.95\}$): estimates agree with crude Monte Carlo within 95% confidence intervals wherever crude Monte Carlo succeeds, and extend to probabilities as small as 10^{-31} , where it fails entirely.
- Designed and benchmarked two heuristic tilting families (rate-reversal, level-weighted) with pilot-run selection; diagnosed over-tilting at extreme rarity through likelihood-ratio calibration statistics, motivating the ongoing computation of the optimal state-dependent tilt.

Stability Analysis of Cell-Average Neural Networks for PDEs

May 2026 – present

Undergraduate Researcher, Department of Mathematics, Iowa State University. Advisor: Prof. Jue Yan. Funded by the NSF D4 NRT. Joint with Mengyuan Yang.

- Adapting von Neumann stability analysis to neural-network PDE solvers: deriving the linearized amplification factor of the learned time-stepping scheme and characterizing how perturbations propagate through it, toward stability conditions on the trained weights analogous to those of classical finite-difference methods.
- Reimplementing the group's solver in Python to enable systematic stability experiments across schemes and step sizes.

MANUSCRIPTS IN PREPARATION

1. *Large-Deviation-Guided Importance Sampling for Rare Events in the Mean-Field Join-the-Shortest-Queue Model.* With R. Wu.
2. *Langevin Dynamics and Transport-Coefficient Estimation for Molecular Systems.* With D. Herzog.
3. *Stability Certificates for Cell-Average-Based Neural Network Solvers: von Neumann Analysis of Trained Flux Networks.* With M. Yang and J. Yan.

AWARDS AND HONORS

- Dean's High Impact Undergraduate Research Award, Iowa State University, 2026.
- Schillmoeller Family Scholarship in Statistics.
- Mead Fund Award in Statistics.
- James L. Cornette Mathematics and Interdisciplinary Studies Award.
- Dean's List, every semester.

LEADERSHIP AND SERVICE

- Treasurer, Iowa State Data Science Club, 2025 – present. Secured \$60,000+ in funding supporting 130+ members.
- Research Ambassador, Iowa State University Honors Program.
- FAA Private Pilot Certificate, high-performance endorsement, 2025. Volunteer pilot and recruitment advisor, Pilots N Paws animal-rescue flights.

TECHNICAL SKILLS

Languages and tools. PyTorch and CUDA for neural-network and GPU-accelerated simulation; Python (NumPy, SciPy, pandas, scikit-learn, matplotlib); R; L^AT_EX; git.

Methods. Measure-theoretic probability and stochastic differential equations; MCMC (MALA, Metropolis–Hastings) and importance sampling; large-deviation asymptotics; numerical analysis of time-stepping schemes and von Neumann stability; reproducible computation with recorded seeds and parameter sidecars, so every figure regenerates from saved results.