Md Badrul Hasan

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Computational Fluid Dynamics | Transport Phenomena & Multiphase Flow | CFD Simulation & Validation | Scientific Python & HPC

Professional Summary

Ph.D. candidate in Mechanical Engineering (expected May 2026) with 5+ years developing and validating CFD models for coupled fluid dynamics, heat transfer, and species transport. Experienced building finite-volume solvers from first principles, benchmarking against reference data, and integrating physics-constrained ML models into production-scale solvers on HPC clusters.

Technical Skills

- **Simulation Tools:** ANSYS Fluent (including UDFs), COMSOL Multiphysics, custom finite-volume and finite-difference solvers in Fortran and Python; coupled heat transfer, fluid flow, species transport, and reacting flow modeling
- **Programming:** Python (PyTorch, NumPy, xarray, Pandas), MATLAB, Fortran, Bash
- **Engineering Tools:** Microsoft Excel (data analysis, charting); technical report and white paper writing
- **Numerical Methods:** Finite-difference, finite-volume, and spectral methods; multiphase flow, heat and mass transport, and reaction kinetics coupling; numerical stability and dissipation analysis; solver verification and validation; time-domain and steady-state PDE solution; implicit and explicit time integration schemes
- **High-Performance Computing:** MPI/OpenMPI parallel computing, Slurm scheduling, Linux clusters, batch workflows

Research Experience

Graduate Research Assistant, Computational Mechanics Laboratory, UMBC — *Jan 2022 to Present*
Department of Mechanical Engineering, University of Maryland Baltimore County — Baltimore, MD

- Developed and validated CFD models of turbulent boundary layer flows with coupled heat transfer, fluid dynamics, and species transport; benchmarked model predictions against reference data across grid resolutions on HPC clusters.
- Modeled subgrid-scale stress and transport behavior in high-resolution simulations; validated predictions against high-fidelity reference data through systematic grid-convergence and accuracy studies.
- Designed physics-constrained neural network models (Galilean and rotational invariance) as hybrid ML surrogates for expensive transport computations; integrated learned models into large-scale production solvers and benchmarked stability, accuracy, and speedup.
- Built Python pipelines to process and analyze terabyte-scale simulation outputs, correlating model predictions with observational and experimental data.

Graduate Research Assistant, Joint Center for Earth Systems Technology (JCET) — *Jan 2020 to Jun 2022*
UMBC, in collaboration with NOAA-affiliated research teams — Baltimore, MD

- Quantified how discretization choices affect energy and momentum transport fidelity in PDE-based solvers; benchmarked accuracy across grid resolutions and identified scheme-dependent error sources.
- Correlated simulation predictions against radar and remote sensing observational data; findings contributed to a peer-reviewed publication on solver fidelity under rapidly evolving flow conditions.

Key Research Projects

Physics-Constrained ML Surrogates for Transport Modeling — *2023 to Present*

- Designed invariance-embedded neural networks to replace expensive subgrid-scale stress computations with fast learned surrogates, embedding physical symmetry and conservation constraints directly in the model architecture (arXiv:2504.14473, under review).
- Integrated learned closures into large-scale CFD solvers; evaluated numerical stability, physical accuracy, and computational speedup through systematic a posteriori testing.

Numerical Dissipation Analysis and Wave Solver Design — *2020 to 2022*

- Quantified how discretization choices introduce artificial dissipation in wave-transport solvers, linking numerical scheme design to physical accuracy; findings directly guided downstream solver selection.

Selected Publications

- **Hasan, M. B.**, Yu, M., Oates, T. (2025). *Invariance-embedded ML Subgrid-scale Stress Models for Mesoscale Boundary Layer Simulation.* arXiv:2504.14473. *(Under review)*
- **Hasan, M. B.**, Yu, M., Oates, T. (2026). Semi-a priori Evaluation of Backscatter-Admitting ML Subgrid-Scale Models in WRF. *AIAA Aviation 2026. (Accepted)*
- **Hasan, M. B.**, Guimond, S. R., Yu, M., et al. (2022). *Effects of Numerical Dissipation on Hurricane Rapid Intensification. JAMES*, 14, e2021MS002897.

Education

University of Maryland, Baltimore County (UMBC) — *Baltimore, MD*
Ph.D., Mechanical Engineering *Advisor: Dr. Meilin Yu* — Expected May 2026
Dissertation: Invariance-Embedded ML Subgrid-Scale Models for Hurricane Boundary Layer Simulations: Development and *a priori/a posteriori* Tests with WRF

University of Maryland, Baltimore County (UMBC) — *Baltimore, MD*
M.S., Mechanical Engineering *Advisor: Dr. Meilin Yu* — Dec 2022
Thesis: Numerical Dissipation Effects on Mesoscale Hurricane Intensification Simulations

Bangladesh University of Engineering and Technology (BUET) — *Dhaka, Bangladesh*
B.Sc., Mechanical Engineering — 2017