Mohammad Afzal Shadab

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Education

Doctor of Philosophy | ***Computational Science, Engineering & Mathematics*** Aug 2019 – Dec 2024 (Expected)
The University of Texas at Austin, United States GPA: 3.90/4.0
Advisor: Prof. Marc Hesse

Master of Science | ***Computational Science, Engineering & Mathematics*** Aug 2019 – Aug 2021
The University of Texas at Austin, United States GPA: 3.90/4.0
Advisor: Prof. Marc Hesse

Master of Philosophy | ***Mechanical Engineering*** Aug 2016 – Sept 2018
The Hong Kong University of Science and Technology, Hong Kong GPA: 4.0(A)/4.3(A+)
Thesis: Fifth-order Finite Volume WENO in General Orthogonally-curvilinear Coordinates
Advisor: Prof. Kun Xu

Bachelor of Technology | ***Mechanical Engineering*** Aug 2012 – June 2016
Aligarh Muslim University, India GPA: 9.62/10.0
Thesis: Designing and Analysis of Supersonic Combustion Ramjet Engine
Advisor: Prof. M.F. Baig

Research Experience

Modeling meltwater percolation in Greenland's firn NASA Jet Propulsion Lab, Caltech
NASA JPL Graduate Fellow (Stipend: $900/week) May 2022 – July 2022
Advisor: Dr. Surendra Adhikari

- Developed a two-dimensional, three-phase (snow/water/air), firn infiltration simulator.
- Derived and validated vertically integrated model for meltwater gravity currents.
- Formulated kinematic wave theory of firn infiltration, inverted for model parameters and investigated meltwater infiltration in Greenland.

Two Phase Flow in Viscously Compacting Matrix The University of Texas at Austin
Graduate Research Assistant, *Doctoral Thesis* (Stipend: $2,500/month) August 2019 – Present
Advisor: Prof. Marc Hesse

- Developed and validated a conservative finite-difference based solver in Python for simulating a 2D two-phase flow in non-deforming porous media.
- Implemented the solver to study the behavior of Post Impact Hydrothermal systems on Mars.
- Implementing the solver to investigate the melt percolation on ice masses to study effects of global warming.

Investigating Groundwater Flows using Physics Informed Neural Networks UT Austin
Independent Research August 2020 – Present
Collaborators: DingCheng Luo, Yiran Shen, Eric Hiatt, and Prof. Marc Hesse

- Wrote python codes for data-driven discovery of steady-state PDE from experimental data.
- Investigated the effect of PDE regularization in PINNs and the role of PDE & data misfit.
- Learned the PDE parameters and boundary conditions for the transient seepage across edge of a porous reservoir simulated using finite-differencing.

Free Fall of a Viscous Drop in a Viscoelastic Medium Massachusetts Institute of Technology
Visiting Graduate Student Researcher (Stipend: $2,150/month) October 2018 – April 2019
Advisor: Prof. Irmgard Bischofberger

- Performed a literature review of computational and experimental methods for investigating drop dynamics.
- Designed the experiments and apparatus with high-speed imaging.
- Wrote MATLAB scripts for analysing moving camera videos using template matching.

High-Order Finite-Volume Reconstruction in Curvilinear Coordinates HKUST, Hong Kong
Graduate Research Assistant, *M.Phil. Thesis* (Stipend: $2,150/month) December 2016 – September 2018
Advisor: Prof. Kun Xu

- Proposed a general theory for state-of-art fifth order finite volume WENO in curvilinear coordinates.
- Derived analytical relations and developed Fortran codes along with Riemann solvers and gas-kinetic scheme.

Modal Decomposition Techniques on a Thermoacoustic System HKUST & U of Cambridge
Collaborative Research (Stipend: $2,150/month) August 2016 – December 2016
Advisor: Prof. Larry Li

- Analyzed and compared the prominent modal decomposition techniques for developing low order models.
- Investigated nonlinear interactions between flame & external forcing for different amplitudes & frequencies.

Designing & Analysis of Supersonic Combustion Ramjet Engine Aligarh Muslim University, India
Bachelor's Thesis September 2015 – June 2016
Advisor: Prof. M.F. Baig

- Developed and validated Fortran codes for designing Scramjets and analyzed its performance during unstart.
- Proposed Single-Input-Single-Output mechanism based on pressure feedback to avert engine unstart.

Effective Lewis Number for Multicomponent Hydrocarbon-Air Mixtures IIT–Delhi, India
Summer Research Intern June 2015 – August 2015
Advisor: Prof. M.R. Ravi

- Analyzed combustion characteristics of methane and natural gas mixtures with varying hydrogen blending.
- Performed the experiments using constant pressure combustion chamber apparatus with Schlieren imaging.
- Simulated the corresponding flames in 1D on CHEMKIN using PREMIX module.

Industrial Experience and Projects

Hummingbird – Wearable Device for Exchanging Information MIT & Hong Kong Innovation Node
Co-founder *(US based Startup Project)* May 2018 – February 2019

- Ideated and validated consumer problems and market opportunities through market research.
- Designed prototype on AutoCAD, fabricated using 3D printing, and implemented fast & accurate algorithms.
- Received MIT Sandbox Innovation Fund worth $5000 and won both Judge's & Audience Awards at MIT Entrepreneurship and Maker Skills Integrator program (2018).

Industrial Compressors and Gas Turbines Gas Authority of India Limited, India
Summer Intern June 2014 – July 2014

- Worked at a C2C3 plant at GAIL, participating in its pre-commissioning and commissioning testing.
- Studied the working of several industrial compressors and a gas turbine (Siemens SGT700).

Formula Student Race Car and Hybrid Tricycle Society of Automotive Engineers, Aligarh Chapter
Technical Member & Team Lead January 2013 – June 2014

- Conceptualized ergonomically designed the vehicles with improved aerodynamic performance.
- Designed the vehicles on AutoCAD, simulated on ANSYS, and then finally fabricated.

Teaching Experience

Pedagogical Training: Teaching Preparation Series Spring - Fall 2022
The University of Texas at Austin Austin
Advance teaching certificate for learning and practicing techniques of good classroom teaching.

GEO325C/398C Continuum Mechanics (Level: Graduate) Fall 2022
University of Texas at Austin Austin
Position: Teaching Assistant, *Instructor*: Prof. Marc Hesse

MECH-3690 Aerospace Engineering Laboratory (Level: Senior, Junior) Spring 2017
The Hong Kong University of Science and Technology Hong Kong
Position: Teaching Assistant, *Instructor*: Prof. Jinglei Yang

MECH-1907 Introduction to Aerospace Engineering (Level: Freshman, Sophomore) Spring 2018
The Hong Kong University of Science and Technology Hong Kong
Position: Teaching Assistant, *Instructor*: Prof. Rhea Liem

For all teaching feedback reports, click .

Honors and Awards

UT Austin Professional Development Award October 2022
For presenting two researches conducted at the UT Austin. $500

NASA Jet Propulsion Laboratory Graduate Fellowship April - June 2022
To study effect of climate change on Greenland ice sheet with Dr. Surendra Adhikari at JPL. $9,000

Purdue Climate Scholar by Purdue University and Office of Naval Research June - August 2022
To attend Summer Institute for Sustainability & Climate Change at Purdue University. $4,000

MIT - Houston Energy Innovation Student Fellow March 2022
Representing UT Austin as a liaison between MIT's Martin Trust Center and Greentown Labs.

Lunar and Planetary Institute Career Development Award Feb 2022
For first author abstract and application materials submitted at LPSC 2022. $1,000

UT Austin Cactus Standout Award (estd. 1894) April 2022
For academic excellence and leadership contributions. Inducted into Annual Yearbook, 2022.

Student Research Award in Planetary Habitability by Cent. for Planetary Sys. Habitability Jan 2022
For proposal on finding life-supporting conditions on Europa using computational methods. $16,425

Outstanding Student Presenters Award by Unsaturated Zone Technical Committee, AGU Dec 2021
Third prize for oral presentation: H52D-10 Rainwater Infiltration at AGU Fall Meeting 2021. $175

SIAM Certificate of Recognition by Society for Industrial and Applied Mathematics February 2021
For outstanding service and contributions to the UT Austin Student Chapter of SIAM.

University of Texas Institute for Geophysics Student Fellowship by UTIG, UT Austin January 2021
Year-long fellowship covering tuition, insurance & stipend awarded for collaborative research. $2,491/month

Best Teaching Assistant Award - II by Dept of Mech & Aero Engg, HKUST August 2018
Awarded for MECH-1907 Introduction to Aerospace Engineering course based on
student surveys and jury of professors. HK$300

Judge's Award and Audience Award at MIT MEMSI Program June 2018
Awarded by MIT and Hong Kong Innovation Node to best startup idea & pitch in the program.

Outstanding Contribution in Reviewing Recognition by Journal of Computational Physics June 2018
For being in the top 10th percentile of reviewers.

Postgraduate Studentship by HKUST Aug 2016 – Sept 2018
Competitive stipend for research postgraduate students (M.Phil.) at HKUST. $2,150/month

Global Scholar Award by Sir Syed Education Society of North America May 2015
For top 20 students of AMU based on their academic achievements and research, for higher education. $1,000

National Summer Research Fellowship by Indian Academy of Sciences March 2015
Awarded national fellowship to pursue research in Indian research institutes like IITs/IISc. $220/month

University Merit Scholarship by AMU Alumni Association Toronto, Canada March 2015
Merit based scholarship for students pursuing education at AMU. $70

Travel Grants And Funded Short Schools

Center for Planetary Systems' Habitability Student Travel Funding Award February 2022
Awarded a travel grant to attend the LPSC 2022. $1,000

AGU Fall Meeting Grant December 2021
Awarded a travel grant to attend the AGU Fall Meeting 2021.

SIAM Student Travel Award June 2021
Awarded a student travel grant to attend the SIAM Annual Meeting 2021. $650

ICOSAHOM Conference Travel Grant July 2018
Awarded a student travel grant to attend the International Conference on Spectral And High Order Methods at Imperial College London. $2500

Numerical Simulations ICNM 2017 Conference Travel Grant July 2017
Awarded full funding from HKUST for attending the 5th International Conference on Numerical Simulations for Multimaterial and Multiphysics Problems in China. $2200

Advanced Research in Turbomachniery Summer School Grant July 2019
Received a scholarship to attend this summer school organized by the University of Florence, Italy and sponsored by ANSYS and GE. €800

MIT StartMIT Course Grant January 2019
Received full sponsorship from MIT Martin Trust Center to attend this hands-on MIT course on entrepreneurship involving multiple trips to companies within USA.

Fluid Dynamics across Scales Summer School Grant July 2018
Received full-funding from HKUST to attend the Centre for Doctoral Training in Fluid Dynamics across Scales at Imperial College London. $1000

MIT Entrepreneurship and Maker Skills Integrator Bootcamp Funding June 2018
Received full funding from MIT and Hong Kong Innovation Node to attend the program involving trips to startup incubators in China.

Community Involvement

Exec. Board Member, US Association of Polar Early Career Scientists (USAPECS) Sept 2022 – Present
Fostering climate-conscious collaborations between academia & polar organizations.

MIT - Houston Energy Innovation Student Fellow March 2022 – Present
Creating energy innovation ecosystem considering the threat of climate change.

Mentor, American Geophysical Union Earth & Planetary Surface Processes (EPSP) Oct 2022 – Present
Mentoring graduate students across the world for developing technical and research skills in EPSP. Virtual

Geoscience Ambassador, Jackson School of Geosciences, UT Austin Sept 2021 - Present
Making geoscience accessible to broader community & promoting interdisciplinary research. Austin, USA

Session Chair, Society for Industrial & Applied Mathematics Annual Meeting 2021 July 2021
Chaired the "CP15: Machine Learning and Data Mining" Session. Virtual

President & Senior Advisor, Soc. for Industrial & Applied Math, Austin Chapter Sept 2020 – Present
Spearheaded several programs & Won Best Graduate Organization at UT Austin Award. Austin, USA

Mentor, Mentoring365, American Geophysical Union Aug 2021 – Present
Facilitating an exchange of professional knowledge, skills, and experiences in Earth and space sciences. Virtual

Mentor, SIAM Applied Mathematics Mentorship Jan 2021 – Present
Conceptualized the program and mentoring UT students for applied math concepts and prospects. Austin, USA

Volunteer, Lunar and Planetary Science Conference 2022 March 2021
Managed a virtual and an in-person session and moreover conference logistical tasks. Houston, USA

Mentor, Sir Syed Global Scholar Award Jan 2016 – Present
Mentoring top AMU students from humble backgrounds for US grad school applications. Aligarh, India

Vice-Chairperson, American Society of Mechanical Engineers, Aligarh Chapter Sept 2014 – June 2016
Organized various events including paper presentation and annual technical festival. Aligarh, India

Zonal Head & College Head Ambassador, Smilyo Educational Charitable Society Jan 2014 – Jan 2015
Managed multi-university teams & provided educational resources to not-so-privileged. New Delhi, India

Senior Under Officer, National Cadet Corps, Govt. of India (Similar to ROTC) Jan 2013 – April 2015
C certificate holder, best cadet, organized blood donation, awareness, & army camps Aligarh, India

Reviewer for Technical Journals

Geoscience: Computational Geoscience, Water Resources Research, Journal of Geophysical Research
Fluid Mechanics: Journal of Fluid Mechanics, Physics of Fluids, Physical Review Fluids, Springer Nature
Numerical Methods: Journal of Computational Physics, Computer and Fluids, Computer and Geotechnics

Skills

Languages: C, C++, Fortran 77/90, Python (SciPy, NumPy, Matplotlib, Pandas, Tensorflow, Tkinter), MATLAB, Mathematica, Shell Scripting, LaTeX, High Performance Computing
Software: AutoCAD, SolidWorks, ANSYS, Fluent, COMSOL Multiphysics, TecPlot, ParaView, CHEMKIN, COSILAB, Microsoft Office, Git, Travis CI, Docker, Hydrus, VPLanet
OS: Linux, Windows, Mac

Student Membership

American Geophysical Union
Association of Polar Early Career Scientists
Society for Industrial and Applied Mathematics
American Physical Society

Peer Reviewed Publications

Shadab, M.A. and Hesse, M.A., 2022. Analysis of gravity-driven infiltration with the development of a saturated region, Water Resources Research (AGU), DOI: 10.1029/2022WR032963 (in press)

Shadab, M.A. and Hesse, M.A., 2022. A hyperbolic-elliptic PDE model and conservative numerical method for gravity-dominated variably-saturated groundwater flow. arXiv preprint arXiv:2210.04724. (submitted to Journal of Computational Physics, Elsevier)

Hiatt, E. **Shadab, M.A.**, Hesse, M., Goudge, T., Gulick, S., 2022. Limited Recharge of a Deep Groundwater Aquifer In the Southern Highlands On Early Mars. (submitted to Geophysical Research Letters, AGU)

Shadab, M.A., Luo, D., Shen, Y., Hiatt, E. and Hesse, M.A., 2021. Investigating Steady Unconfined Groundwater Flow using Physics Informed Neural Networks. arXiv preprint arXiv:2112.13792. (under review in Advances in Water Resources, Elsevier)

Shadab, M.A., Balsara, D., Shyy, W. and Xu, K., 2019. Fifth order finite volume WENO in general orthogonally - curvilinear coordinates. Computers & Fluids (Elsevier), 190, pp.398-424.

Shadab, M.A., Ji, X. and Xu, K., 2018. Fifth-order finite-volume WENO on cylindrical grids. Spectral and High Order Methods for Partial Differential Equations (Springer), p.637.

Conferences

Shadab, M.A., and Hesse, M.A., 2022. An extended kinematic-wave theory for infiltration in soils with declining porosity causing delayed perching. 2022 American Geophysical Union (AGU) Fall Meeting.

Shadab, M.A., and Hesse, M.A., 2022. Extending Richards equation to simulate variably saturated flows. 2022 AGU Fall Meeting.

Hiatt, E. **Shadab, M.A.**, Hesse, M., Goudge, T., Gulick, S., 2022. Limited Recharge On Early Martian Aquifers: Numeric Analytic Recharge Rate Estimates As Constrained By Geomorphic and Geochemical Observations. 2022 AGU Fall Meeting.

Barnes, R., ... **Shadab, M.A.**,..., 2023. History and Habitability of the LP 890-9 Planetary System. 241st American Astronomical Society Meeting 2023. (submitted)

Shadab, M.A., Hiatt, E., and Hesse, M.A., 2022. Estimates of Martian mean recharge rates from analytic groundwater models. 53rd Lunar and Planetary Science Conference 2022, Abstract #1775.

Hiatt, E., **Shadab, M.A.**, et al, 2022. Estimates of groundwater divides and basins on Noachian Mars. 53rd Lunar and Planetary Science Conference 2022, Abstract #2618.

Shadab, M.A., Grima, C., Rutishauser, A., and Hesse, M.A., 2021. Analytical Solutions for Melt Percolation in Ice Masses and a Pathway to Ice Lens Formation. 2021 AGU Fall Meeting.

Shadab, M.A., and Hesse, M.A., 2021. Fluid Infiltration in Unsaturated Porous Medium with The Development of a Saturated Region. 2021 AGU Fall Meeting.

Hesse, M.A., **Shadab, M.A.**, Luo, D., Shen, Y., and Hiatt, E., 2021. Investigating Groundwater Flow Dynamics using Physics Informed Neural Networks (PINNs). 2021 AGU Fall Meeting.

Hiatt, E., **Shadab, M.A.**, et al, 2021. Experimental and Numerical Investigation of Seepage Face Dynamics. 2021 AGU Fall Meeting.

Hesse, M.A., **Shadab, M.A.**, Hiatt, E., Liebeck, J., 2021. Groundwater-ocean interaction on Mars. 2021 AGU Fall Meeting.

Hiatt, E., **Shadab, M.A.**, et al, 2021. Numerical Modeling of the Formation of Hellas Planitia with Focus on Spatio-Temporal Scales Required for Hydrologic Equilibration. 2021 AGU Fall Meeting.

Shadab, M.A., Luo, D., Shen, Y., Hiatt, E., and Hesse, M.A., 2021. Investigating fluid drainage from the edge of a porous reservoir using Physics Informed Neural Networks. 2021 SIAM Annual Meeting.

Shadab, M.A., Divoux, T. and Bischofberger, I., 2020. Suppression of drop breakup in a viscoelastic bath. Bulletin of the American Physical Society.

Hiatt, E., **Shadab, M.A.** et al., 2020. Groundwater filling times for large impact basins on early Mars and implications for the onset of post impact hydrothermal systems. American Geophysical Society 2020 Fall Meeting.

Shadab, M.A., Ji, X. and Xu, K., 2018. Fifth-order finite-volume WENO on Cylindrical Grids: Flux Evaluation Using Riemann Solvers and Gas-kinetic Scheme. In International Conference on Spectral And High Order Methods (ICOSAHOM), Imperial College London.

Shadab, M.A., and Xu, K., 2017. Fifth order finite volume WENO in orthogonally-curvilinear coordinates. In 5th International Conference on Numerical Simulations for Multimaterial and Multiphysics Problems.

Shadab, M.A. and Baig, M.F., 2017. Investigation and Control of Unstart Phenomenon in Scramjets. In 21st AIAA International Space Planes and Hypersonics Technologies Conference (p. 2298).

Media Coverage

Fulfilling my NASA dream - Sir Syed Global Scholar Award Story of the Month Aug 2022
On my post-baccalaureate experience towards landing a graduate fellowship at NASA JPL.

Mars may have less water than previously estimated - Multiple news outlets April 2022
UT Austin Website (front cover) & , Phys.org , Times of India , Bailey Universe

Outstanding Student Presentation Award at AGU 2021 - UT Austin April 2022
For outstanding student presentation on Rainwater Infiltration in AGU Fall Meeting 2021.

CPSH Travel Grant Sends 11 Students to LPSC - UT Austin March 2022
For travel grant of $1,000 from Center for Planetary Systems Habitability to attend LPSC 2022.

Lunar & Planetary Institute Career Devel. Award News - UT Austin , LPI News Feb 2022
For outstanding first-authored work on fate of water on early Mars submitted at LPSC conference.

How To Stay Productive While in Quarantine - Oden Institute Feature Article March 2021
For academic & research achievements and service at Oden Institute during quarantine.

Softwares

Shadab, M.A., Luo, D., Shen, Y., Hiatt, E., and Hesse, M.A., 2021. PINNs for Unconfined Groundwater Flow (v1.0). Zenodo. https://doi.org/10.5281/zenodo.5803542

Shadab, M.A. and Hesse, M.A., 2022. Gravity driven infiltration with the development of a saturated region (v1.0). Zenodo. DOI: 10.5281/zenodo.6558260. URL: https://github.com/mashadab/hyperbolic-infiltration-theory

Shadab, M.A., 2021. Reservoir-Simulator. Zenodo. DOI: https://doi.org/10.5281/zenodo.6581752. URL: https://github.com/mashadab/Reservoir-Simulator