AMLAN SINHA

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RESEARCH STATEMENT

I am a Ph.D. candidate in Mechanical and Aerospace Engineering at Princeton University, specializing in *dynamical systems*, *optimal control* and *nonlinear optimization*. My research aims to unify tools from these three domains to develop an efficient algorithmic framework with formal guarantees to design robust trajectories for low-thrust spacecrafts under operational uncertainties such as partial or complete engine loss in complex multibody dynamical systems.

Research Interests: Optimal Control, Dynamical Systems, Nonlinear Optimization, Bi-level Optimization, Numerical Methods, Machine Learning, Astrodynamics, Classical Mechanics.

ACADEMIC BACKGROUND

Princeton University   *Aug 2018-Present*
Doctoral Candidate in Aerospace Engineering
Thesis: *Low-Thrust Spacecraft Trajectory Design with Robustness against Operational Uncertainties*
Dissertation Committee: Ryne Beeson (adviser), Naomi Ehrich Leonard, Robert J. Vanderbei
Certificates: Computational Science & Engineering, Teaching Transcript Program
Princeton University   *May 2020*
M.A. (incidental) in Mechanical Engineering
Cornell University   *May 2018*
B.S. in Mechanical Engineering, Minor in Aerospace Engineering
GPA: 3.52/4.00 (*Cum Laude*)

FELLOWSHIPS, AWARDS AND HONORS

Research Opportunities in Space and Earth Science, *Research Grant*, NASA (2024, 2025)	**$200,000**
Crocco Award, *Teaching Award*, Princeton University (2024)	**$1,000**
C.V. Starr Fellowship, *Merit Scholarship*, Princeton University (2020)	**$100,000**
Graduate Teaching Fellowship, *Teaching Award*, Princeton University (2020)	**$1,000**
University Administrative Fellowship, *Professional Development Award*, Princeton University (2019)	**$1,000**
Engineering Learning Initiative, *Research Fellowship*, Cornell University (2015, 2016, 2017)	**$15,000**
Undergraduate Scholarship, *Full-Ride Merit Scholarship*, Cornell University (2014-18)	**$320,000**

RESEARCH EXPERIENCE

Beeson Lab   Jan 2022 - Present
Graduate Research Assistant, Adviser: Ryne Beeson   *Princeton, NJ*

· Qualitatively and quantitatively investigated the role of dynamical structures on robust low-thrust spacecraft trajectory design in complex multibody dynamical environments using tools from dynamical systems,
· Developed efficient computational approaches for robust low-thrust spacecraft trajectory design through better initial guess generation, analytic derivatives computation, and parallel computation strategies,
· Designed a bi-level optimal control framework to provide formal guarantees for robust low-thrust spacecraft trajectory design, bridging the gap between theoretical optimality and practical implementation.

Rowley Lab   Aug 2018 - Dec 2021
Graduate Research Assistant, Adviser: Clarence Rowley   *Princeton, NJ*

· Developed a bayesian optimal control algorithm to minimize the worst-case regret for a linear dynamical system with an unknown system parameter under perturbative additive noise.

JOURNAL PUBLICATIONS

J.1 **Amlan Sinha** and Ryne Beeson, "Statistical Analysis of the Role of Invariant Manifolds on Robust Trajectories", Journal of Guidance, Control, and Dynamics, Vol. 48, No. 8 (2025), pp. 1818-1839, doi: doi/abs/10.2514/1.G008818.

J.2 **Amlan Sinha** and Ryne Beeson, "Initial Guess Generation for Low-Thrust Trajectory Design with Robustness to Missed-Thrust-Events", Journal of Guidance, Control, and Dynamics, (*in-press, accepted for publication*).

CONFERENCE PUBLICATIONS

C.1 **Sinha, A.**, Beeson, R. (2025) *"A Bi-Level Optimal Control Framework for Relative Low-Thrust Spacecraft Motion under Missed Thrust Events,"* 2025 AAS/AIAA Astrodynamics Specialist Conference, Boston, MA.

C.2 Chhabra, A., **Sinha, A.**, Beeson, R. (2025) "*Adaptive Keep-Out Zones For Cislunar Orbital Debris Mitigation*," 2025 AAS/AIAA Astrodynamics Specialist Conference, Boston, MA.

C.3 Palomo, M., **Sinha, A.**, Jo, S. G., Graebner, J., Canales, D., Beeson, R. (2025) "*Near-Optimal Transfers from Varying Orbit Families to Low-Lunar Orbits via Analytical Lower-Bound Delta-V Comparison*," 2025 AAS/AIAA Astrodynamics Specialist Conference, Boston, MA.

C.4 **Sinha, A.**, Beeson, R. (2025) "*Comparative Study of Derivative Methods in Robust Low-Thrust Trajectory Design*," 34th AIAA/AAS Space Flight Mechanics Meeting, Kaua'i, HI.

C.5 **Sinha, A.**, Chhabra, A., Beeson, R. (2024) "*Debris Proliferation Modeling and Risk Analysis for Cislunar Orbits*," International Astronautical Congress, Milan, Italy.

C.6 **Sinha, A.**, Chhabra, A., Kon, E., Beeson, R. (2024) "*Incorporating Orbital Debris Risk Analysis into Cislunar Orbital Procedures and Post-Mission Disposal*," International Astronautical Congress, Milan, Italy.

C.7 Chhabra, A., **Sinha, A.**, Beeson, R. (2024) "*Incentivizing Adoption of Cislunar Orbital Debris Mitigation Policies via Norms of Behaviour*," International Astronautical Congress, Milan, Italy.

C.8 **Sinha, A.**, Beeson, R. (2024) "*On Robust Low Thrust Trajectories and Invariant Manifolds (Part II)*," 2024 AAS/AIAA Astrodynamics Specialist Conference, Broomfield, CO.

C.9 **Sinha, A.**, Beeson, R. (2024) "*Analysis of Robust Low Thrust Trajectories for The Lunar Gateway (Part II)*," 2024 AAS/AIAA Astrodynamics Specialist Conference, Broomfield, CO.

C.10 Graebner, J., Li, A., **Sinha, A.**, Beeson, R. (2024) "*Learning Optimal Control and Dynamical Structure of Global Trajectory Search Problems with Diffusion Models*," 2024 AAS/AIAA Astrodynamics Specialist Conference, Broomfield, CO.

C.11 Gi Jo, S., **Sinha, A.**, Anderson, A., Graebner, J., Schmitt, J., Palomo, M., Canales Garcia, D., Beeson, R. (2024) "*Global Analysis of Optimal Trajectories from Earth-Moon 9:2 Near Rectilinear Halo Orbit to Low-Lunar Orbits*," 2024 AAS/AIAA Astrodynamics Specialist Conference, Broomfield, CO.

C.12 Olson, A., **Sinha, A.**, Chhabra, A., Fry, S., Ahner, K., Beeson, R. (2024) "*A Feasibility Study of Microsat Mission Architectures for Ring Science in the Uranian System*," 34th AIAA/AAS Space Flight Mechanics Meeting, Orlando, FL.

C.13 **Sinha, A.**, Beeson, R. (2023) "*On Robust Low Thrust Trajectories and Invariant Manifolds*," 2023 AAS/AIAA Astrodynamics Specialist Conference, Big Sky, MT.

C.14 **Sinha, A.**, Beeson, R. (2023) "*Analysis of Robust Low Thrust Trajectories for The Lunar Gateway*," 2023 AAS/AIAA Astrodynamics Specialist Conference, Big Sky, MT.

C.15 Li, A., **Sinha, A.**, Beeson, R. (2023) "*Amortized Global Search for Efficient Preliminary Trajectory Design with Deep Generative Models*," 2023 AAS/AIAA Astrodynamics Specialist Conference, Big Sky, MT.

C.16 Beeson, R., **Sinha, A.**, Jagannatha, B., Bunce, D., and Carroll, D. (2022) "*Dynamically Leveraged Automated Multibody (N) Trajectory Optimization*," 2022 AAS/AIAA Astrodynamics Specialist Conference, Charlotte, NC.

C.17 Soto, G., **Sinha, A.**, Savransky, D., Delacroix, C., Garrett, D. (2017) "*Starshade Orbital Maneuver Study for WFIRST*," SPIE Proc. Techniques and Instrumentation for Detection of Exoplanets VIII.

C.18 Soto, G., Lloyd, J., Savransky, D., Grogan, K., **Sinha, A.** (2017) "*Optimization of High-Inclination Orbits using Planetary Flybys for a Zodiacal Light-Imaging Mission*," SPIE Proc. Techniques and Instrumentation for Detection of Exoplanets VIII.

TEACHING EXPERIENCE

Graduate Teaching Assistant   2018-Present
Princeton University   *Princeton, NJ*

· MAE 206 (Engineering Dynamics)
· MAE 342 (Space Systems Design)
· MAE 433 (Automatic Control Systems)
· MAE 501 (Mathematical Methods of Engineering Analysis)

Teaching Transcript (McGraw Center): Teaching development program consisting of pedagogy workshops and classroom observations

Undergraduate Teaching Assistant 2014-2018
Cornell University *Ithaca, NY*
· ENGRG 1112 (Practical Computing in Engineering)
· MAE 2030 (Engineering Dynamics)
· MAE 2210 (Thermodynamics)
· MAE 3260 (System Dynamics)

MENTORSHIP EXPERIENCE

Graduate Students 2018-Present
Princeton University *Princeton, NJ*
· Anjian Li, Ph.D. Candidate in Electrical and Computer Engineering at Princeton University
· Arjun Chhabra, Ph.D. Candidate in Mechanical and Aerospace Engineering at Princeton University
· Yujing Zhou, Commercial Airline Pilot at Cathay Pacific
· Jannik A. Graebner, Ph.D. Student in Mechanical and Aerospace Engineering at Princeton University

Undergraduate Students 2018-Present
Princeton University *Princeton, NJ*
· Kristen Ahner, Ph.D. Candidate in Mechanical and Aerospace Engineering at University of Colorado Boulder
· An-Ya Olson, Discovery Program Associate Staff at Johns Hopkins Applied Physics Laboratory

OUTREACH EXPERIENCE

Case Competition Chair Aug, 2023 - May, 2024
Graduate Consulting Club *Princeton, NJ, USA*
· Organized the largest ivy league case competition with 250+ participants (1.5× growth), built sustainable sponsorship pipelines with 7 industry/consulting sponsors raising $15,000 (2.5× growth) in funding, co-led ∼15 weekly case practice sessions with 100+ participants.

Instructor Aug, 2021 - Present
Garden State Youth Correctional Facility *Crosswicks, NJ, USA*
· Developed a math course for 15 incarcerated youth, organized 3 workshops to explore post-release career opportunities, facilitated team-building activities in collaboration with 50+ volunteers across different facilities.

Sustainability Chair Jan, 2019 - Dec, 2020
Department of Mechanical and Aerospace Engineering, Princeton University *Princeton, NJ, USA*
· Led departmental sustainability initiatives reducing annual energy consumption by 5%, served as liaison between department and graduate school to advocate for sustainable practices within department, wrote bi-weekly newsletters to 300+ students and faculty members.

Co-Founder Jan, 2019 - Dec, 2019
Start Smart *Dhaka, Bangladesh*
· Co-founded non-profit focused on educational advancement, provided college application support for 500+ low-income high school students from Bangladesh securing a cumulative total of $1 million in financial aid, organized 10+ networking events with industry professionals.

RELEVANT COURSEWORK

Optimal Control, Data Assimilation, Dynamical Systems, Linear Optimization, Convex Optimization, Numerical Methods, Machine Learning

TECHNICAL STRENGTHS

Programming Languages	C, C++, Python, Julia, Matlab
Research Tools	Bash, Git, CI, Docker, Jira, Latex, Mathematica
Research Skills	Mathematical Modeling, Stochastic Calculus, Time-Series Analysis (MA, AR, ARMA, ARIMA, ARCH, GARCH), Model Reduction (FA, PCA, ICA, ISOMAP, t-SNE, UMAP), Machine Learning (Supervised, Unsupervised), Neural Networks, Diffusion Models, Monte Carlo Simulations, High Performance Computing, Parallel Programming (shared, distributed), Data Visualization
Design and Fabrication	Solidworks, ANSYS, Arduino, Raspberry Pi