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 *optimization*. My research aims to unify tools from these three domains to develop a theoretical and algorithmic framework 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, Robust Control, Classical Mechanics, Dynamical Systems, Linear Optimization, Convex Optimization, Bi-level Optimization, Numerical Methods, Machine Learning.

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, Statistics & Machine Learning, 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 by using tools from dynamical systems,
· Improved efficiency of global search algorithms in robust low-thrust spacecraft trajectory design by developing novel algorithmic techniques,
· Currently working on applying tools from bi-level optimal control theory to design efficient algorithms for robust low-thrust spacecraft trajectory design under operational uncertainties, focusing both on theoretical questions of existence and uniqueness of solutions and algorithm development (e.g., use of diffusion models

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 **Sinha, A.**, Beeson, R. (2024) "Statistical Analysis of the Role of Invariant Manifolds on Robust Trajectories.", *Journal of Guidance, Control, and Dynamics* (*accepted*)

J.2 **Sinha, A.**, Beeson, R. (2024) "Initial Guess Generation for Low-Thrust Trajectory Design with Robustness to Missed-Thrust-Events." (*submitted, in review*)

J.3 Beeson, R., Li, A., **Sinha, A.** (2024) "Global Search of Optimal Spacecraft Trajectories using Amortization and Deep Generative Models." (*submitted, in review*)

CONFERENCE PUBLICATIONS

C.1 **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.2 **Sinha, A.**, Chhabra, A., Beeson, R. (2024) "*Debris Proliferation Modeling and Risk Analysis for Cislunar Orbits,*" International Astronautical Congress, Milan, Italy.

C.3 **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.4 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.5 **Sinha, A.**, Beeson, R. (2024) "*On Robust Low Thrust Trajectories and Invariant Manifolds (Part II),*" 2024 AAS/AIAA Astrodynamics Specialist Conference, Broomfield, CO.

C.6 **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.7 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.8 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.9 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.10 **Sinha, A.**, Beeson, R. (2023) "*On Robust Low Thrust Trajectories and Invariant Manifolds,*" 2023 AAS/AIAA Astrodynamics Specialist Conference, Big Sky, MT.

C.11 **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.12 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.13 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.14 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.15 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 ($1.5\times$ growth), built sustainable sponsorship pipelines with 7 industry/consulting sponsors raising \$15,000 ($2.5\times$ growth) in funding, co-led $\sim$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