

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 , <i>Research Grant</i> , NASA (2024, 2025)	\$200,000
Crocco Award , <i>Teaching Award</i> , Princeton University (2024)	\$1,000
C.V. Starr Fellowship , <i>Merit Scholarship</i> , Princeton University (2020)	\$100,000
Graduate Teaching Fellowship , <i>Teaching Award</i> , Princeton University (2020)	\$1,000
University Administrative Fellowship , <i>Professional Development Award</i> , Princeton University (2019)	\$1,000
Engineering Learning Initiative , <i>Research Fellowship</i> , Cornell University (2015, 2016, 2017)	\$15,000
Undergraduate Scholarship , <i>Full-Ride Merit Scholarship</i> , 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.”, *Journal of Guidance, Control, and Dynamics* (*submitted, in review*)
- J.3 Beeson, R., Li, A., **Sinha, A.** (2024) “Global Search of Optimal Spacecraft Trajectories using Amortization and Deep Generative Models.”, *Journal of Guidance, Control, and Dynamics* (*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

Princeton University

2018-Present

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

Cornell University

2014-2018

Ithaca, NY

- ENGRG 1112 (Practical Computing in Engineering)
- MAE 2030 (Engineering Dynamics)
- MAE 2210 (Thermodynamics)

- MAE 3260 (System Dynamics)

MENTORSHIP EXPERIENCE

Graduate Students

Princeton University

2018-Present

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

Princeton University

2018-Present

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

Graduate Consulting Club

Aug, 2023 - May, 2024

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 ~ 15 weekly case practice sessions with 100+ participants.

Instructor

Garden State Youth Correctional Facility

Aug, 2021 - Present

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

Department of Mechanical and Aerospace Engineering, Princeton University

Jan, 2019 - Dec, 2020

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

Start Smart

Jan, 2019 - Dec, 2019

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