

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 dynamical systems and optimal control 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, Dynamical Systems, Classical Mechanics, Astrodynamics, 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>Excellence-in-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>Merit Fellowship</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 trajectories in complex multibody dynamical environments using tools from dynamical systems,
- Developed algorithmic techniques to improve efficiency of global search algorithms in robust trajectory optimization problems,
- Currently working on applying tools from bi-level optimal control theory to design efficient algorithms for 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 algorithm to determine optimal control strategies minimizing the worst-case regret for a linear dynamical system with an unknown system parameter with additive Gaussian 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

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 ($1.3\times$ growth), built sustainable sponsorship pipelines with 7 industry/consulting sponsors raising \$15,000 ($1.5\times$ 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 an introductory course for 15 incarcerated youth, arranged 2 workshops to discuss post-graduation career opportunities in STEM, designed multiple team-building activities in collaboration with 50+ volunteers

Sustainability Chair

Department of Mechanical and Aerospace Engineering, Princeton University

Jan, 2019 - Dec, 2020

Princeton, NJ, USA

- Served as liaison between department and graduate school advocating for environmentally conscious practices (reducing annual energy consumption by 5%), managed programming for 3 sustainability focused events, wrote bi-weekly newsletters to 250+ 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 250+ low-income high school students from Bangladesh securing a cumulative total of \$1 million in financial aid, planned 10+ networking events with industry professionals

RELEVANT COURSEWORK

Optimal Control, Dynamical Systems, Linear/Nonlinear Optimization, Convex Optimization, Machine Learning, Numerical Analysis

TECHNICAL STRENGTHS

Programming Languages

C, C++, Python, Julia, Matlab

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