

AMLAN SINHA

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RESEARCH STATEMENT

I am a Ph.D. candidate in Mechanical and Aerospace Engineering at Princeton University, specializing in optimal control, dynamical systems, 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, Bi-level Optimal Control, Dynamical Systems, Classical Mechanics, Linear Optimization, Convex Optimization, Numerical Methods, Astrodynamics, Machine Learning.

ACADEMIC BACKGROUND

Princeton University Aug 2018-Present

Doctoral Candidate in Aerospace Engineering

Thesis: *Low-thrust spacecraft trajectory design with robustness guarantees against engine failures*

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

Crocco Award , <i>Excellence-in-Teaching Award</i> , Princeton University (2024)	\$1,000
C.V. Starr Fellowship , <i>Merit Fellowship</i> , Princeton University (2020)	\$100,000
University Administrative Fellowship , <i>Professional Development Award</i> , Princeton University (2019)	\$1,000
Engineering Learning Initiative , <i>Summer Research Fellowship</i> , Cornell University (2015-17)	\$12,000
Undergraduate Scholarship , <i>Full-Ride Coverage</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 optimal control and 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* (*submitted, in review*)

J.2 **Sinha, A.**, Beeson, R. (2024) “Algorithmic Considerations for Effective Global Search of Robust Low-Thrust Trajectories.” (*submitted, in review*)

CONFERENCE PUBLICATIONS

C.1 **Sinha, A.**, Chhabra, A., Beeson, R. (2024) “*Debris proliferation modeling and risk analysis for cislunar orbits*,” International Astronautical Congress, Milan, Italy.

- C.2 **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.3 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.4 **Sinha, A.**, Beeson, R. (2024) “*On Robust Low Thrust Trajectories and Invariant Manifolds (Part II)*,” 2024 AAS/AIAA Astrodynamics Specialist Conference, Broomfield, CO.
- C.5 **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.6 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.7 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.8 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.9 **Sinha, A.**, Beeson, R. (2023) “*On Robust Low Thrust Trajectories and Invariant Manifolds*,” 2023 AAS/AIAA Astrodynamics Specialist Conference, Big Sky, MT.
- C.10 **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.11 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.12 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.13 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.14 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 <i>Princeton University</i>	2018-Present <i>Princeton, NJ</i>
<ul style="list-style-type: none"> 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 <i>Cornell University</i>	2014-2018 <i>Ithaca, NY</i>
<ul style="list-style-type: none"> ENGRG 1112 (Practical Computing in Engineering) MAE 2030 (Engineering Dynamics) MAE 2210 (Thermodynamics) MAE 3260 (System Dynamics) 	

MENTORSHIP EXPERIENCE

Graduate Students <i>Princeton University</i>	2018-Present <i>Princeton, NJ</i>
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· Anjian Li, Arjun Chhabra, Yujing Zhou, Jannik A. Graebner

Undergraduate Students
Princeton University

2014-2018
Princeton, NJ

· Kristen Ahner, An-Ya Olson

OUTREACH EXPERIENCE

Case Competition Chair
Graduate Consulting Club

Aug, 2023 - Present
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