Chad Harper

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Education

Ph.D. in Physics (Expected 2026)
University of California, Berkeley

M.A. in Physics (Spring 2025)
University of California, Berkeley

B.A. in Mathematics and Physics (May 2018)
Grinnell College, Grinnell, IA

Research Experience

Graduate Student Researcher, Bouchard & DeWeese Labs (August 2022 – Present)
University of California, Berkeley

- Developed a graph-theoretic extension of mutual information to quantify how local network substructures contribute to the predictability of global dynamics.
- Applied an information-theoretic metric to model "intrinsic dynamical complexity" in single neurons using Dynamical Components Analysis (DCA), distinguishing predictive dynamical structure from static variance.
- Analyzed 110 TB of simulation data from 169 biophysically detailed cortical neuron models (Blue Brain Project) to characterize the biophysical determinants of information processing.
- Applied Random Forest regression to map high-dimensional biophysical features to complexity scores, identifying dendritic morphology and specific ion channel kinetics (e.g., Kv3.1, SK) as primary drivers of neuronal predictive capacity.
- Extending the process motif formalism to multilayer networks, formulating layer-aware walk counts, multilayer motif equivalence classes, and convergent motif expansions on supra-adjacency representations.

Researcher, Stanford Med-Currie Lab (May 2022 – Spring 2025)
Stanford University

- Applied formal ethical and statistical techniques to transform a complex public health challenge into a quantifiable optimization problem, leading to a policy proposal currently submitted to bioethics journal.
- Conducted a methodological critique of established policy algorithms, including the UNOS Continuous Distribution System (CDS) and the Complete Lives System (CLS), arguing their theoretical foundations are flawed.
- Modeled and optimized a Rawlsian social welfare function to balance competing ethical principles in transplant policy, specifically addressing distributive justice and patient access to scarce resources.

Research Fellow, Perlmutter Group (June 2018 – September 2018)
Lawrence Berkeley National Lab

- Tested modified gravity theories using maximum likelihood analysis of Type Ia SNe peculiar velocities.

Summer Undergraduate Research Fellow (SURF) (June 2017 – August 2017)
NASA Jet Propulsion Laboratory / Caltech, Pappalardo Group

- Modeled stress and strain on icy satellites to develop and improve SatStress GUI, a planetary physics tool.
- Derived new expressions for stress due to ice shell thickening.

Mentored Advanced Project (January 2018 – May 2018)
Grinnell College

- Applied deep learning to chaotic physical systems to predict next time step in evolution.
- Machined a mechanically driven double pendulum.

Peer-Reviewed Publications

- "ON-OFF Neuromorphic ISING Machines Using Fowler-Nordheim Annealers." *Nature Communications* 16, 3086 (2025). 96th percentile Altmetric score.
- Kim, A., Aldering, G., Antilogus, P., et al. (2019). *BAAS*, 51, 140. arXiv:1903.07652.

Other Publications

- "How to Apply Category Theory to Thermodynamics" (with Nandan Kulkarni), *The n-Category Café* [Academic blog publication].

Fellowships & Awards

Outstanding Graduate Student Instructor (Spring 2026)
University of California, Berkeley

- Selected by the Physics Department from among all GSIs based on student evaluations, faculty nominations, and demonstrated pedagogical excellence; awarded to no more than 10% of departmental GSIs annually

Kavli Center for Ethics, Science, and the Public Graduate Fellow (2024 – Present)
University of California, Berkeley

- Bridge fellowship focusing on the ethical implications of emerging scientific technologies.
- Developing legally defensible identifiability methods for discriminatory ML models, drawing on mechanistic interpretability and law. To be presented at Law and Society Association Annual Meeting, 2026.
- Co-authoring guidelines for responsible AI integration in digital citizen science (Zooniverse), addressing volunteer agency and public trust.
- Exploring whether model multiplicity can illuminate questions of informed consent in algorithmically informed medical decisions.

Teaching Experience

Instructor of Record, Physics Department (Fall 2025 – Present)

Laney College

- Physics 10 (Conceptual Physics): Grounded the course in formal ideas from philosophy of science, including abduction, falsifiability, and the scientific attitude, to help students understand the broader project of science.
- Physics 3A: General Physics with Calculus (Mechanics)
- Implemented a flipped, 35-student classroom model to maximize active learning and student engagement during contact hours.
- Designed and conducted one-on-one oral final exams to rigorously assess conceptual understanding and problem-solving reasoning.
- Provide free tutoring in physics, calculus, and discrete math.
- Offer free transfer counseling for community college students.

Faculty Instructor (Volunteer), Mathematics Department (2022 – Present)

Mount Tamalpais College at San Quentin Rehabilitation Center

- MTH 050A: Developmental Math I
- MTH 050B: Developmental Math II
- MTH 099: Elementary Algebra
- MTH 115: Intermediate Algebra
- Developed new course (Spring 2025): "From Particles to People to Planets: The Physics of Everything."

Graduate Student Instructor, Physics Department

University of California, Berkeley

- Careers in the Mathematical and Physical Sciences (Fall 2025)
- Physics of Music (Spring 2023)
- Sense and Sensibility in Science (Spring 2022)
- Physics 8A: Introductory Physics for Medical Students (Fall 2021)
- Led directed reading on dynamical systems (Strogatz, Nonlinear Dynamics and Chaos).
- Led directed reading on random graphs and complex networks (Mendes, Evolution of Networks).
- Guest presenter for Careers in the Mathematical and Physical Sciences; give talks on navigating undergraduate studies in preparation for graduate school at Berkeley and Laney College.

Teaching Assistant, Physics & Mathematics Departments (2016 – 2018)

Grinnell College, Grinnell, IA

- Classical Mechanics, Physics II, Computational Physics

Supplemental Instructor and Tutor (2015 – 2016)

Armstrong State University

- Calculus I, Biology, Physics, Linear Algebra

Private Tutor (2021 – 2023)

Statistical Physics for Masters of Engineering students

Professional Experience

Scientific Data Analyst / Consultant (September 2018 – June 2021)
Deloitte Consulting LLP, Rosslyn, VA

- Developed a Neo4j-based graph representation for DHS critical infrastructure risk.
- Built an autoencoder neural network for water quality anomaly detection.
- Led a 2-person data analysis team to inform IRS change management.
- Created an ML pipeline for opioid epidemic analysis (Ohio State Health Department).
- Used NLP to identify market-competitive opportunities for a leading platform.

Conference Publications & Presentations

- "Keeping the Citizen in Science: Building Trust, Transparency, and Reciprocity in the Age of Algorithms." Kavli Center for Ethics, Science, and the Public December Showcase, UC Berkeley, 2025.
- "Tracing Discrimination in AI: Mechanistic Interpretability and Less-Discriminatory Alternatives." Kavli Center for Ethics, Science, and the Public December Showcase, UC Berkeley, 2025. To be presented at Law and Society Association Annual Meeting, 2026.
- "Fairness, Network Dynamics and Decision-Making." Kavli Center for Ethics, Science, and the Public Symposium, UC Berkeley, 2024.
- "Using SatStressGUI to Calculate Tidal Stresses on Moons: Applications to Europa." Conference Publication.
- "Modelling Stresses on Icy Satellites." American Astronomical Society, Division of Planetary Science, October 2017.
- "Methodology to Constrain the Growth Rate of Structure in Anticipation of the Cadenced Wide-Field Imaging Survey." Berkeley Lab Research Symposium, July 2018.
- "Formation of Surface Features on Icy Satellites." Grinnell Physics Seminar, February 2018.
- "Navigating Race in Science." IINSPIRE LSAMP Annual Conference, Ames, IA, February 2017.

Leadership & Service

National Society of Black Physicists (NSBP), UC Berkeley Chapter (Spring 2025)
Chapter Co-Initiator & President

- Individually contacted every Black PhD admit each spring to answer questions and support their transition; helped grow Black graduate student representation in the department from one to over ten.

Undergraduate Research Mentorship
University of California, Berkeley

- Mentor undergraduate students in research annually; mentees present their work at Berkeley's undergraduate research symposium.

Black Students in STEM Organization, Grinnell College (August 2017)
Co-Founder

Teaching and Mentorship Statement

Teaching is one of my deepest commitments. My approach to pedagogy is shaped by the conviction that every student, regardless of background, can achieve real conceptual understanding, when given the right scaffolding, intellectual respect, and space to struggle productively. I think seriously about course design, assessment, and how to make advanced ideas genuinely legible to beginners.

At Laney College, I implemented a flipped classroom model for calculus-based mechanics, designing one-on-one oral final exams to assess conceptual reasoning rather than rote calculation. In my conceptual physics course (Physics 10), I have been exploring how grounding the course from the outset in formal ideas from philosophy of science, including abduction, falsifiability, and the scientific attitude, helps students understand the broader project of science itself. Beyond the classroom, I provide free tutoring in physics, calculus, and discrete math at Laney, offer transfer counseling to community college students drawing on my own experience as a transfer student, and regularly give talks on navigating undergraduate studies in preparation for graduate school.
At Mount Tamalpais College (San Quentin), I have taught over 100 incarcerated students across arithmetic, college algebra, pre-calculus, and intermediate algebra, and I developed a new interdisciplinary course, "From Particles to People to Planets: The Physics of Everything," which brings university-level physics thinking to students who have often been told science is not for them.
Mentorship is central to how I understand my role in the academy. When I arrived at Berkeley, I was the only Black graduate student in the physics department. Each spring since, I individually called every Black PhD admit to answer their questions and help them envision a future in the department. There are now over ten of us, and I founded and serve as president of Berkeley's chapter of the National Society of Black Physicists.

My teaching is inseparable from my research: both are driven by a desire to make rigorous ideas accessible, to build bridges between disciplines, and to demonstrate that intellectual depth and human significance are not in tension.

Research Statement

My research sits at the intersection of physics, mathematics, neuroscience, and computation. I use tools from statistical physics, information theory, and dynamical systems to study how structure shapes dynamics in complex systems, with a particular focus on biological and neural networks. A central question in my work is: if we know the local connectivity patterns of a network, what can we infer about the global dynamical behavior of processes running on that network?

In computational neuroscience, I develop information-theoretic frameworks to characterize how individual neurons process information, working toward mathematically interpretable measures of dynamical complexity. This work draws on large-scale biophysical simulations and hopes connects single-cell computation to network-level phenomena.

In network science and applied mathematics, I extend the process motif formalism to decompose global information-theoretic quantities into graph-structured contributions. More broadly, I am drawn to questions of emergence: how local mechanisms generate global behavior, how structure constrains information flow, and how mathematical abstractions connect to lived and institutional reality.

Parallel to my theoretical work, I engage seriously with applied ethics, especially where formal methods, public policy, and scientific practice meet. This work focuses on algorithmic fairness,

biomedical resource allocation. Generally, im interested in asking questions about the design and governance of quantitative systems acting on human lives.