Annual Progress Report 2025–2026

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This report covers my first year in the Ph.D. program in Applied Physics at Harvard University, from September 2025 to August 2026. With the support of the Shida Scholarship Program, I was able to start my doctoral studies in Boston without financial worries and devote myself to coursework and research. Below, I describe my courses, two research projects, and interactions with the Kyodai Collaborative community.

Coursework

The degree requirements of the Harvard Applied Physics program consist roughly of ten courses, one semester of teaching, a qualifying exam, and a thesis defense. Students can choose their courses fairly freely, but are required to take one course each in quantum mechanics, electromagnetism, and statistical mechanics.

In the fall semester, I took a course on information theory and machine learning (APPHY 286, Prof. Sharad Ramanathan), which fulfills the statistical mechanics requirement, and a course on materials simulation (APPHY 275, Prof. Boris Kozinsky). Both courses had assignments every other week and concluded with a final project and presentation.

In the spring semester, I took High Performance Computing (CS 2050, Dr. Chuck Witt) and Statistical Physics of Fields at MIT (8.334, Prof. Mehran Kardar). In CS 2050, I systematically learned parallel computing methods such as OpenMP, MPI, and CUDA. For the final project in 8.334, I reformulated a geometric theory of few-shot learning (learning new concepts from only a few examples) in the language of statistical mechanics, and analyzed the crossover from few-shot to many-shot learning using a scaling framework. The project report is available on the course website.

Research

Generative AI for materials discovery (MIT Quantum Measurement Group)

During my first semester, I conducted research in the Quantum Measurement Group at MIT led by Prof. Mingda Li. The group works on a broad range of topics, ranging from machine learning for materials science to experiments and theory on quantum materials, and I took part in several projects. One of them, a study on tuning the chiral anomaly signature in the Dirac semimetal Cd_3As_2 via fast-ion implantation, was published in *Nano Letters* with me as a co-author. Visits to our collaborators at Michigan State University and Brookhaven National Laboratory, as well as attending the MRS Fall Meeting in Boston, one of the largest conferences in materials science, greatly broadened my perspective. I am continuing to collaborate with this group on a project that combines

diffusion models, a class of generative AI, with Direct Preference Optimization (DPO) to discover crystal structures of new materials with desirable properties.

Statistical physics of generalization in neural networks (Harvard, Prof. Subhabrata Sen)

Since the spring of my first year, I have been working with Prof. Subhabrata Sen in the Department of Statistics at Harvard on understanding, through analytical methods from statistical physics, why neural networks can make accurate predictions on data they have never seen (generalization). I am currently focusing on graph neural networks (GNNs), which learn from graph-structured data. In real-world networks, the same people are often connected through several types of relationships, such as friendships, research collaborations, and email exchanges. For such graphs composed of multiple layers, my current goal is to theoretically determine when and how the information from each layer should be combined to minimize the generalization error of GNNs.

Interactions with Kyodai Collaborative

In January 2026, I attended a lunch gathering in Washington, D.C. organized by Ms. Rika Okayama of Kyodai Collaborative (photo). I had the chance to talk with many Kyoto University alumni who are active in the United States and to hear about their careers and their lives here. Meeting people connected to Kyoto University across fields and generations renewed my determination to produce strong research results as a member of this network. Many thanks to Ms. Okayama for bringing us together.

Lunch gathering with Kyodai Collaborative in Washington, D.C., January 2026.

Acknowledgment

Finally, I thank the Shida family, the Shida Scholarship Program, and Kyodai Collaborative for making my doctoral studies at Harvard possible. I am also grateful to Ms. Rika Okayama and Ms. Nanako Tojo, who always responded quickly and patiently whenever I needed help with paperwork. Their support allowed me to concentrate on research throughout a year full of new beginnings. In my second year, I hope to turn the projects described above into published results and to give back to this community through my work.