

# Kelvin Peng

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## Education

### University of Waterloo

Bachelor of Mathematics – Major in Combinatorics & Optimization

Sept 2023 – Present

(Expected 2027)

### Relevant Coursework:

Number Theory, Quantum Info Processing, Applied Cryptography, Graph Theory, Convex Optimization, Linear Algebra.

## Research & Technical Projects

### TopoAdamW: TDA-Guided Meta-Optimizer

Python, PyTorch, Gudhi

 [github.com/SVAH-X/topoadamw](https://github.com/SVAH-X/topoadamw)

- Designed **TopoAdamW**, a non-convex optimizer that integrates **Topological Data Analysis (TDA)** signals into gradient-based updates to better navigate sharp minima in complex loss landscapes.
- Implemented real-time **Persistent Homology** computation (Gudhi) to extract topological invariants (e.g., Betti numbers / connected components) from the loss surface and use persistence-based cues to trigger escape behavior.
- Ongoing work: analyzing the relationship between persistence profiles and the **flatness of minima** to better understand and improve neural network generalization.

### Geometry Dash AI Verifier (DreamerV3)

RL, JAX

*Independent Research Project*

- Developed a **DreamerV3** world-model agent for *Geometry Dash*, a high-frequency physics platformer requiring frame-level control under strict collision constraints.
- Improved representation stability by mitigating **discrete latent space collapse** in stochastic regimes via symlog prediction tuning and discrete autoencoder bottleneck adjustments.
- Demonstrated long-horizon planning behavior in constrained environments, supporting automated verification of level completability.

### Efficient Large Language Model Fine-Tuning

LLMs, DeepSpeed, RunPod

*Technical Implementation*

- Built an efficient fine-tuning pipeline for **Dream-7B** and **GPT-OSS-20B** on mathematical datasets (e.g., OpenWebMath), targeting both single-GPU (16GB) and multi-GPU setups.
- Applied **QLoRA (4-bit)**, gradient checkpointing, and **DeepSpeed** optimizations to maximize throughput while reducing memory footprint.
- Achieved **20% improvement** in math reasoning benchmarks with over **60% VRAM reduction**, enabling cost-effective customization of large models.

## Technical Skills

- Languages:** Python, C/C++, Racket, SQL, Bash, LaTeX
- AI Frameworks:** PyTorch, JAX, DeepSpeed, HuggingFace, BitsAndBytes
- Research Tools:** Gudhi (TDA), Ripser, WandB, RunPod/Cloud Computing
- Mathematics:** Combinatorial Optimization, Graph Theory, TDA, Bayesian Statistics, Cryptography

## Awards

### Euclid Mathematics Contest

2021 – 2022

School Champion (2x), Honour Roll, **Top 1 in BC Province**.

### Canadian Senior Mathematics Contest (CSMC)

2022

School Champion, Honour Roll.