Arnav Kumar

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Education

Candidate for BSc. Computer Science (4th year) @ University of Waterloo *Waterloo, ON.* | 2022 - Present
- 4.0 GPA, all advanced level courses, and term distinction. Received four merit based scholarships totaling $46,000.

High School Diploma @ Webber Academy *Calgary, AB.* | 2008 - 2022
- President of the Student Union and annual merit scholarship recipient.

Experience

Graphics & 3D Geometry Software Engineer @ Arcol.io *San Francisco, USA* | Sep 2025 - Dec 2025
- Designed and implemented a Rust algorithm to reconstruct terrain meshes from raw, unstructured contour data spanning areas over 5km^2.
- Performed prototyping, iteration, and proof-of-concepts to choose and implement the most suitable approach.
- Rendered generated terrain and contour lines, sent over the Wasm ABI to TypeScript, with Three.js and WebGL.

Software Engineer @ Trend Micro *Kanata, ON.* | Jan 2025 - Apr 2025
- Engineered utility functions for Alicloud's webservices, optimizing cloud workflows and securing data management.
- Developed serverless functions to send scan metrics and results to the backend, helping identify details about customer errors and significantly cutting customer costs.

Combinatorics Researcher @ University of Waterloo *Waterloo, ON.* | May 2024 - Aug 2024
- Authored a paper (The dimension of sparse random graph orders) in pre-print in arXiv (https://arxiv.org/abs/2504.19029).
- Worked on novel research exploring random graph orders and poset dimension utilizing configuration models, approximation techniques, convergence in probability, devising constructions, and computationally searching for counterexamples.
- Developed two theorems about the nature of poset dimension for bipartite posets based on the dimension of induced subposets and for random graph orders.
- Engaged in regular meetings to discuss and advance research, demonstrating capacity for effective collaboration.

Blockchain Software Engineer @ Dandelion Networks *Remote* | May 2023 - Aug 2023
- Developed and implemented an enhanced lattice syncing and node discovery algorithm in Go, querying peers with Protocol Buffers to identify and address missing blocks in the local lattice with secure and concurrent updates.
- Created and deployed a locally hosted debugging website in Go to be run by each node of the blockchain network.
- Designed multiple mock servers, clients, and services with Ginkgo and Gomega to test the algorithms.
- Created Jenkins pipeline which automatically build, test, vet, and format pushed code to catch regressions.

Data Science Intern @ Tektorch.ai *Online* | Apr 2022 - Aug 2022
- Extracted features such as job title, location, classification, and pay from a job listing website using Python, Beautiful Soup 4, NumPy, and Pandas to create a dataset for analysis.
- Developed an end-to-end data visualization pipeline to ingest data and display trends using Matplotlib and NumPy.

Math Competition Teacher @ Webber Academy *Calgary, AB.* | Aug 2021 - June 2022
- Taught 4 children every week for 90 minutes after school, covering various math competition tricks.

Student Council President @ Webber Academy *Calgary, AB.* | Sep 2021 - Jun 2022
- Organized numerous events and lead monthly school assemblies, and weekly council meetings.

Machine Learning Research Intern @ University of Alberta *Remote* | Jul 2021 - Aug 2021
- Trained and employed Natural Language Processing (NLP) models to help determine the cause of a change in depressive language in Tweets as part of a psychology study.
- Created an evaluation framework with graphs and videos to analyse subject mouse position data during exams.
- Developed automation pipeline in Bash to reduce time spent by 20× on the application of the evaluation framework.

Projects

4D Raymarching Pathtracer | *C++*
- Implemented SDF raymarching in 4D space with CPU pathtracing to contruct GIF renders of the scene.
- Encoded the render such that every frame in the GIF, the camera sends out rays into a 3D affine subspace of the 4D space, which are scattered into 4D space upon colliding at a surface.
- Designed and wrote a powerful material system with microfacet BRDFs, glass, volumetric fog, and more with the ability to assign more than one material to a geometry. to describe infinitely many hyperspheres as one geometry with different materials.

Rigid-body Particle Simulation | *C++*
- Simulated gravity, spherical constraints, and collision physics for rigid body particles.

Software Rasterizer | *C++*
- Recreated the whole rasterization process on the CPU, including perspective transformation, triangle rasterization, depth buffering, and perspective correct interpolation.

Software Raytracer | *C++*
- Implemented the Möller–Trumbore algorithm for fast ray-triangle intersection
- Programmed Lambertian diffuse, specular refraction, and specular reflection behaviour, and support for spherical environment mapping

Renovating the Labyrinth (Game) | *JavaScript*
- Solo submission for the 72 hours Waterloo game jam; voted winner of the technical achievement award.
- Built a real time optimized ray caster with ordered Bayer matrix dithering.
- Programmed 2D rigid body collision behaviour and a randomized Prim's algorithm for map generation.

Software Raycaster | *JavaScript*
- Built a raycaster that renders a specified scene to a canvas element.
- Enabled options for Bayer matrix dithering, scene customization, and different casting algorithms.

Bloom (Game) | *Godot, GDScript*
- Team submission made in 72 hours with Godot for the UW Game Dev Club's spring 2024 game jam.
- Implemented colour mixing, screen wrapping, movement, and flower spawning mechanics.

InterPlanetary File Explorer (IPFE) | *Go, Python, Scikit-learn, Estuary, Co:here, Three.js*
- Created vector embeddings for files with their headers using Co:here's NLP embeddings to facilitate classification of files.
- Performed principal component analysis of the vector embeddings to reduce the dimensionality from 4096 to 3 to be plotted and displayed interactively in 3D space using Three.js.

Prognosing Idiopathic Pulmonary Fibrosis (IPF) | *Python, Tensorflow2, Pandas, Scikit-learn*
- Implemented an auto-encoder, linear regression, dense neural network, and bayesian model in order to accurately predict future lung capacity and give a confidence value using initial lung capacity data, age, sex, smoking status, and more.
- Obtained a Laplace Log Likelihood score of -6.9 (much better than the baseline score -8.1) with $\sigma \approx 200$mL.

Achievements

- Technical Achievement award, **UW Game Dev Club Game Jam** ..... Fall 2024
- 335^{th} (top 10%), with score 26, **William Lowell Putnam Mathematical Competition** 2022
- 10^{th} in Canada, **Asian Pacific Mathematics Olympiad (APMO)** 2022
- 11^{th} in Canada, **Canadian Association of Physicists High School Exam** 2022
- 12^{th} in Canada, 17^{th} internationally, **Sir Isaac Newton Physics Exam** ..... 2021 - 2022
- 18^{th} in Canada, 2 time qualifier, **Canadian Mathematical Olympiad (CMO)** ..... 2021 - 2022
- Canadian Honour Roll, Top in Alberta, **Canadian Open Mathematics Challenge** ..... 2017 - 2022
- 2 time qualifier, **American Invitational Mathematics Exmaination** ..... 2021 - 2022
- Part II winner, 3 time part I winner, **Alberta High School Mathematics Competition** ..... 2018 - 2022
- Invited to write, **United States of America Mathematical Olympiad (USAMO)** 2022
- Bronze medalist for machine learning project on prognosing IPF, **Canada Wide Science Fair** 2021
- Estuary Sponsor Prize Winner, **UofTHacks X** 2023

Presentations

Dimension of Posets and Random Graph Orders @ University of Waterloo *Waterloo, ON.* | Aug 2024
- A presentation of work completed during my research term under Jane Gao.

Streams and Lazy Evalutation @ Webber Academy Programming Club *Calgary, AB.* | Oct 2023
- An introduction to simulating infinite lists with streams and their manipulation.

On the Catalan Numbers @ Webber Academy Math Society *Calgary, AB.* | Oct 2023
- A derivation of the closed formula for the Catalan Numbers and examples of well known problems where the Catalan Numbers appear.

Introductory Combinatory Logic @ Webber Academy Math Society *Calgary, AB.* | Oct 2022
- Understanding how combinators interact with each other and showing natural numbers and their operations can be expressed as combinators.

Attended Programs

- **International Summer School for Young Physicists (ISSYP)** @ Perimeter Institute ..... Summer 2021
- **Auckland Lloyd Invitational Math Camp** @ University of Waterloo ..... June 2021
- **Quantum Cryptography School for Young Students (QCSYS)** @ IQC, University of Waterloo ... Summer 2020