

# Saksham Rathi

## Curriculum Vitae

Department of Computer Science,  
Indian Institute of Technology Bombay  
Mumbai—400076  
✉ 22b1003@iitb.ac.in  
📁 [sakshamrathi21.github.io/](https://github.com/sakshamrathi21)

### Education

- 2022 - 2026 **Indian Institute of Technology Bombay** *Bachelor's of Technology*  
Pursuing majors in Computer Science and Engineering (**CSE**) along with **honors** and **minor** in Machine Intelligence and Data Science (**CMInDS**) (CPI - **9.69/10**)
- 2020 - 2022 **Disha Delphi Public School, Kota** *Senior Secondary Education*  
Secured **99.0%** in CBSE Class **12th** Board Examination
- 2008-2020 **Delhi Public School, Kota** *Primary and Secondary Education*  
Secured **98.6%** in CBSE Class **10th** Board Examination

### Internships and Research Experience

- Current **Software Engineering Internship**  
*Citadel, London*  
(a) **Commodities**
- 2024 **Applied Scientist Internship**  
*Amazon, Bangalore*  
(a) Worked on Amazon's Large Language Model **Olympus** and improved its instruction following ability  
(b) Implemented **Classifier-free Guidance** method to enhance focus on key parts of user queries and system prompts, optimizing the balance between conditional and unconditional probabilities using a hyper-parameter  
(c) Evaluated the performance of Olympus and some open source models on various single and multi-turn datasets
- 2024-25 **Compressive Lognormal Regression**  
*Indian Institute of Technology Bombay. Guide: Prof. Ajit Rajwade.*  
(a) Enhanced viral load estimation in pooled **RT-PCR** via **Bayesian** inference and compressed sensing  
(b) Developed a superior Orthogonal Matching Pursuit (**OMP**) variant using combinatorial group testing  
(c) Optimized **sparse** recovery using **block gradient descent**, LASSO, NNLS, and proximal algorithms

### Academic Achievements

- 2022 Secured **All India Rank 18** in **Joint Entrance Examination Advanced** among 250,000 selected students
- 2023 Awarded the **Institute Academic Prize** for being among the **top 20** out of 1400 students in first year
- 2023, 25 Achieved **10** Semester Performance Index (**SPI**) by scoring a perfect grade in two of the Spring Semesters
- 2020 Awarded the **NTSE Scholarship** after a two-tier merit-based procedure by NCERT, Government of India
- 2021, 22 Recipient of the **Kishore Vaigyanik Protsahan Yojana**, a coveted fellowship by the Department of Science and Technology, Government of India by securing **All India Ranks 24** and **33** in the SX and the SA streams
- 2022, 25 Granted the distinguished **AP** (Advanced Performer) grade, given to the highest **1%** among **1400+** students, twice: in Calculus as well as in Advanced Machine Learning
- 2022 Secured **All India Rank 321** in **JEE-Main** with **99.97** percentile among **1 million+** students

### Olympiads and Competitions

- 2022 Among the **top 26** students to clear the Indian National Astronomy Olympiad (INAO) and selected to attend the **Orientation-Cum-Selection Camp** for **International Astronomy Olympiad** (IOAA)
- 2024, 25 Was among the **top 50** at Limestone Data Challenge conducted by **Tower Research Capital**, India in collaboration with the Finance Club, IIT Bombay amongst 200+ participating candidates across all academic years
- 2020 Selected among the **top 40** students to clear the Indian National Junior Science Olympiad (INJSO) and selected to attend the **Orientation-Cum-Selection Camp** for **International Junior Science Olympiad** (IJSO)
- 2022 Among the top 300 students selected for the **Indian National Physics Olympiad** conducted by HBCSE
- 2018 Selected among the top 300 students for the **Indian National Mathematics Olympiad**, HBCSE

### Key Projects

- Spring 2025 **Analyzing Selfish Mining and Eclipse Attack in a P2P Cryptocurrency Network**  
*Guide: Prof. Vinay Ribeiro | Course Project: Blockchains, Cryptocurrencies and Smart Contracts*  
Developed a **P2P blockchain** network simulator with **100+** nodes to demonstrate how coordinated attackers can manipulate block propagation through combined Selfish Mining and Eclipse Attack strategies

Conducted comprehensive analysis showing attack effectiveness at various adversary thresholds (**5%-100%**), revealing that malicious control of **>50%** network nodes results in complete blockchain takeover  
Designed and implemented a **trust-based** countermeasure system that reduced malicious block acceptance by 95%, effectively neutralizing attacks even with 40% malicious nodes present

Autumn 2023 **Socket-Based Trading Engine with Arbitrage Detection**

*Guide: Prof. Ashutosh Gupta | Course Project: Data Structures and Algorithms*

Devised trading strategies utilizing **sockets** and **threads** to enhance market responsiveness and execution efficiency

Developed a **dynamic market** platform that intelligently matches traders based on optimal prices, enhancing overall market performance and has robust measures to identify and prevent **arbitrage** opportunities

Implemented **median trading** and **statistical arbitrage**, to exploit market anomalies and drive consistent returns

Spring 2025 **Approximate Nearest Neighbour Search via Group Testing**

*Guide: Prof. Ajit Rajwade | Course Project: Advanced Image Processing*

Implemented a novel **FLINNG** algorithm combining Locality Sensitive Hashing with distance-sensitive Bloom filters to optimize nearest neighbor search operations

Designed and evaluated a **parameterized search index** achieving  $O(N^{1/2 + \gamma})$  query time complexity, demonstrating significant performance improvements over traditional approaches

Conducted comprehensive performance analysis across multiple metrics (**precision, recall, F1 score**) to validate theoretical guarantees and practical efficiency of the proposed method

Summer 2023 **Modeling Economic Systems with Reinforcement Learning**

*Web and Coding Club | Seasons of Code*

Formulated and implemented various economic problems as **Markov Decision Processes** in the Gym framework  
Employed a combination of **Bandit** algorithms and **Reinforcement Learning** algorithms, known for their adaptability and learning capabilities, to address complex matching markets, auction dynamics, and allocation problems

Modeled **stock exchange** as a **double auction**, which incorporated market sentiment and the individual objectives of users and conducted simulations involving a diverse group of over **100** participants to assess the model's efficacy

Spring 2025 **Automated Index Creation in a Database**

*Guide: Prof. Sudarshan | Course Project: Database and Information Systems*

Developed an automatic indexing system for PostgreSQL that dynamically creates and removes indices based on query patterns, reducing execution time by **40%** in tests

Implemented adaptive indexing policies using weighted **attribute frequencies** and PostgreSQL's query planner to optimize database performance without manual DBA intervention

Created a real-time query monitoring interface with custom data structures that tracks attribute access patterns and applies cost-aware filtering through the **hypopg** extension

Autumn 2023 **Working with Low Level Systems**

*Guide: Prof. Biswabandan Panda | Course Project: Digital Logic and Computer Architecture*

Utilized the **champsim** simulator to implement and analyze **stream** and **IP stride prefetchers**, while evaluating the effectiveness of **LRU, FIFO, LFU** and **BIP** replacement policies based on IPC and accuracy metrics

Designed a **VHDL** circuit which encodes **musical chords**, achieving conversion of 8-bit binary notes into chords  
Implemented **Heap Sort, Merge Sort** and Binary Search algorithms in the **MIPS** and **x86** Assembly Language

Spring 2025 **C Compiler Development**

*Guide: Prof. Uday Khedker | Course Project: Implementation of Programming Languages*

Built a complete **C compiler** in C++ using **Lex** and **Yacc**, creating lexical analyzer, parser, **context-free grammar** and **abstract syntax** trees for simplified C language

Implemented full compilation pipeline from source to assembly, developing all compiler phases including **intermediate code** generation and **assembly code** generation through six progressive steps

Added comprehensive **error detection** and validation across all compilation phases to identify and reject invalid C programs during compilation

Summer 2024 **Mathematics of Derivative Pricing**

*Maths and Physics Club | Summer of Science*

Achieved proficiency in **mathematical models** used in derivative pricing through comprehensive coursework

Acquired knowledge about Derivatives such as **Futures** and **Options**, with a focus on trading strategies

Gained in-depth understanding of **Black-Scholes model, Binomial model**, and **Greeks** for risk management

Spring 2025 **Building Decentralized Exchange**

*Guide: Prof. Vinay Ribeiro | Course Project: Blockchains, Cryptocurrencies and Smart Contracts*

Engineered a complete Automated Market Maker (AMM) **DEX** system using **Solidity**, implementing the constant

product mechanism with ERC-20 token support, liquidity pool management, and LP token minting/burning mechanisms

Developed an **arbitrage** detection smart contract that automatically identifies profitable trading opportunities between DEXes, factoring in swap fees and minimum profit thresholds

Analyzed key metrics like Total Value Locked (**TVL**), **reserve ratios**, **slippage** impact, and trading volumes while documenting security measures against front-running attacks

#### Spring 2024 **Systems Programming**

*Guide: Prof. Mythili Vutukuru | Course Project: Operating Systems*

Implemented **producer-consumer** thread pools, **reader-writer** locks and custom **semaphores** using pthreads API

Built a comprehensive **Unix shell** from scratch supporting foreground/background execution, **signal** handling, process groups, **serial/parallel** command execution, and built-in commands

Extended **xv6** operating system with custom system calls, implemented memory-mapped I/O with **demand paging**, and developed **copy-on-write fork** mechanism with reference counting

---

## Other Projects

#### Autumn 2024 **Image Compression**

*Guide: Prof. Ajit Rajwade | Course Project: Digital Image Processing*

Implemented multiple image compression algorithms including **JPEG-inspired DCT** with quantization, run-length encoding, and advanced **PCA** techniques

Implemented and enhanced **Edge-Based** Image Compression with **Homogeneous Diffusion**, reducing artifacts in uniform intensity regions through artificial segmentation

Conducted performance analysis across diverse image datasets, evaluating **RRMSE vs BPP** metrics to quantify compression efficiency while preserving visual quality

#### Spring 2024 **Game of Trust**

*LimeStone Data Challenge | Tower Research Capital*

Reverse-engineered player strategies from noisy game data by developing mathematical models to characterize decision-making patterns in a **multi-round Prisoner's Dilemma variant**, successfully identifying distinct algorithmic strategies despite **10% miscommunication** rates

Built machine learning models to **predict player moves** and classify strategic behaviors, using historical game data to forecast opponent actions across multiple rounds

Created simulation framework to **test strategy performance** and rankings, evaluating how different **noise levels** affect optimal gameplay and developing winning **counter-strategies**

#### Autumn 2024 **Audio Network Communication**

*Guide: Prof. Vinay Ribeiro | Course Project: Computer Networks*

Utilized **frequency based** bit transmission with robust error correction through **CRC** algorithm capable of detecting and correcting upto **2-bit** errors

Implemented a modified **CSMA-CA** protocol with **RTS/CTS** mechanism for collision avoidance and included specialized handling for **broadcast** messages

Built a **multi-threaded** architecture with one thread managing message buffering and another handling the communication protocol, complete with exponential backoff strategy for collision management and clock synchronization via NTP

#### Spring 2025 **LLM Decoding Techniques Implementation and Analysis**

*Guide: Prof. Sunita Sarawagi | Course Project: Advanced Machine Learning*

Implemented multiple **LLM sampling** strategies (greedy, **temperature scaling**, top-k, **nucleus**) on **Llama-2** for Hindi-English translation, achieving **BLEU** score of **0.31** on IN22-Gen dataset

Developed word-constrained decoding using **Trie** structures to leverage oracle word lists, improving BLEU score from 0.31 to **0.51** and outperforming all baseline methods

Implemented **Medusa speculative decoding** with **multi-head beam search** optimization, analyzing **RTF** vs. quality trade-offs across various beam widths and head configurations

#### Spring 2025 **Denoising Diffusion Probabilistic Models**

*Guide: Prof. Sunita Sarawagi | Course Project: Advanced Machine Learning*

Built and evaluated **unconditional** and **conditional DDPMs** across multiple datasets, studying effects of diffusion steps and **noise schedules** (linear, cosine, sigmoid) using **NLL** and **EMD**

Implemented **Classifier-Free Guidance** (CFG), analyzing guidance scale impact on sample quality using both trained classifiers and DDPM-based classifiers

Integrated **Soft Value-Based Decoding** (SVDD) for **reward-guided** sampling from unconditional models using classifier-derived rewards

- Spring 2024 **Saliency-Guided GMM Image Segmentation**  
*Guide: Prof. Suyash Awate | Course Project: Medical Image Computing*  
 Implemented **Gaussian Mixture Model** (GMM) with **Saliency Map** for accurate image segmentation  
 Achieved better accuracy and reduced computational cost over Markov Random Field and mean template based GMM
- Autumn 2024 **Network Routing Protocol Implementation**  
*Guide: Prof. Vinay Ribeiro | Course Project: Computer Networks*  
 Built a custom **routing protocol** in C++ that finds shortest paths between network nodes, achieving convergence **under 1ms** for networks up to **50 nodes** through optimized table sharing and **split-horizon** techniques  
 Implemented packet forwarding system with automatic handling of node failures, **TTL-based loop prevention**, **validity counters** for route expiration, and broadcast mechanisms for network discovery
- Spring 2025 **Probabilistic Graphical Models and Message Passing Implementation**  
*Guide: Prof. Sunita Sarawagi | Course Project: Advanced Machine Learning*  
 Implemented **junction tree** algorithms for probabilistic inference including graph **triangulation** via minimum degree heuristic and maximal clique extraction using **Bron-Kerbosch** algorithm  
 Developed **sum-product** and **max-product** message passing algorithms to compute exact marginal probabilities and MAP assignments on complex probabilistic networks  
 Optimized **top-K** assignment retrieval with pruning strategies to reduce computational complexity while maintaining accuracy on multi-variable graphical models
- Summer 2023 **Option Pricing Models**  
*Finance Club | Finsearch*  
 Engaged in **Stock Markets** and **Options Trading**, with a focus on understanding diverse Option Strategies  
 Implemented the **Black-Scholes** model, the **Binomial** model, and **Monte Carlo** simulations using Python libraries  
 Evaluated the precision and **performance** of the Black-Scholes Model by applying it to **real-world** data sourced from the National Stock Exchange (**NSE**) markets and achieved a high accuracy by optimizations
- Spring 2025 **Gambler's Triumph**  
*LimeStone Data Challenge | Tower Research Capital*  
 Developed predictive models for autoregressive card sequences using **time series forecasting** techniques, achieving optimal strategy formulation across **5** different **casino tables** with varying statistical distributions  
 Reverse-engineered hidden data patterns to decode the relationship between backend system values and **card outcomes**, achieving **100% accuracy** in predicting card values from data streams  
 Built coordinated **multi-table strategy** to simultaneously optimize gameplay across **three correlated tables**, leveraging cross-table information to maximize winnings through strategic timing
- Spring 2025 **Simulation of a P2P Cryptocurrency Network**  
*Guide: Prof. Vinay Ribeiro | Course Project: Blockchains, Cryptocurrencies and Smart Contracts*  
 Implemented a simulator modelling transaction generation, message propagation with realistic network latencies and Proof-of-Work (PoW) mining using exponential distributions  
 Analyzed blockchain tree evolution to assess the impact of node speed and CPU power on mining success and fork resolution
- Summer 2023 **Exploring Reinforcement Learning**  
*Maths and Physics Club | Summer of Science*  
 Completed an extensive **reading project** on Reinforcement Learning (main reference: **Sutton & Barto**)  
 Investigated Dynamic Programming, Monte Carlo Methods, n-step bootstrapping, **Temporal Difference** learning and **on-policy** methods with their applications and **implemented** all the algorithms in Python
- Spring 2023 **Python Web Crawler**  
*Guide: Prof. Kameswari Chebrolu | Course Project: Software Systems Lab*  
 Designed a sophisticated Web Crawler equipped with the ability to **recursively extract** all the hyperlinks of a webpage and generating a comprehensive **graph** showcasing various link types, with user-defined recursion levels  
 Harnessed the power of **Python libraries** to visualize this wealth of data, resulting in an interpretable representation
- Winter 2022 **Alien Invasion Game**  
*Self Project*  
 Developed a **customized** version of Alien Invasion Game with **pygame** aiming for an engaging gameplay experience  
 Added layers of excitement and depth to the gaming experience by allowing the players to shoot advancing extraterrestrial invaders, encountering three **unique types**, each with individually tailored point rewards  
 Enhanced gameplay by introducing escalating difficulty **levels**, with each new level increasing game speed and

point rewards for aliens and implemented a **high-score** tracking system that saved and retrieved player high scores

## Positions of Responsibility

- 2025 **Teaching Assistant** | Discrete Structures, IIT Bombay  
*Instructor: Prof. Akshay S*
- 2025 **Teaching Assistant** | Operating Systems, IIT Bombay  
*Instructor: Prof. Mythili Vutukuru*  
Collaborated with the professor in creating labs, exams and autograders
- 2024-25 **DAMP Mentor** | Department Academic Mentorship Programme, IIT Bombay CSE  
Selected via a rigorous procedure of SoP, Peer Reviews, and Interviews to be part of a team of 37 out of 90 applicants  
Guiding sophomores on academic and extra-curricular decisions and helping them navigate their curriculum
- 2024 **Teaching Assistant** | Data Analysis and Interpretation, IIT Bombay  
*Instructor: Prof. Sunita Sarawagi*  
Instructed sophomore students, offering guidance and support both during tutorials and doubt solving sessions  
Collaborated with the professor in creating weekly quizzes, exams, assignments, practice problems, tutorial notes and grading
- 2024 **Teaching Assistant** | Software Systems Lab, IIT Bombay  
*Instructor: Prof. Kameswari Chebrolu*  
Instructed a cohort of 50 freshman students, offering guidance and support both during tutorial and lab hours  
Collaborated with the professor in creating labs, exams, autograders, quizzes, practice problems and tutorial notes
- 2024 **Mentor** | Seasons of Code, IIT Bombay  
*Web and Coding Club*  
Instructed a group of 25 students for Competitive Programming and provided them the appropriate resources and problems for Dynamic Programming, Sorting, Greedy, Graphs, Trees, Range and String Algorithms
- 2023 **Teaching Assistant** | Calculus, IIT Bombay  
*Instructor: Prof. Ravi Raghunathan*  
Guided and instructed a group of 40 freshmen students enrolled in a semester-long calculus course  
Actively collaborated with the professors to ensure the seamless and effective execution of the course
- 2023 **Mentor** | Winter in Data Science, IIT Bombay  
*Analytics Club*  
Provided mentorship to a team of 10 students for a **data analysis** project involving **Python** and **MATLAB**, guiding them in presenting results on a personal website through HTML, JavaScript, and CSS integration

## Coursework

<b>Computer Science</b>	Data Structures and Algorithms <sup>§</sup> , Design and Analysis of Algorithms, Digital Logic Design and Computer Architecture <sup>§</sup> , Computer Networks <sup>§</sup> , Programming Paradigms <sup>§</sup> , Implementation of Programming Languages <sup>§</sup> , Database and Information Systems <sup>§</sup> , Logic and theory for Computation, Operating Systems <sup>§</sup> , Software Systems Lab <sup>§</sup> , Computer Programming and Utilization <sup>§</sup> , Computing and Science <sup>§</sup> , Applied Algorithms, Game Theory and Algorithmic Mechanism Design, Blockchains, Cryptocurrencies and Smart Contracts
<b>Mathematics</b>	Discrete Structures, Calculus, Linear Algebra, Differential Equations, Mathematical Structures for Control
<b>Data Science</b>	Data Analysis and Interpretation, Optimization, Medical Image Computing, Artificial Intelligence and Machine Learning <sup>§</sup> , Digital Image Processing, Advanced Image Processing, Advanced Machine Learning
<b>Others</b>	Organic and Inorganic Chemistry <sup>§</sup> , Physical Chemistry <sup>§</sup> , Classical and Quantum Physics, Makerspace, Management, Philosophy, Biology, Economics, Design Thinking for Innovation, Development of Mathematics in India, Physiology, Environmental Studies, Entrepreneurship

<sup>§</sup> along with a lab component

## Technical Skills

<b>Programming Languages</b>	C++, Python, HTML, CSS, Git, JavaScript, VHDL, MIPS, Sed, Awk, Shell, Bash
<b>Software Tools</b>	L <sup>A</sup> T <sub>E</sub> X, Qiskit, GitHub, Autodesk Fusion 360, Arduino, Pygame
<b>Data Science</b>	Matplotlib, MATLAB, NumPy, Keras, TensorFlow, PyTorch, SciPy, Pandas
<b>Verbal</b>	Debate, Group Discussion

---

## Extracurriculars

- 2024 Received the **Excellence in CSE Teaching Assistantship** Award for the Software Systems Lab course
- 2025 Awarded special recognition for outstanding dedication and contribution to the **DAMP** program
- 2023 Engineered a manually controlled **robot**, imbued with the ability to navigate through a diverse array of obstacles while participating in the prestigious **XLR8** Competition, the Robotics Club of IIT Bombay
- 2019 Secured **third rank** in Rajmata Gayatri Devi National Inter-School **Verbattle Debate** Competition
- 2024 Actively involved in Competitive Programming contests on **Codeforces (Expert)**
- 2025 Acknowledged for my contributions as a **Department Academic Mentor** in the CSE department
- 2019 Appointed as the **Prime Minister** during a **Model United Nations** session, which serves as a platform aimed at fostering political discourse and encouraging the exchange of thoughtful ideas of international affairs
- 2023 Completed a one-year course in **Weightlifting** under National Sports Organization, IIT Bombay
- 2019 Secured **First Rank** in **Science Quiz** organised by Defence Laboratory, Jodhpur on National Science Day
- 2019 Secured **First Rank** in **Science Quiz** organised by Career Point World School on National Science Day