Farhan Ali

Curriculum Vitae

Delhi Okhla Industrial Estate, Phase III
New Delhi
India
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Education

2021–Present **Bachelor of Technology in Computer Science and Engineering**,
Indraprastha Institute of Information Technology Delhi, New Delhi, India,
Cumulative GPA: 9.37/10

Research Interests

- Complexity Theory
- Graph Algorithms
- Cryptography
- Quantum Computation

Research Experience

Lattice Cryptography

April 2024 – Present **Fine-grained Hardness of Lattice Problems**,
Undergraduate Thesis, Summer Semester 2024 - Present,
Advisor: Dr. Rajendra Kumar (IIT Delhi)
Co-Advisor: Dr. Debajyoti Bera

- Currently working on trying to find new hardness results for CVP in ℓ_2 norm, by using non-standard problems to reduce from, such as SET COVER and LABEL COVER
- Additionally, working on trying to find new subexponential time reductions based on LABEL COVER to various approximation problems
- Furthermore, trying to find new directions on unsolved problems related to CVP in ℓ_2 norm

Quantum Compexity Theory

June 2024 – August 2024 **Quantum Boolean Circuit Complexity**,
Independent Project, Summer Semester 2024, IIIT Delhi, India,
Advisor: Dr. Debajyoti Bera (IIIT Delhi), Sagnik Chatterjee (IIIT Delhi)

- Reviewed the following papers for hardness results on PARITY in circuit classes such as:
  - "On the Pauli Spectrum of QAC^0" by Shivam Nadimpalli, Natalie Parham, Francisca Vasconcelos, Henry Yuen
  - "Parity vs. AC^0 with Simple Quantum Preprocessing" by Joseph Slote
  - "The power of shallow-depth Toffoli and qudit quantum circuits" by Alex Bredariol Grilo, Elham Kashefi, Damian Markham, Michael de Oliveira
- Worked on trying to improve existing separations between classical and quantum depth circuits for PARITY
- **Grade recieved: A**

Parameterized Algorithms and Complexity

May 2023 – August 2023

Separation Problems in Special Graph Classes,
Summer Undergraduate Research Fellow (SURF) 2023, IIIT Delhi, India,
Advisor: Dr. Diptapriyo Majumdar (IIIT Delhi)

- Worked on trying to find parameterized algorithms faster than $\mathcal{O}(2^k\text{poly}(n))$ and polynomial kernels of size smaller than $\mathcal{O}(k^3\ell^7)$ for different variants of MULTICUT in interval and proper interval graphs.
- Found new results for the UNRESTRICTED MULTICUT variation of the problem :
  1. Developed a FPT algorithm that runs in $\mathcal{O}(2^k\text{poly}(n))$ time for interval graphs
  2. Developed a polynomial kernel of size $\mathcal{O}(k^2\ell^5)$ for connected interval graphs

August 2023 – December 2023

Cuts and Separation Problems in Special Graph Classes,
Undergraduate Research, Monsoon Semester 2023, IIIT Delhi, India,
Advisor: Dr. Diptapriyo Majumdar (IIIT Delhi)

- Reviewed existing literature for the parameterized complexity of MULTICUT and ODD CYCLE TRANSVERSAL in planar graphs
- Worked on trying to find a polynomial kernel for MULTICUT variants on planar graphs
- Additionally, worked on trying to improve existing deterministic polynomial size kernels for ODD CYCLE TRANSVERSAL
- **Grade recieved: A**

Combinatorics

June 2023 – August 2023

Covering Grids with Hyperplanes,
Polymath Jr 2023 Research Program, *(online)*,
Advisors: Dr. Anurag Bishnoi (TU Delft), Dr. Aditya Potukuchi (York University), Daniel Hathcock (CMU), Kevin Pratt (CMU)

- Worked along with 20-30 people on trying to improve known results for the covering problem $\text{cov}_k(\Gamma_n)$(minimum number of lines to cover all points in a nxn grid except one corner point, k many times) such as:
  - Determining exact asymptotic value of $\text{cov}_k(\Gamma_n)$
  - Determining k-covering problem over fields other than $\mathbb{R}$
  - Extending known results for $\mathbb{R}^2$ to higher dimensions
  - Determining a closer threshold for the Ball-Serra bound to be tight

Awards

- Dean's List for Academic Performance (2021-2022)
  Awarded for academic excellent academic performance
  (More than 9/10 GPA in both semesters of an academic year)
- Dean's List for Academic Performance (2022-2023)
  Awarded for academic excellent academic performance
  (More than 9/10 GPA in both semesters of an academic year)
- Distinguished Dean's List for TA Performance (2023-2024)
  Awarded for excellent TA performance
  (Specifically nominated by the faculty for a course, twice in an academic year)
  Only undergraduate recipient for this academic year

Teaching and Mentorship Experience

MTH240 **Real Analysis-I**, (Monsoon Semester, 2023),
(Instructor: Dr. Debika Banerjee)
- Held weekly tutorials and office hours
- Graded exam and quiz papers
- Helped prepare grading rubrics and tutorial solutions
- Provided regular guidance and doubt sessions to struggling students
- **Nominated for Distinguished TA Award (2023-2024)**

CSE322 **Theory of Computation**, (Winter Semester, 2024),
(Instructor: Dr. Syamantak Das)
- Held weekly tutorials and office hours
- Graded exam papers
- Helped prepare quizzes, exams, tutorials and problem sets
- Helped prepare grading rubrics and problem set solutions
- Help co-ordinate work among other teaching assistants
- Provided regular guidance and doubt sessions to struggling students
- **Nominated for Distinguished TA Award (2023-2024)**

Relevant Coursework

Reading Groups and Courses

March 2023 – **Interactive Coding Theory**,
May 2023 *Organizer: Dr. Manuj Mukherjee*
- Covered tree codes and interactive coding schemes based upon it

May 2023 – **Spectral and Algebraic Graph Theory**,
July 2023 *Organizer: Dr. Manuj Mukherjee*
- Followed Dr. Daniel A. Spielman's notes
- Covered Chapters 2 - 7, 9, 19 - 21 and 27
- Presented Chapter 20

August 2024 – **Theory of Probability**,
Present *Organizer: Dr. Manuj Mukherjee*
- Following Probability Theory by Achim Klenke
- Covered first chapter
- Expected to cover first 6 chapters by January

Graduate Courses

COL872	Lattices in Computer Science *(at IIT Delhi)*		*(Ongoing)*
(CSE902)	*(Instructor: Dr. Rajendra Kumar)*		*Monsoon Semester, 2024*
CSE558	Data Science		*(Ongoing)*
	(Instructor: Dr. Supratim Shit)		*Monsoon Semester, 2024*
MTH542	Introduction to Functional Analysis		*(Ongoing)*
	(Instructor: Dr. Subhajit Ghosechowdhury)		*Monsoon Semester, 2024*
CSE646	Information Theory		*A*
	(Instructor: Dr. Manuj Mukherjee)		*Winter Semester, 2024*
CSE622	Introduction to Quantum Computing		*A*
	(Instructor: Dr. Debajyoti Bera)		*Winter Semester, 2024*
COL759	Cryptography *(at IIT Delhi)*		*A-*

(CSE901)	*(Instructor: Dr. Venkata Koppula)*	*Monsoon Semester, 2023*
CSE586	Algorithms Under Uncertainty	A-
	(Instructor: Dr. Syamantak Das)	*Monsoon Semester, 2023*
MTH551	An Introduction to Quantum Information Theory	A-
	(Instructor: Dr. Satish Kumar Pandey)	*Winter Semester, 2024*
MTH510	Advanced Linear Algebra	B
	(Instructor: Dr. Debika Banerjee)	*Winter Semester, 2024*
MTH562	Point Set Topology	*Audit*
	(Instructor: Dr. Prahllad Deb)	*Monsoon Semester, 2023*

Undergraduate Courses

CSE319	Modern Algorithm Design	*(Ongoing)*
	(Instructor: Dr. Syamantak Das)	*Monsoon Semester, 2024*
CSE322	Theory of Computation	**A+**
	(Instructor: Dr. Syamantak Das)	*Winter Semester, 2023*
CSE101	Introduction to Programming	**A+**
	(Instructor: Dr. Pankaj Jalote)	*Monsoon Semester, 2021*
MTH240	Real Analysis-I	**A+**
	(Instructor: Dr. Debika Banerjee)	*Monsoon Semester, 2022*
MTH212	Abstract Algebra-I	**A+**
	(Instructor: Dr. Krishanu Roy)	*Winter Semester, 2023*
MTH211	Number Theory	**A+**
	(Instructor: Dr. Sneha Chaubey)	*Monsoon Semester, 2022*
MTH201	Probability and Statistics	**A+**
	(Instructor: Dr. Acushla Saraswat)	*Winter Semester, 2022*
CSE401	Competitive Programming 2 (CP2)	A
	(Organizer: FooBar (Programming Club at IIIT Delhi))	*Summer Semester, 2024*
CSE222	Algorithm Design and Analysis	A
	(Instructor: Dr. Diptapriyo Majumdar)	*Winter Semester, 2023*
MTH204	Differential Equations	A
	(Instructor: Dr. Sneha Chaubey)	*Winter Semester, 2023*
MTH100	Linear Algebra	A
	(Instructor: Dr. Acushla Saraswat)	*Monsoon Semester, 2021*
CSE121	Discrete Mathematics	A-
	(Instructor: Dr. Bapi Chatterjee)	*Monsoon Semester, 2022*
CSE102	Data Structures & Algorithms	B
	(Instructors: Dr. Piyus Kedia & Dr. Bijendra Nath Jain)	*Winter Semester, 2022*

Relevant Course Projects and Presentations

1) **Pokémon Battle Calculator**, *(Course Project for Introduction to Programming)*, Github Repository Link

2) Tower Defense, *(Course Project for Introduction to Programming)*,
Github Repository Link

3) On-line Generalized Steiner Problem, *(Paper Presentation for Algorithms Under Uncertainty)*,
Paper Link   Overleaf Project Link

4) Some Multisecret-Sharing Schemes over Finite Fields, *(Paper Presentation for Information Theory)*,
Paper Link

5) On the Lattice Isomorphism Problem, Quadratic Forms, Remarkable Lattices, and Cryptography, *(Paper Presentation for Lattices in Computer Science)*,
Paper Link

Workshops

Coresets, *AISS 2023 (IIIT Delhi)*,
Speaker: Dr. Supratim Shit
○ The talks were on the theoretical understanding of and application of coresets in practice

Federated Learning, *AISS 2023 (IIIT Delhi)*,
Speaker: Dr. B N Bharath (IIT Dharwad)
○ The talks were on the theoretical understanding of Federated Averaging and similar variants

Algorithmic Frontiers of Fairness, *FSTTCS 2023 (IIIT Hyderabad)*,
Organizers: Dr. Umang Bhaskar (TIFR, Mumbai), Dr. Sujit Gujar (IIIT Hyderabad), Dr. Siddharth Barman (IISc)
○ Topics covered were Fair Division, Voting Algorithms and Efficient Allocation Algorithms

Spectral Methods in Algorithms, *FSTTCS 2023 (IIIT Hyderabad)*,
Organizers: Dr. Akash Kumar (IIT Bombay), Dr. Anand Louis (IISc) and Dr. Piyush Srivastava (TIFR, Mumbai)
○ Topics covered were Spectral Method based Learning Algorithms along with High Dimensional Expanders and its applications

Technical Skills

Languages	Python, C, C++, Java, Bash, Assembly, Javascript, HTML, CSS, Matlab, GNU Octave, LaTeX, Beamer, SageMath
Technologies	Linux, Git, Figma, Numpy, Pandas, Matplotlib, Qiskit, D-Wave, Pennylane

Co-curriculars

Technical Event Involvement

2022, 2023 and 2024	**Organising team for Simon Marais Math Competition**, *International Undergraduate Mathematics Competition*

○ Held preparation sessions for interested undergraduates
○ Organized and invigilated examination

June 2023 – August 2023	**Events Organizing Team Member of Esya'23**, *Annual Tech Fest at IIIT Delhi*, **Events:** Perplexicon, ZPT (Zero Prerequisite Tournament) and Prosort Euler

- Prepared event handouts and questions
- Organized and held all events

December 2023	**Panelist in Joy of Theory** Session organised by CSE and ECE faculty, for encouraging undergraduates to take part in theory research

Club Involvement

2022–2024	**Club Head of Évariste**, *Mathematics and Theoretical CS Club at IIIT Delhi*

- Selected as a freshman
- Organized regular monthly events such as Zero-Prerequisite Competitions, Speed Proving Tournaments and Theory Talks
- Additionally organized crossover events such as Stratazénith (with IGTS NSUT Delhi) and Crypto CTF (with d4rkc0de at IIIT Delhi)
- Helped prepare handouts and questions for most events conducted
- Helped organize events for the Mathematics department such as Pi Day 2024

Social Event Involvement

July 2023 - December 2023	**Self Growth Activity**, *The 65th Square (Chess Club at IIIT Delhi)*

- Learnt the basics of Chess
- Took part in online and offlien tournaments
- Practiced using puzzles on lichess.org
- At the end, presented my learnings and performance in Chess

January 2024 - May 2024	**Community Work Activity**, *Bachpan Bachao Foundation, Badarpur, New Delhi*

- Taught English, Mathematics and Environmental Science to underprivileged children from Grade 1 and Grade 2 in Badarpur, New Delhi
- At the end, presented my experiences and lessons learnt from interacting with children

The above information is accurate as of November 1, 2023