# Sayak **Chakrabarti** (he/him)

(+91) 8777582670 | sayaksc@gmail.com | sayaksc.github.io | sayaksc

## Education

**Dual BT-MT in Computer Science and Engineering** — *Kanpur, India*

Indian Institute of Technology, Kanpur — *Jul 2017 - May 2022 (expected)*

- **M. Tech CPI - 10.0/10.0** Supervisor- **Prof. Nitin Saxena**
- **B. Tech CPI - 9.0/10.0**

## Research Interests

Algebraic Complexity, Computational Algebra and Number Theory, Pseudorandomness, Coding Theory, Computational Complexity Theory

## Publications

1. **On algorithms to find $p$-ordering** [arXiv]
   - Aditya Gulati, **Sayak Chakrabarti**, Rajat Mittal
   - 7th Annual **Conference on Algorithms and Discrete Applied Mathematics (CALDAM)**, 2021
   - *submitted to* the special issue of Discrete Applied Mathematics dedicated to CALDAM 2021
2. **Graphon Estimation from Partially Observed Network Data** [arXiv]
   - Soumendu Sundar Mukherjee, **Sayak Chakrabarti**
   - *submitted to* the **Journal of Computational and Graphical Statistics (JCGS)** [*under major revision*]

## Honors & Awards

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|---|---|
| 2020 | **Research Fellow**, Max Planck Institute of Software Systems |
| 2017 | **All India Rank- 181, Joint Entrance Exam, Advanced**, among 200,000 candidates |
| 2017 | **All India Rank- 287, Joint Entrance Exam, Main**, among 1.2 million candidates |
| 2017 | **State Rank- 10, West Bengal Joint Entrance Exam**, among 150,000 candidates |
| 2017 | **Qualified Indian National Physics Olympiad (INPhO)**, among top 34 students selected from India |
| 2016 | **Qualified Indian National Mathematical Olympiad (INMO)**, among top 30 students selected from India |
| 2015 | **All India Rank- 115, Kishore Vaigyanik Protsahan Yojana**, among 100,000 candidates |

## Research Experience

**Roots of multivariate polynomials modulo powers of large primes [M. Tech Thesis]** — *Kanpur, India*

Prof. Nitin Saxena, IIT Kanpur — *Jul 2020- Present*

- Reviewed literature on factorization and root counting of univariate polynomials modulo prime powers
- Learnt about techniques from computational algebra including multivariate Taylor's expansion, resultants etc.
- Studied algebraic geometry, with a focus on the complexity of Hilbert's Nullstellensatz, dimension of a variety, algebraic set decomposition etc.
- Applied techniques to lift roots of multivariate polynomials from finite fields $\mathbb{F}_p$ to $p$-adic fields
- Devised an algorithm to find roots of degree-$d$ $n$-variate polynomials modulo prime powers for constant $d$ and $n$

**Root sets and $p$-ordering** — *Kanpur, India*

Prof. Rajat Mittal, IIT Kanpur — *Jun 2020 - Present*

- Literature review on $p$-ordering, it's properties and factorial function generalization
- Studied root sets of polynomials, their properties and methods to calculate the number of root sets modulo prime powers
- Devised an efficient algorithm to find $p$-ordering of integers and root sets in $\mathbb{Z}/p^k\mathbb{Z}$ given in succinct representations
- Attempted to use representative roots to check if a given set is a valid root set
- Currently working on solving linear inequalities in integers and optimizing to find the polynomial representing the root set

**Designer Commutative Algebra** — *Helsinki, Finland*

Prof. Petteri Kaski, Aalto University — *Apr 2021 - Present*

- Studied multivariate batch evaluation, multivariate interpollation, Gröbner basis etc.
- Experimented with some ideals to find a ring extension followed by a substitution forfaster multivariate polynomial evaluation
- Currently analyzing existing results and attempting to find faster methods of multivariate evaluation by studying ring extensions and homomorphisms

**Factorization of polynomials modulo prime powers** — *Kanpur, India*

Prof. Rajat Mittal, IIT Kanpur — *Aug 2019-Jun 2020*

- Learnt about algorithms on factorization of polynomials in finite fields and methods to lift them to modulo prime powers
- Literature review on factorization of polynomials modulo $p^k$ for $k \leq 4$, Newton polygons etc.
- Learnt about representative roots and root-finding modulo prime powers
- Attempted to use $p$-ordering to find factorization of polynomials modulo prime powers
- Worked on finding factorization techniques to return a factorization of polynomials with maximum number of linear factors $\mod p^k$
- Gave a result for degree $3$ polynomials to show that linear factors correspond to different representative roots

### Continuous Skolem Problem for higher dimensions

*Saarbrücken, Germany*

Dr. Engel Lefaucheux, Dr. Eike Neumann, Prof. Jöel Ouaknine, MPI-SWS — *May 2020 - Jul 2020*

- Learnt about Real Algebraic Geometry with an emphasis on Semi-algebraic sets and their decomposition
- Studied the work done upto dimension $8$ and attempted to extend it to higher dimensions using Schanuel's conjecture and Leon Ehrenpreis' conjecture
- Attempted to prove the decidability of zeroes of exponential polynomials for low codimension cases
- Devised a parameterization of a semi-algebraic set which contains the zeroes of the given function
- Modified a proposition from "Real Algebraic Geometry" by Bochnak, Coste and Roy to show that the parameterized semialgebraic set can be extended to $\bar{0}$

### Graphon Estimation from Partially Observed Network Data

*Kolkata, India*

Prof. Soumendu Sundar Mukherjee, ISI Kolkata — *Dec 2018 - Dec 2020*

- Learnt about graphons, symmetric measurable functions $f : [0, 1]^2 \to [0, 1]$ used to denote network edge probabilities of dense graphs
- Learnt about graphon estimation methods including universal singular value thresholding, stochastic blockmodel approximation, matrix completion, neighborhood smoothing etc.
- Extended the neighborhood smoothing technique to give an algorithm to estimate the underlying graphon with high accuracy on partially revealed graphs, both on simulated networks from standard graphon functions and real networks
- Estimated graphons using various existing alternative methods and compared those against the proposed algorithm

## Teaching Experience

### Tutor, ESC101: Fundamentals of Computing

*Kanpur, India*

Instructors: Prof. Swarnendu Biswas and Prof. Hamim Zafar, IIT Kanpur — *Oct 2021 - Present*

- Conducted weekly tutorial sessions, helped with setting questions for quizzes and labs, graded labs and exams

### Teaching Assistant, CS203: Probability for Computer Science

*Kanpur, India*

Instructor: Prof. Nitin Saxena, IIT Kanpur — *Mar 2021 - May 2021*

- Conducted doubt clearing classes, graded exams and assignments

### Teaching Assistant, CS202: Logic for Computer Science

*Kanpur, India*

Instructor: Prof. Sunil Simon, IIT Kanpur — *Jan 2021 - Feb 2021*

- Graded exams

### Volunteer, Shiksha Sopan

*Bara Sirohi village, India*

Sopan School — *Apr 2019 - Mar 2020*

- Volunteered with Shiksha Sopan, an NGO aimed at providing education to economically weaker section of the society
- Conducted weekly English Grammar classes to children of classes 6-8

### Academic Mentor, MTH101: Single Variable Calculus & MTH102: Linear Algebra and ODEs

*Kanpur, India*

Counselling Services, IIT Kanpur — *Aug 2018 - Apr 2019*

- Helped students facing academic problems in mathematics by conducting doubt clearing sessions and one-to-one mentorship

## Talks & Presentations

### Quantum Information Theory and Applications to Local Decoding

*Apr 2021*

Course: Quantum Computing — [Slides]

### Towards Mordell's Theorem- Weierstrass Normal Form & A Useful Homomorphism

*Nov 2020*

series of two talks, Course: Arithmetic Geometry — [Slides-1] [Slides-2]

### Factorization of polynomials modulo prime powers

*Jul 2020*

Undergraduate Project — [Slides]

## Graduate Courses

Randomized Methods in Computational Complexity,
Algebraic Number Theory,
Computational Number Theory and Algebra,
Geometric Topology,
Modern Cryptology,
Arithmetic Geometry,
Quantum Computing,
Algorithmic Information Theory,
Computational Complexity Theory*

* - *ongoing course*

## Other Professional Activities

**Sub-Reviewer** | Journal of Number Theory — *Aug 2021 - Sep 2021*

- Sub-reviewed a paper for Journal of Number Theory under the guidance of and edited by Prof. Nitin Saxena

**Project Mentor** | Association for Computing Activities — *Jan 2019 - Apr 2019*

- Guided a group of first year students in topics of Theoretical Computer Science

**Student Guide** | Counselling Service — *Jul 2018 - Apr 2019*

- Provided emotional and academic assistance to 4 freshmen and helped them adjust to campus environment

## Skills

**Programming** Python, C/C++, R, SageMath, Haskell, Verilog, PHP
**Tools** LaTeX, Bash, Git, MySQL
**Libraries** Qiskit, Pytorch, Tensorflow, Numpy, Keras, OpenCV