# Haricharan Balasundaram

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## EDUCATION

**Indian Institute of Technology, Madras**  **CGPA: 9.57/10.00, Department Rank 1**

*B. Tech. (Hons.) in Engineering Physics + M. Tech. in Electrical Engineering; Minor in Computer Science*  *Nov 2021 - Present*

## PUBLICATIONS ⎘

**Accepted:**

1. *Estimating Error in Natural Distribution Estimation* ⎘
   H. Balasundaram, A. Thangaraj.  *Annual Allerton Conference on Communication, Control, and Computing 2025.*
2. *Stability Notions for Hospital Residents with Sizes* ⎘
   H. Balasundaram, Krishnashree J. B., G. Limaye, M. Nasre.  *Foundations of Software Technology and Theoretical Computer Science 2025.*

**Ongoing:**

1. *Learning to Transmit Over Unknown Erasure Channels with Empirical Erasure Rate Feedback* ⎘
   H. Balasundaram, K. Jagannathan.
2. *Generalized Capacity Planning for the Hospital-Residents Problem* ⎘
   H. Balasundaram, G. Limaye, M. Nasre, and A. Raja.  *Submitted to Elsevier Theoretical Computer Science.*

## AWARDS AND ACHIEVEMENTS

— Presented research at **Allerton Conference** held at University of Illinois, Urbana–Champaign in the *Informational Characterization* session.
— Sole undergraduate recipient of *Teaching Assistant Recognition Award (TARA)* 2025 in the EE Dept for serving as Head TA.
— Recipient of *Ms. Latha and Sampath Srinath* prize for *Highest CGPA* in semesters 3 and 4 in the Engineering Physics program.
— Achieved an *JEE Advanced* All India Rank of *1153* and *JEE Mains* All India Rank of *2565* out of over 1 million candidates.
— *Candidate Master* on Codeforces Competitive Programming; Global Rank #59 in Round #886 among 25,000 participants.

## RESEARCH EXPERIENCE

**Uniformity Testing of the Missing Mass [Dual Degree Project]**
*Guide: Prof. Andrew Thangaraj, Department of Electrical Engineering, IIT Madras*  *Feb 2025 - Present*

— Studied **distribution estimation** of an unknown discrete distribution over large a alphabet, where *natural estimators* incur large error
— Introduced a novel *error statistic* that captures the unavoidable estimation error at frequency $l$ and proposed a *non-linear estimator* for this
— Proved low bias and consistency for the estimator and validated the approach using simulations on *synthetic and natural language datasets*

**Constrained Online Convex Optimization with Adversarial Constraints**
*Guide: Prof. Rahul Vaze, School of Technology and Computer Science, Tata Institute of Fundamental Research*  *May 2025 - Present*

— Addressed the problem of **constrained online convex optimization (COCO)**— simultaneous minimization of regret and constraint violation
— Improved analysis for the existing gradient descent method, thus breaking the long-standing $O(\sqrt{T})$–cumulative constraint violation bound
— Provided lower bound of $O(T^{\beta})$–regret and $O(T^{1-\beta})$–cumulative constraint violation, confirming the optimality of pre-existing algorithms

**Learning to Transmit over Unknown Erasure Channels [B. Tech. Project]**
*Guide: Prof. Krishna Jagannathan, Department of Electrical Engineering, IIT Madras*  *Dec 2023 - May 2025*

— Developed algorithms for *transmission over erasure channels* with unknown erasure rates, using limited empirical erasure feedback
— Analyzed two strategies: *Estimate-then-Transmit* (1 query, $O(T^{2/3})$ regret) and *Windowing* (logarithmic queries, $O(\sqrt{T})$ regret)
— Established theoretical regret guarantees and validated performance through simulations, showing applicability to low-feedback IoT systems

**Approximation Algorithms for Hospital-Resident Matchings**
*Guide: Prof. Meghana Nasre, Department of Computer Science and Engineering, IIT Madras*  *Oct 2023 - Nov 2024*

— Developed *approximation algorithms* and *inapproximability results* for quota augmentation in the **Hospital–Residents** setting
— Analyzed *the Hospital–Residents problem with Sizes (HRS)*, studying occupancy-stability and designing efficient approximation algorithms

**Many-to-oneness of Lattice Filters**
*Guide: Prof. C. S. Ramalingam, Department of Electrical Engineering, IIT Madras*  *Sep 2023 - Nov 2023*

— Utilized MATLAB to carry out brute-force calculations to determine the *oddness or evenness* of lattice coefficients
— Explored conditions on one-oneness and many-oneness of the mapping from lattice coefficients to transfer functions

**Control Systems for Rehabilitation** [PYTHON PACKAGE]
*Guide: Prof. Sourav Rakshit, Gait and Motion Analysis (GAMA) Lab, Machine Design Section, IIT Madras*  *Sep 2022 - Jan 2023*

— Applied *LQR, iLQR,* and *SAC* control systems for trajectory tracking in **gait training** of paralyzed patients, achieving 75% accuracy
— Created Python package and contributed to *open-source repository* for implementing LQR to achieve multi-motor position control

## TEACHING EXPERIENCE

— **Head Teaching Assistant (TA)** for Signals and Systems (EE1101), coordinated 400+ students and 6 faculty members– **TA award**
— **TA** for Multirate Digital Signal Processing, Probability Foundations– formulated assignments and conducted tutorial sessions
— *Shaastra 2023:* conducted workshop on Cryptography and *Shaastra 2024:* conducted workshop on Probability, Statistics and Finance
— Conducted information session on *Fundamentals of Mathematics and Programming* to incoming freshers in 2023

## RELEVANT COURSEWORK

| **EE:** | Information Theory | Estimation Theory | Detection Theory | Convex Optimization |
|---|---|---|---|---|
| | Multirate DSP | RF and Optical Communication | Communication Networks | Linear Algebra |
| | Probability and Statistics | Mathematical Physics | Advanced Topics in Communications (5G) | |
| **Minor in CS:** | Approximation Algorithms | Parameterized Algorithms | Advanced Graph Algorithms | Linear Programming |

## PROFESSIONAL EXPERIENCE

**Software Developer Intern at D. E. Shaw India**
*Using LLMs to Automate Processing Vendor Emails*      *May 2024 - Jul 2024*

— Built Python pipelines to process and validate large-scale financial data, improving speed and accuracy of business operations
— Leveraged LLMs to automate vendor *email classification* and data extraction, reducing manual effort and streamlining workflows

## SELECTED COURSE PROJECTS

**EE5111: Estimation Theory** [SLIDES]
*Prof. Sheetal Kalyani, Department of Electrical Engineering, IITM*      *May 2025*

— *'Source Enumeration using Linear Shrinkage Coefficients'*– addressed limitations of existing methods in *low SNR* regimes
— Introduced a novel *running average–based filter* on the shrinkage coefficients to enhance detection accuracy
— Achieved better results than traditional methods for *source enumeration* under colored noise, with applications to cellular communications

**EE5143: Information Theory** [SLIDES]
*Prof. Andrew Thangaraj, Department of Electrical Engineering, IITM*      *Feb 2024*

— Presented **Lempel-Ziv compression algorithms (LZ77 and LZ78)**, focusing on information-theoretic analysis and optimality
— Compared advantages of LZ compression over Huffman-coding, explained practical applications such as gzip and GIF formats

**CS6130: Advanced Graph Algorithms** [SLIDES]
*Prof. Meghana Nasre, Department of Computer Science and Engineering, IIT Madras*      *Apr 2024*

— Presented '*Vital Edges for* $(s,t)$*–min-cut*': classification into tight and loose vital edges and a general Maxflow-Mincut theorem
— Explained utilization of data structure (ancestor tree) to compute all tight edges and bounded the number of loose edges

**EE5121: Convex Optimization** [POSTER]
*Prof. Uday Khankhoje, Department of Electrical Engineering, IIT Madras*      *Nov 2023*

— Poster presentation on the paper '*Subsampled Hessian Newton methods for solving supervised learning problems*'
— Achieved *12% improvement* on overqualified constraint datasets by integrating approximate Hessian direction with the gradient

**CS6841: Approximation Algorithms** [SLIDES]
*Prof. Meghana Nasre, Department of Computer Science and Engineering, IIT Madras*      *Nov 2023*

— Presented an approximation algorithm for the '*Connected Dominating Set problem using only local information*' in graphs
— Proved that the algorithm achieved a $H_n$–approximation factor, matching the theoretical lower bound on approximation

## POSITIONS OF RESPONSIBILITY

**Head and Founder**
*Mathematics Club, Centre for Innovation, IITM*      *Nov 2022 - Mar 2024*

— Co-founded and headed the *Mathematics Club* at IIT Madras, building a community with a reach of 1000+ students
— *Conducted sessions* on number theory, probability, and linear algebra and headed projects on probability and group theory
— Supervised a cohort of 76 members, including 4 project leads, 15 coordinators, and 57 deputy coordinators during 2023–24

## EXTRA-CURRICULAR ACTIVITIES

- Presented Mathematics Club achievements at the *G20 Global Summit* held at IIT Madras to national and international delegates
- *Bronze Medal* in the Inter-IIT Tech Meet Quant Competition (Dec 2023)
- *Strategist* in the Programming and Cybersecurity clubs
- Heading the *Communications* problem at Inter-IIT Tech Meet '25
- Selected for ICPC Regionals at Amritapuri
- Member of the Quiz Club IITM, winner of Shaastra SciTech Quiz '25
- Correspondent for *The Fifth Estate*, IITM's newsletter