

# Manav Batavia

Curriculum Vitae

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## EDUCATION

### Purdue University

*Candidate for Ph.D. in Mathematics*

- Current GPA: 4.00/4.00

Indiana, USA

Aug 2022 - Present

### Indian Institute of Technology Bombay

*Integrated Master's of Science (B.S.+M.Sc.) in Mathematics*

- Awarded the Institute Silver medal.
- Cumulative Performance Index (CPI) : 9.82/10.
- Minor in Computer Science and Engineering, Minor CPI: 9.60/10.

Mumbai, India

Jul 2017 – Jun 2022

## PUBLICATIONS, PREPRINTS AND WORKING PAPERS

3. H. Ananthnarayan, **M. Batavia**, O. Javadekar, ***When do Associated Graded Modules have Pure Resolution?***, in preparation.
2. A. Agarwal, **M. Batavia**, Z. Lihn, H. Lu, A. Maithani, A. Pradhan, S. Rath, A. Seceleanu, ***Betti Numbers of Quadratic Ideals of Low Embedding Dimension***, in preparation.
1. S. Banerjee, **M. Batavia**, B. Kane, M. Kyranbay, D. Park, S. Saha, H. C. So, P. Varyani, ***Fermat's Polygonal Number Theorem for Repeated Generalised Polygonal Numbers***, Journal of Number Theory, Volume 220, 2021, Pages 163-181. [doi]

## TECHNICAL SKILLS

**Programming Languages:** C++, Python, MATLAB.

**Softwares:** Macaulay2, L<sup>A</sup>T<sub>E</sub>X, SolidWorks, AutoCAD, Xcircuit.

## RESEARCH EXPERIENCE

### Master's Thesis and Further Research

*Guide: Prof. Ananthnarayan Hariharan, Department of Mathematics*

Jul 2021 – Dec 2022

IIT Bombay

- Proved a necessary and sufficient condition for the existence of a pure resolution of the associated graded module corresponding to a module over a Noetherian local ring. The proof involves an explicit construction of the said pure resolution.
- Independently proved the Auslander-Buchsbaum-Serre equivalences, and studied Burch's work on constructing ideals with arbitrarily large projective dimension, generated by three or fewer elements.
- Explored Schreyer's algorithm for computing the projective resolution of a finitely generated module over a polynomial ring in finitely many variables.
- Explored the theory of Stanley-Reisner ideals and Fröberg's work on Stanley-Reisner rings.
- Studied the Eliahou-Kervaire resolution and Peeva's work on consecutive cancellations in Betti numbers.
- Studied Avramov and Eisenbud's work on the regularity of modules over a Koszul algebra.

### Betti Tables of Quadratic Ideals in Characteristic Two

*Guide: Prof. Alexandra Seceleanu, Department of Mathematics*

Jun - Aug 2021

University of Nebraska-Lincoln

This research was done as part of the Polymath Jr. 2021 program.

- Succeeded in resolving all quadratic ideals with three generators in a polynomial ring in three variables over a field of characteristic two. The results attained are easily applicable to larger ideals and larger polynomial rings.
- The approach involved classification of all such ideals into certain categories and subcategories, followed by suitable application of results on Koszul complexes and mapping cones, among others.
- In particular, application of mapping cone theory, coupled with degree comparisons, enabled us to resolve ideals with higher number of generators using well known results on ideals with fewer generators.
- Acquainted myself with the computer algebra system Macaulay2, critical for the computational aspect of the project.
- Presented our results at the Young Mathematicians Conference 2021, organised by the Ohio State University.
- Currently compiling the work done in this project for publication.

## Drinfeld Modular Forms

May – Jul 2021

Guide: Prof. Giovanni Rosso, Department of Mathematics and Statistics

Concordia University, Montreal

- Versed myself with the theory of additive polynomials over a finite field, and Carlitz and Drinfeld modules from David Goss's text "Basic Structures of Function Field Arithmetic".
- Proceeded to read Richard Pink's trifecta of papers on the Galois representations associated to a Drinfeld module in special characteristic.

## Parameterized Verification under Sequential Consistency

Mar – Jun 2020

Guide: Prof. Roland Meyer, Institute of Theoretical Computer Science

Technische Universität Braunschweig

- Worked on proving that the parameterized reachability problem under sequential consistency is EXPTIME-complete.
- The approach involved reduction of Boolean pushdown to parameterized program under sequential consistency and vice versa, drawing on techniques used by Farzan and Vandikas in their paper on automated hypersafety verification.

## Generalization of Fermat's Polygonal Number Theorem

May – Jul 2019

Guide: Prof. Ben Kane, Department of Mathematics

The University of Hong Kong

- Acquired minimal number of terms for which certain weighted sums of generalized polygonal numbers are universal.
- The approach involved using Siegel and Weil's work on local representations to conclude a special universality of the sum of five generalised polygonal numbers, and consequently treating the smaller cases using a variety of methods.
- The work done resulted in the aforementioned publication in the Journal of Number Theory.

## ACADEMIC ACHIEVEMENTS

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- Department Rank 1 in mathematics at IIT Bombay.
- Awarded Advanced Performance (AP) grade in Group and Ring Theory (MA419), Complex Analysis (MA412), Introduction to Numerical Analysis (MA214) and Logic for CS and Automata Theory (CS228) at IIT Bombay (awarded to exceptional performers).
- All India rank of 174 in IIT JEE Advanced (out of 0.17 million candidates).
- All India rank of 8 in the B.Math entrance exam for Indian Statistical Institute (ISI).
- Awarded the Mitacs Globalink scholarship for a research internship in Canada.

## OTHER PROJECTS

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### Cohen-Macaulay Modules

Jan 2023 - Present

Guide: Prof. Lingnan Ma, Department of Mathematics

Purdue University

### Commutative Ring Theory

Jan 2023 - Present

Guide: Prof. Bernd Ulrich, Department of Mathematics

Purdue University

### Decoding Cyclic Codes: The Cooper Philosophy

Oct 2021

MA5105: Coding Theory

IIT Bombay

- Learned about Cooper's ideas on decoding BCH cyclic codes using the theory of Gröbner bases.
- Read and presented the ideas outlined by Chen, Reed, Hellesteth and Truong in their work on the use of Gröbner bases to decode binary cyclic codes up to the true minimum distance.

### Combinatorial Algorithm for Computing Determinants

Nov 2020

CS711: Computational Ring Theory

IIT Bombay

- Read and presented the purely combinatorial algorithm proposed by Mahajan and Vinay to compute the determinant over arbitrary commutative rings. In the same paper, they also proved that the complexity class GapL characterizes the complexity of computing the determinant of matrices over the integers.

### Automata Theory

Jan – May 2020

Guide: Prof. Krishna S., Department of Computer Science and Engineering

IIT Bombay

- Explored a number of references and research papers related to automata theory, such as Dexter Kozen's "Automata and Computability" and the research papers Automated Hypersafety Verification (by Farzan and Vandikas) and Analysis of Boolean Programs (by Godefroid and Yannakakis).
- Studied the concepts of pushdown automata, context free grammar, Boolean programs, looping tree automata and reductions, among others.

### Speech Command Classification

Apr 2020

CS419: Introduction to Machine Learning

IIT Bombay

- Developed a Google Speech Command dataset classifier using deep learning.
- Programmed a convolution based neural network for time series data analysis and some preprocessing.

### Texture Synthesis by Non-Parametric Sampling

Nov 2019

CS663: Digital Image Processing

IIT Bombay

- Implemented Efros and Leung's work on texture synthesis via MATLAB.

## TEACHING ASSISTANTSHIPS

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<b>Calculus II</b>   <i>MA16200, Purdue University</i>	Aug 2022 – Present
<b>Linear Algebra</b>   <i>MA106, IIT Bombay</i>	Mar – May 2022
<b>Calculus I</b>   <i>MA109, IIT Bombay</i>	Nov 2021 – Jan 2022
<b>Introduction to Calculus</b>   <i>MA105, IIT Bombay</i>	Jul – Nov 2019

## PUBLIC TALKS

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M.Sc. Thesis Stage 2   <i>IIT Bombay</i>	May 2022
Operad Theory   <i>Homotopy Theory Course Seminar, IIT Bombay</i>	Apr 2022
M.Sc. Thesis Stage 1   <i>IIT Bombay</i>	Nov 2021
Decoding Cyclic Codes: The Cooper Philosophy   <i>Coding Theory Course Seminar, IIT Bombay</i>	Oct 2021
Betti Tables of Quadratic Ideals in Characteristic Two   <i>Young Mathematicians Conference</i>	Aug 2021
Explicit Factorisation over a Dedekind Domain   <i>Algebraic Number Theory, IIT Bombay</i>	Apr 2021
Length of Finite Free Resolutions   <i>Advanced Commutative Algebra Course Seminar, IIT Bombay</i>	Feb 2021
Combinatorial Computation of the Determinant   <i>Computational Ring Theory Course Seminar, IIT Bombay</i>	Nov 2020
Discrete Valuation Rings   <i>Ring and Module Theory Course Seminar, IIT Bombay</i>	Nov 2019

## RELEVANT COURSEWORK

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<b>Advanced Instructional Course in Commutative Algebra</b>	Jan – May 2021
<i>Instructors: Prof. Dilip Patil, Prof. Indranath Sengupta, Prof. Jugal Verma</i>	<i>National Centre for Mathematics</i>

- Flat and faithfully flat modules, faithfully flat descent, Tor and Ext functors, injective, projective and global dimension, regular local rings, flat extensions of regular local rings, Serre's normality criterion.
- Krull dimension, Noether's normalization lemma, Hilbert-Samuel functions and polynomials, normal rings, finiteness of integral closure, complete local rings, formal smoothness, Cohen's structure theorem for complete local rings.
- Regular sequences, quasi-regular sequences, depth and grade, Cohen-Macaulay rings and modules, homological characterization of injective dimension, Gorenstein rings, injective modules, Matlis duality.

**Selected Courses in Mathematics:** Graduate Combinatorics, Advanced Commutative Algebra, Topics in Algebra, Algebraic Topology, Topics in Topology, Algebraic Number Theory, Analytic Number Theory, Coding Theory, Representation Theory of Finite Groups, Commutative Algebra, Ring and Module Theory, Algebraic Topology, Functional Analysis, Partial Differential Equations, Measure Theory, Applied Stochastic Processes, Probability

**Computer Science:** Computational Ring Theory, Logic for CS and Automata Theory, Data Structures and Algorithms, Design and Analysis of Algorithms, Introduction to Machine Learning, Digital Image Processing.

## POSITIONS OF RESPONSIBILITY

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<b>Department Academic Mentor</b>   <i>IIT Bombay</i>	Apr 2019 – May 2022
<ul style="list-style-type: none"><li>• Delivered multiple seminars aimed at freshmen and sophomore students in the mathematics department, advising them on their academic choices and future avenues.</li><li>• Responsible for mentoring 12 sophomore students to ensure their academic and holistic development.</li><li>• Co-founded the Mathematics D-AMP blog, intended to be a one-stop destination for academic resources, course reviews, internship experiences and other resources for undergraduate math students at IIT Bombay.</li></ul>	
<b>National Service Scheme (NSS) Volunteer</b>   <i>IIT Bombay</i>	Jul 2017 – May 2018
<ul style="list-style-type: none"><li>• Dedicated over 80 hours towards various activities directed toward sustaining the environment, including creating awareness and recycling plastic waste, among other ventures.</li><li>• Visited government schools and imparted environmental education to underprivileged children.</li></ul>	

## EXTRA-CURRICULAR ACTIVITIES

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- Mentored 12 students as part of the Summer of Science program at IIT Bombay, providing them with necessary guidance in group and ring theory, topology and real analysis.
- Finished 3rd in Math Bazinga 2018 - an annual mathematics competition open to all students in IIT Bombay.
- Developed an autonomous Arduino robot which navigates through mazes, as part of a competition at IIT Bombay.
- Finished in the top 5 (out of 400+ participants) in a cricket trivia competition at EnB Buzz, IIT Bombay.