SHIV NADAR

INSTITUTION OF EMINENCE DEEMED TO BE UNIVERSITY

DELHI NCR

DEPARTMENT OF MATHEMATICS

SCHOOL OF NATURAL SCIENCES

UNDERGRADUATE PROSPECTUS

2023

www.snu.edu.in

Contents

Overview of the Department

The Department of Mathematics established in 2011, is one of the founding departments at the Shiv Nadar Institution of Eminence (Deemed to be university).

The faculty at the department are active researchers in diverse areas such as Functional analysis, Optimization, Algebra, Complex systems, Artificial intelligence and Mathematical finance. This research transcends into our BSc (Research) Mathematics programme in the form of undergraduate thesis which opens up avenues to higher academic degrees, placements and internships in popular emerging technologies.

Empowerment through rigorous learning and research in fundamental areas of mathematics and emerging technologies is at the core of the undergraduate programme. Students have an opportunity to choose their electives from a wide variety of pure and applied mathematics courses to tailor their degree according to their aptitude and ambition highlighting interdisciplinary and the multidisciplinary nature of the university. The Department offers undergraduate thesis and specializations in Applied algebra, Mathematical finance, and Statistical learning & Artificial intelligence, as a mandatory credit requirement.

The faculty at the Department of Mathematics is constantly striving to explore new and emerging transdisciplinary domains of knowledge which are relevant to societal benefit and sustainable development goals, like Human-nature interaction and Artificial intelligence. Some of the frontier areas in which the faculty has reputed publications include Complex systems modelling, Statistical learning, Minimal surfaces, and Mathematical finance. The Department's engagement with these emerging paradigms of learning promotes novel dimensions to our research focus that transcends to the Doctoral programme which has these as thrust areas in addition to modern areas in Functional analysis, Algebra, Optimization, and Geometry.

The Department has been conferred the DST-FIST grant in 2015 towards setting up a Departmental Research Computer Lab, as well as a dedicated Department Library. In addition to organising the National Conference in Complex Networks and a workshops in Zero Mean Curvature, the Department has been regularly hosting important national conferences and schools such as the Annual Foundational School, and Advanced Instructional School, organized by the National Board of Higher Mathematics.

The department also offers a **Minor in Mathematics** for students not majoring in Mathematics can complete a Minor in Mathematics by earning appropriate course credits from the department.

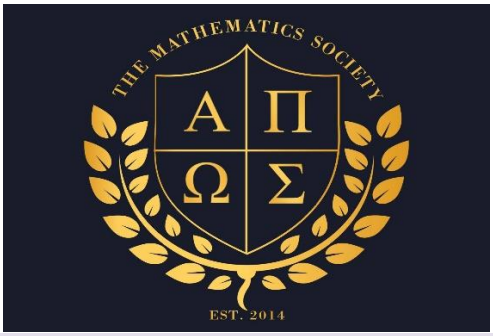
Our alumni have gone on to further studies in mathematics, economics and data analytics in leading institutions like the ETH Zurich, National University of Singapore, University of Bonn, Dublin City University, Institute of Mathematical Sciences (Chennai), Tata Institute of Fundamental Research (Mumbai), University of Göttingen (Germany), Institute of Higher Economics (Russia), Moscow Institute of Physics and Technology (Russia), University of Chicago (USA), Arizona State University (USA), and Delhi School of Economics. Some havetaken up jobs in academia as well as in industry.

Department photograph with graduating batch of 2023.

Prof. R. Bapat giving a glimpse of Spectral graph theory to Undergraduate and Graduate students.

Undergraduate students in the Department Library, set up under a DST-FIST grant.

The Department of Mathematics is housed in the School of Natural Sciences.



The Mathematics Society of the department strives to promote students' independent thinking and critical ability in mathematics by organizing a variety of activities such as student seminars, talks, workshops, and games.

Faculty members with the founding batch of BSc (Research) Mathematics 2011.

Mission of the Undergraduate Program in Mathematics

Our fundamental mission is to empower the students through rigorous training in fundamental areas of mathematics and in emerging technologies. This enables our students to pursue careers and achieve leadership roles in both academia and industry. We promote critical thinking through training in logical reasoning, the nature and types of proof, abstraction, the presentation and analysis of data. We enable students to realise and develop their interests through a diverse set of elective courses as well as opportunities for research with faculty mentors. Students are also exposed to the connections between mathematics and other disciplines.

Our undergraduate program is further distinguished by the following features:

- Melting of the artificial barriers between pure and applied mathematics and between mathematics and other disciplines.
- Training in modern computing skills and applications to real-world problems.
- Accessibility to students from diverse backgrounds.

Learning Outcomes of the Undergraduate Program in Mathematics

Through their study of the core undergraduate mathematics curriculum and their choice of elective courses, all Shiv Nadar University mathematics majors develop their ability to:

- Formulate and express mathematical statements and arguments.
- Translate intuitive understanding into formal definitions and proofs.
- Solve new problems.
- Abstract from the particular to the general.
- Communicate mathematical ideas through oral and written presentations.
- Create mathematical models for applications in other disciplines, especially physics, economics, biology and data science.
- Show individual ability and creativity through participation in projects and research.

Faculty

The faculty members of the department of mathematics at SNIOE have studied or worked at leading institutions. Their mathematical interests vary widely across pure and applied mathematics.

Faculty Member	Designation	Teaching/Research Interest
Dr. Sanjeev Agrawal	Professor	Functional Analysis, Operator Theory, Error Correcting Codes, Encryption, Mathematics Education
Dr. Sudeepto Bhattacharya	Professor & Head	Complex systems, Game theory, Network Theory, Mathematical Modeling
Dr. Samit Bhattacharyya	Associate Professor	Applied Mathematics and Computational Biology
Dr. Indranil Biswas	Senior Professor	Algebraic geometry, Differential geometry
Dr. Priyanka Grover	Associate Professor	Matrix Analysis, Operator Theory
Dr. Neha Gupta	Assistant Professor	Quantum Groups, Category Theory
Dr. Amber Habib	Professor	Representation Theory, Mathematical Finance
Dr. Qazi Azhad Jamal	Assistant Professor	Estimation Theory
Dr. Ajit Kumar	Assistant Professor	Partial Differential Equations,Finite Element Method
Dr. Pradip Kumar	Assistant Professor	Differential Geometry
Dr. Sneh Lata	Assistant Professor & Graduate Advisor	Frame theory, Operator Theoryand Function Theory
Dr. A. Satyanarayana Reddy	Associate Professor	Algebraic Graph Theory, Discrete Mathematics, Algebraic Number Theory
Dr. Niteesh Sahni	Associate Professor & Undergraduate advisor	Artificial Intelligence, Mathematical modelling, Harmonic Analysis
Dr. Charu Sharma	Assistant Professor	Mathematical Finance, Statistical Modelling
Dr. Santosh Singh	Associate Professor	Medical image analysis, Image reconstruction, Filter bank theory, Computational photography, Light field and Optimization technique

Dr. TSSK Rao	Distinguished Professor	Harmonic Analysis, Approximation theory

B.Sc. (Research) Mathematics

The basic undergraduate degree program offered by the Department of Mathematics is B.Sc. (Research) in Mathematics. By taking appropriate elective courses, in consultation with the Undergraduate Advisor of the Department, a student can also be eligible for award of one of the following:

- B.Sc. (Research) in Mathematics with a Mathematics Specialization
- B.Sc. (Research) in Mathematics with a Minor

Every mathematics undergraduate student of the University is required to take a number of credits from courses broken up into the following categories:

a) CCC (Core Common Curriculum courses offered by the university)
b) UWE (University Wide Electives; courses so designated and offered by departments other than Mathematics)
c) Core Mathematics Courses ("Major Core")
d) Elective Mathematics Courses ("Major Elective")
e) Undergraduate Thesis

The minimum credit requirements are described below.

B.Sc. (Research) in Mathematics		
S. No.	Category	Credits
1	CCC	18
2	UWE	18
3	Major Core	72
4	Major Electives A	12
5	Major Elective B	12
6	Floating*	6
7	Undergraduate Thesis	12
	Total	**150**

Floating* 6 credits can be chosen from either CCC or UWE or Major Electives.

The **Elective A** credits have to be earned from a basket of 8 courses. These courses lay the foundations for advanced specializations or higher studies in pure mathematics. The **Elective B** credits can be earned from any major electives offered by the Department of Mathematics (including the Elective A basket).

The basic degree can be supplemented by **Specializations** in particular aspects of Mathematics and its applications. Two Specializations are available to students admitted to B.Sc. (Research) in Mathematics in 2023:

1. **Mathematical Finance**
2. **Applied Algebra**

These can be completed using the Elective slots and are described in detail later.

A student must complete all requirements for the degree in a minimum of three years and a maximum of six years.

The **Minor** requirements are set by the department offering it. It is expected that a student will complete the minor by concentrating his/her UWE choices accordingly, though a student may need to take extra UWE credits to complete a particular Minor.

Semester-wise Plan

A typical path through the B.Sc. (Research) in Mathematics program is shown below. Students may be allowed by the Department Undergraduate Committee to alter the sequence of core courses in order to ease goals such as obtaining a Minor from another department, or to complete prerequisites for a summer program or internship.

Similarly, each student will have individually guided choice in timing CCC, UWE and Mathematics Elective courses.

Yr	Monsoon Semester	Credits	Spring Semester	Credits
1	MAT100 Foundations MAT101 Calculus I CSD101 Introduction to Programming MAT160 Linear Algebra I CCC	19	MAT102 Calculus II MAT132 Vector Calculus and Geometry MAT150 Mathematical Modelling UWE CCC	19
2	MAT184 Probability MAT220 Real Analysis I MAT240 Algebra I UWE CCC	19	MAT221 Real Analysis II MAT280 Numerical Analysis I MAT241 Algebra II MAT283 Introduction to Statistics UWE or CCC	19
3	MAT230 Ordinary DifferentialEquations MAT360 Linear Algebra II Major Elective UWE CCC	19	MAT330 Partial Differential Equations MAT399 Undergraduate Seminar Major Elective Major Elective UWE or CCC	19
4	MAT499 Undergraduate Thesis Major Elective Major Elective UWE CCC	18	MAT499 Undergraduate Thesis Major Elective UWE CCC	18

Most CCC courses are of 1.5 credits and are taught over a half-semester. Some are 3 credits and the compulsory CCC on Environment is of 4 credits. Similarly, UWE courses can have different credits, and are typically for 3 or 4 credits. The UWE and CCC slots shown above are therefore indicative only.

Minor in Mathematics

Undergraduate students of the university who are *not* majoring in Mathematics have the option to take a **Minor in Mathematics**. A Minor in Mathematics can serve two distinct functions (apart from enjoying its beauty and intellectual stimulation!):

- Acquiring the academic background for higher studies in mathematics.
- Acquiring modeling and computational skills for applications of mathematics in other disciplines or in industry.

Academic Requirements

You have to acquire a minimum of **20 credits as University Wide Electives** (UWE) from the courses offered by the Department of Mathematics. These credits must satisfy the following minimum requirements:

(1) At least 8 credits from the following: MAT 101 (Calculus I), MAT 102 (Calculus II), MAT 132 (Vector Calculus and Geometry), MAT 160 (Linear Algebra I), MAT 184 (Probability), MAT 220 (Real Analysis I), MAT 230 (Ordinary Differential Equations), MAT 240 (Algebra I), MAT 280 (Numerical Analysis), MAT 284 (Probability & Statistics).

(2) At least 8 credits from all other MAT courses numbered 200 or above, available as UWE, and not included in item (1).

Your choice of courses is subject to the following restrictions:

- A course cannot count towards both Major and Minor requirements. For example, Economics students cannot count MAT 101 towards the Minor because it is a compulsory course in their Major.

- Certain course combinations are not allowed. If you have already credited a course with significant overlap with a certain MAT course, or a more advanced course than the MAT course, you may not earn credit for the Minor from that MAT course. A list of such banned combinations will be published before each semester's course registration.

The Undergraduate Advisor for Mathematics will help you work out an appropriate choice of courses depending on your interests and background.

Specializations in Mathematics

Students of B.Sc. (Research) in Mathematics can choose to specialize in certain areas, especially in applications of Mathematics.

Mathematical Finance is a modern study area where advanced mathematical methods are used to create and add immense value in a practical environment. Typically banks, insurance companies and institutional investors rely on mathematical models to drive both their investment and risk management strategies. The study of Mathematical Finance provides ample opportunities for continuation into research. Alternatively it can be essential in finding employment in many areas in the financial industry.

Modern algebra, with its emphasis on the study of relationships and symmetry, has brought greater clarity to all parts of mathematics and its applications. The specialization in **Applied Algebra** offers the opportunity to study several topics in algebra which are especially popular today, with applications as diverse as playing a scratched CD, protecting online transactions, the design of statistical experiments, and representing molecular structures.

To obtain a Specialization the student must complete the credit requirements listed below.

- **Specialization in Mathematical Finance:**
  - MAT 390 (Introduction to Mathematical Finance)
  - Any three of MAT 490 (Discrete Time Finance), MAT 384 (Econometrics), MAT 484 (Advanced Statistics), MAT394(Machine Learning through R), MAT494(Deep Learning), MAT 388 (Optimization I), MAT 488 (Optimization II), MAT 584 (Stochastic Processes), MAT 590 (Computational Finance),

- **Specialization in Applied Algebra:**
  - MAT 440 (Elementary Number Theory)
  - Any three of MAT 246 (Combinatorics), MAT 341 (Commutative Algebra), MAT 442 (Graph Theory), MAT 491 (Game Theory), MAT 542 (Cryptography), MAT 543 (Error Correcting Codes), MAT 544 (Combinatorial Design Theory)

Your First Year as a Mathematics Major

The first year of your undergraduate studies will be especially crucial. It typically takes a student this long to transition from doing school mathematics to meeting the much higher expectations of university mathematics. At SNIOE we have taken care to ensure a proper transition so that at the end of the year you are well positioned to embark on a fruitful life with mathematics.

First Semester

Foundations – This course provides an introduction to the nature of mathematics and mathematical thinking, by taking up issues such as the concepts of axioms and proof, the language of sets, functions and relations, the process of abstraction, and the skill of problem-solving.

Calculus I – This course covers one variable calculus and applications. It uses the formal foundations provided in parallel by Foundations and adds the geometric insights which form the heart of Calculus. Calculus I forms the base for subsequent courses in advanced vector calculus and real analysis as well as for applications in probability, differential equations, optimization, etc.

Linear Algebra I – Linear Algebra provides the means for studying several quantities simultaneously. A good understanding of Linear Algebra is essential in almost every area of higher mathematics, and especially in applied mathematics. For example, Google's PageRank algorithm is based on the analysis of eigenvectors of a matrix that represents the interlinking of webpages.

Introduction to Programming – Computers have dramatically affected the sciences over the last 3 or 4 decades, and mathematics is not an exception. With the help of computers we can easily

explore and gain insight into complicated situations. This course introduces you to programming, algorithms and data structures using C Language.

Second Semester

Calculus II – This course covers infinite series and their applications as well several variable differential calculus. The concepts and techniques covered here are used extensively in the social and natural sciences as well as in engineering to study systems with many dimensions.

Vector Calculus and Geometry – This course considers analytic geometry from the modern viewpoint based on linear algebra. It also develops and uses vector calculus to study geometric quantities like length, area, and volume. It culminates with the generalizations of the Fundamental Theorem of calculus to two and three dimensions.

Mathematical Modelling – Mathematics has developed in close association with our attempts at understanding and navigating the world. This course focusses on how real world problems can be rephrased in the language of mathematics leading to a better understanding and solution of those problems as well as to the further development of mathematics.

Apart from these mathematics core courses, you should also take about 6 CCC credits and 3 UWE credits during your first year. These can be chosen from various offerings across the university. The mathematics faculty members also float CCC courses which you can select:

CCC 101 Mathematics in India – Mathematics had a rich history in ancient and medieval India. Indian mathematicians made original contributions to algebra, number theory and geometry; with the Kerala School making fundamental discoveries related to differential calculus and infinite series two centuries before their full development by Newton and Leibniz. This course provides an overview of the story of mathematics in India, and also incorporates the social context and the connections with other cultures.

CCC 803 Art of Numbers – This course deals with two aspects of numbers. The first part of the course takes up some patterns that exist in nature, to study them and understand some of their applications. The second part looks at numbers as carriers of information about our lives. We use spreadsheet programming to analyze the data in depth.

CCC 805 Data Analysis and Business Modelling Using Excel - The spreadsheet program Excel is used by businesses to summarize, report and analyze data, as well as to build analytic models to help your increase profit, reduce cost, or manage operations more efficiently. This course teaches efficient use of tools and methods available in Excel that can save you hours of time and improve approaches for analyzing important business problems.

CCC 825 Shapes in Nature – Our world is full of interesting shapes and Mathematics

plays an important role in understanding and utilizing them. Conversely, our attempts to understand these shapes lead to new mathematics. This course will consider shapes and patterns that occur in nature, and their properties. For example, the geometry of honeycombs, the patterns of mud cracks etc. will be discussed. Soap films and bubbles and their stability are another fascinating topic with many ramifications.

Activities

The Department of Mathematics was one of the founding departments of Shiv Nadar University. It is also among the largest and most active. We have organized national conferences and summer schools as well as Colloquium talks, weekly seminars, and school workshops. Some other activities are:

- The **Mathematics Society** organizes talks, movies, problem-solving sessions and other mathematical activities.
- **Visits** by mathematicians from institutions such as ISI, IIT, TIFR, IISER, Stony Brook University, etc.

Lecture by Prof. Pradeep Dubey, Department of Economics, Stony Brook University

Conferences and Schools organized by the Department of Mathematics

- *Northern Regional Conference of the National Initiative in Mathematics Education* (2011, co-hosted with Ambedkar University, Delhi).
- *Annual Conference of the Ramanujan Mathematical Society* (2012)
- *Annual Foundation School* for PhD students (2015, funded by the National Centre for Mathematics).
- *Mathematical Training and Talent Search* program (2015 and 2016, funded by the

National Board for Higher Mathematics).

- *Advanced Instructional School in Matrix Analysis* (2016, funded by the National Centre for Mathematics).
- *National Conference on Cross-Disciplinary Applications of Complex Networks* (2018, funded by Science and Engineering Research Board).
- *Annual Conference of Indian Women and Mathematics* (2018, funded by National Board for Higher Mathematics and the International Mathematical Union's Committee for Women in Mathematics).
- *Workshop on Zero Mean Curvature surfaces* (2022)

Course Catalog

Brief descriptions of the core courses offered by the department to its undergraduate majors are given below. (The first year courses were described earlier) The detailed syllabi can be viewed on the SNIOE website.

Mathematics Core Courses

First Year (these were described earlier):

MAT 100 – Foundations

MAT 101 – Calculus I

MAT 102 – Calculus II

MAT 150 – Mathematical Modelling

CSD101 – Introduction to Programming

MAT 132 – Vector Calculus and Geometry

MAT 160 – Linear Algebra I

Second Year and After:

MAT 184 – Probability

Probability is the means by which we model the inherent randomness of natural phenomena. This course introduces you to a range of techniques for understanding randomness and variability, and for understanding relationships between quantities. This course is a prerequisite for later courses in Statistics, Stochastic Processes and Mathematical Finance.

MAT 220 – Analysis I

Provides a rigorous base for the geometric facts and relations that we take for granted in one-variable Calculus. This is the foundational course for further study of topics in pure or applied Analysis, such as Metric Spaces, Complex Analysis, Numerical Analysis, and Differential Equations.

MAT 240 – Algebra I

Learning traditional Abstract Algebra in a contemporary style. The course covers the standard algebraic structures of groups and rings, and highlights the connection between groups and geometry through the idea of symmetry.

MAT 280 – Numerical Analysis

Numerical Analysis takes up the problems of practical computation that arise in various areas of mathematics. The focus is on algorithms for obtaining approximate solutions, and their implementation by computer programs. The software Matlab will be extensively used.

MAT 221 – Analysis II

Continuing the work done in MAT 220 of understanding one-variable Calculus, this course dwells on various aspects of functions on more general spaces, namely, metric spaces. This lays the groundwork for the study of functions of several real variables within the course, and of complex functions later.

MAT 241 – Algebra II

The course continues the work begun in Algebra I, on the one hand by extending the study of groups to include group actions and applications, and on the other by studying the abstract structures of rings and fields.

MAT 230 – Ordinary Differential Equations

Ordinary Differential Equations are fundamental to many areas of science. In this course we learn how to solve large classes of them, how to establish that solutions exist in others, and to find numerical approximations when exact solutions can't be achieved.

MAT 283 – Introduction to Statistics

In MAT 184 Probability, we learnt how mathematics can describe aspects of randomness. In this course, we take up applications to real-world problems, developing techniques for interpreting data and using statistics to choose between competing explanations of phenomena as well as to decide whether certain apparent phenomena are genuine.

MAT 330 – Partial Differential Equations

Partial Differential Equations involve functions of several variables – for example, functions that depend on both location and time. PDEs are fundamental in many areas, for example thermodynamics (heat equation), wave motion (wave equation), fluid dynamics (Navier-Stokes equation), quantum mechanics (Schrodinger equation) and even finance (Black-Scholes equation).

MAT 360 – Linear Algebra II

Linear Algebra I treated real and complex linear transformations up to the diagonalizability of symmetric matrices. In this course we take up vector spaces over arbitrary fields and reach more advanced results on expressing linear transformations by appropriate simple matrices.

MAT 399 – Undergraduate Seminar

This is an introduction to the activity of research in mathematics. One aim is to help students prepare for their undergraduate thesis by practicing, on a smaller scale, the skills of literature survey, public presentation, and mathematical writing.

MAT499 – Undergraduate Thesis

This 2 semester long course can take a variety of forms, from a reading course on advanced topics to computational work in an application of mathematics. MAT499 concludes with the submission of a written report and a public presentation.

Mathematics Elective Courses

Elective A: A student has to credit four of the following courses:

1. MAT388 Optimization I (contributes to specialization in Mathematical Finance)
2. MAT390 Introduction to Mathematical Finance (contributes to Specialization in Mathematical Finance)
3. MAT394 Machine Learning through R
4. MAT 422 Metric Spaces
5. MAT424 Complex Analysis
6. MAT 440 Elementary Number Theory (contributes to Specialization in Applied Algebra)
7. MAT442 Graph Theory (contributes to Specialization in Applied Algebra)
8. MAT622 Topology

Elective B: A sample of the elective courses offered in the past is given below:

1. MAT 341 Commutative Algebra
2. MAT 420 Probability and Measure
3. MAT 434 Computational PDE
4. MAT 444 Basic Category Theory
5. MAT 490 Discrete Time Finance
6. MAT494 Deep Learning
7. MAT 542 Cryptography
8. MAT 543 Error Correcting Codes
9. MAT 544 Combinatorial Design Theory
10. MAT 550 Algebraic Topology

Under Elective B students can also credit courses from the Elective A list as well as graduate courses of the Department of Mathematics. They may also, after obtaining the permission of the Department Undergraduate Committee, use credits from mathematically oriented courses taught by other departments.

The full course catalog is available on the SNIOE website.

Contact Us

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The SNIOE website is www.snu.edu.in. This provides detailed descriptions of the admission process, fees and scholarships, and overall structure and rules of the undergraduate program.