SHIV NADAR UNIVERSITY

DEPARTMENT OF MATHEMATICS

SCHOOL OF NATURAL SCIENCES

UNDERGRADUATE PROSPECTUS

2016–17

www.snu.edu.in

Contents

Overview

The Department of Mathematics at SNU offers programs and courses that highlight the interdisciplinary and the multidisciplinary nature of the university. Its academic programs provide a solid base both for further studies as well as for careers in industry. There is a great demand for mathematicians in various sectors: investment banks, insurance companies, engineering consultancies, medical research, bioinformatics, software, computer security, and defense. Well trained students are also sought by universities all over the world for their research programs.

The following distinguishing features are common to all our programs:

- Accessibility to students from diverse backgrounds
- Melting of the artificial barriers between pure and applied mathematics and between mathematics and other disciplines.
- Emphasis on modern computing skills and applications to real world problems.
- Exposure through seminars and online sessions to leading mathematicians, scientists and thinkers from India and abroad.

The department offers the following programs at the undergraduate level:

- **B.Sc. (Research) in Mathematics** – While completing this program, the student may alongside complete a **Minor** from another department, or obtain a further **Specialization** within mathematics.
- **Minor in Mathematics** – Students not majoring in Mathematics can complete a Minor in Mathematics by earning appropriate course credits from the department.

These two programs are described in detail later in the prospectus.

The department has a close relationship with research centers at SNU; especially the **Institute for Innovations and Inventions with Mathematics and IT**, the **Big Data Analytics Center,** and the **Center for Informatics**. We have regular seminars, and have hosted national conferences and schools such as

- The *Northern Regional Conference of the National Initiative in Mathematics Education* (2011, co-hosted with Ambedkar University, Delhi).
- The *27th Annual Conference of the Ramanujan Mathematical Society* (2012)
- The *Annual Foundation School* for PhD students (2015, sponsored by the National Centre for Mathematics).
- The *Mathematical Training and Talent Search* program (2015 and 2016, sponsored by the National Board for Higher Mathematics).
- The *Advanced Instructional School in Operator Theory* (2016, sponsored by the National Centre for Mathematics).

Research is supported by facilities such as individual laptops/desktops for faculty, a 30-PC computer lab with Mathematica and Matlab, a generous library budget for books, and subscriptions to individual journals as well as collections. In 2015, we were awarded a

grant under the DST-FIST scheme for developing a Research Computer Lab and a Department Library. A special advantage of undergraduate education at SNU is that the teachers are also active researchers who are in touch with the latest developments in their subjects.

Prof Sanjeev Agrawal, first Head of Mathematics at SNU, receives a set of the Collected Papers of S R S Varadhan from Prof Rajendra Bhatia.

Participants of the Mathematical Training and Talent Search Programme at SNU in 2015.

Profs M S Raghunathan (President, RMS) and R Balasubramanian (Director, Institute of Mathematical Sciences, Chennai) with SNU students and faculty at the 27th annual conference of the Ramanujan Mathematical Society.

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

Faculty

The members of the faculty of mathematics at SNU have studied or worked at leading institutions. Their mathematical interests vary across areas such as functional analysis, harmonic analysis, representation theory, differential geometry, number theory, encryption, game theory, graph theory, category theory, differential equations, signal processing, computational methods, statistics, mathematical finance, mathematical biology, medical imaging and mathematics education.

The members of the department share a commitment to enrich the classroom experience by integrating hands-on work and research into the curriculum.

Faculty Member	Qualifications	Areas of Interest
Sanjeev Agrawal Professor ; Undergraduate Advisor	PhD Delhi MA Oxford	Functional Analysis, Operator Theory, Error Correcting Codes, Encryption, Mathematics Education
Sudeepto Bhattacharya Associate Professor	PhD Nagpur MSc Nagpur	Complexity, Game theory, Network Theory, Mathematical Modeling
Samit Bhattacharyya Assistant Professor	PhD Calcutta MSc Calcutta	Applied Mathematics and Computational Biology
Debashish Bose Assistant Professor	PhD IIT Kanpur MSc IIT Kanpur	Harmonic Analysis, Number Theory, Combinatorics, Percolation
Suma Ghosh Assistant Professor	PhD Calcutta MSc Burdwan	Mathematical Biology, Nonlinear Dynamics, Optimal Control Theory
Priyanka Grover Assistant Professor, DST-Inspire Fellow	PhD ISI Delhi MSc University of Delhi	Matrix Analysis, Operator Theory
Neha Gupta Assistant Professor	PhD Warwick MSc Warwick	Quantum Groups, Category Theory
Amber Habib Professor & Head	PhD Berkeley MS (Int) IIT Kanpur	Representation Theory, Mathematical Finance, Mathematics Education
R Krishnan Assistant Professor	PhD IMSc MS (Int) IIT Kanpur	Analytic and Transcendental Number Theory
Ajit Kumar Assistant Professor	PhD Houston MS Houston	Partial Differential Equations, Finite Element Method
Pradip Kumar Assistant Professor	PhD HRI MSc IIT Kanpur	Symplectic Geometry, Global Analysis
Sneh Lata Assistant Professor; Graduate Advisor	PhD Houston MS Houston	Frame theory, Operator Theory and Function Theory
A Satyanarayana Reddy Assistant Professor	PhD IIT Kanpur MSc Andhra University	Algebraic Graph Theory, Discrete Mathematics, Algebraic Number Theory
Niteesh Sahni Assistant Professor	PhD Delhi MPhil, MSc Delhi	Functional Analysis, Operator Theory, Dynamical Systems
Charu Sharma Assistant Professor	MS Houston	Bioinformatics, Computational Finance
Santosh Singh Associate Professor; Director BDAC	PhD IIT Kanpur MA, Agra University	Medical image analysis, Image reconstruction, Filter bank theory, Computational photography, Light field and Optimization technique

B.Sc. (Research) in 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 (Common Core 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
d) Elective Mathematics Courses
e) Project

The minimal credit requirements are described below.

B.Sc. (Research) in Mathematics		
S. No.	Category	Credits
1	CCC*	42
2	UWE*	
3	Mathematics Core	56
4	Mathematics Elective A	12
5	Mathematics Elective B	24
6	Project	12
	Total	**146**

*__CCC__ and __UWE__ credits must total at least 42, with at least 18 credits in each category.

The **Elective A** credits have to be earned from a basket of 6 courses of 4 credits each. These courses lay the foundations for advanced specializations. The **Elective B** credits can be earned from any 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. At present three Specializations are available to students of B.Sc. (Research) in Mathematics:

1. **Mathematical Finance**
2. **Applied Algebra**
3. **Data Analytics** (supervised by the Big Data Analytics Center)

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.

Semester	Major Credits			UWE	CCC	
	Core	Elective A	Elective B			
1	Foundations, Calculus I, Linear Algebra I 12			4	3	19
2	Calculus II, Probability, Computing 12			4	3	19
3	Analysis I, Numerical Analysis, Algebra I 12	4			3	19
4	Analysis II, ODE, Algebra II 12			4	3	19
5	PDE, Linear Algebra II 8	4	4	3	3	22
6		4	8	3	3	18
	Core	Elective B	Project	UWE	CCC	
7		12			3	15
8			12		3	15

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 **18 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 220 (Real Analysis I), MAT 240 (Algebra I), MAT 260 (Linear Algebra I), MAT 280 (Numerical Analysis), MAT 284 (Probability).

2. At least 8 credits from MAT courses numbered 300 or above.

3. 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.

4. 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.

Today's world requires us to deal with a deluge of data which record and shape our lives, ranging from large global issues such as climate change to the smallest local problem such as controlling a thermostat. The specialization in **Data Analytics** gives the student an entry into the current efforts to develop theoretical and innovative scientific and technological solutions to cater to the needs of the industry, the society and the environment. This specialization is overseen by the Big Data Analytics Center at SNU.

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

below and also choose a Project within the same area.

- **Specialization in Mathematical Finance:**
  - MAT 390 (Introduction to Mathematical Finance) – 4 credits
  - Either MAT 490 (Discrete Time Finance) or MAT 590 (Computational Finance) – 4 credits
  - Either MAT 384 (Econometrics) or MAT 484 (Advanced Statistics) – 4 credits
  - Either MAT 388 (Optimization I) or MAT 488 (Optimization II) – 4 credits

- **Specialization in Applied Algebra:** The courses listed here are 4 credits each.
  - MAT 440 (Elementary Number Theory)
  - Any three of MAT 442 (Graph Theory), MAT 542 (Cryptography), MAT 543 (Error Correcting Codes), MAT 544 (Combinatorial Design Theory)

- **Specialization in Data Analytics:** These courses can also count towards the Elective B requirements.
  - BDA 671 (Fundamentals of Database Systems) – 3 credits
  - BDA 691 (Advanced Algorithms and Data Structures) – 3 credits
  - BDA 650 (Mining of Massive Datasets) – 4 credits
  - BDA 655 (Machine Learning and Knowledge Discovery) – 3 credits

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 SNU 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 and uses of mathematics and mathematical thinking, by taking up issues such as the concepts of axioms and proof, the language of sets, functions and relations, and the process of abstraction.

Calculus I – This course covers one variable calculus and applications. It uses the formal foundations provided in parallel by MAT 100 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.

Second Semester

Calculus II – This course covers several variable calculus and applications. 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.

Computing – 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/Python and Matlab.

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.

Apart from these mathematics core courses, you should also take about 6 CCC credits and 8 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.

Activities

The Department of Mathematics was one of the founding departments of Shiv Nadar University. It is also among the largest and most active. Within two years, we have organized national conferences and summer schools (listed earlier), as well as weekly seminars and school workshops. Some other activities are:

- **Inviting All Young Minds** summer internship program in collaboration with IIIMIT. IAYM trains university and school students in applicable mathematics and they carry out projects that apply mathematics and computing to real-world problems.
- The **Mathematics Society** organizes talks, movies, problem-solving sessions and other mathematical activities.
- **Visits** by mathematicians from institutions such as Indian Statistical Institute, Indian Institutes of Technology, IISER, etc. At the RMS Conference hosted by us, our students had extensive discussions with leading mathematicians about the discipline and careers related to it.

First meeting of the SNU Mathematics Society

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 downloaded from the SNU website.

Mathematics Core Courses

MAT 100 – Foundations

MAT 101 – Calculus I

MAT 102 – Calculus II

MAT 110 – Computing

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 260 – Linear Algebra I

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 284 – Probability

MAT 320 – 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 340 – Algebra II

Advanced topics from Groups, Rings and Fields.

MAT 360 Linear Algebra II

The study of abstract vector spaces over arbitrary fields and the linear transformations between them.

MAT 430 – 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 431 – 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).

Mathematics Elective Courses

Elective A: A student has to credit three of the following 4-credit courses:

1. MAT 140 Discrete Structures
2. MAT 384/ECO 203 Introductory Econometrics[1]
3. MAT 388 Optimization I
4. MAT 424 Complex Analysis
5. MAT 432 Curves and Surfaces
6. MAT 440 Elementary Number Theory

Elective B: Courses from Elective A can also be used here. This list expands with time.

1. MAT 390/FAC 201 Introduction to Mathematical Finance[2]
2. MAT 420 Probability and Measure
3. MAT 442 Graph Theory
4. MAT 444 Basic Category Theory
5. MAT 490 Discrete Time Finance
6. MAT 522 Fourier Analysis
7. MAT 542 Cryptography
8. MAT 543 Error Correcting Codes
9. MAT 544 Combinatorial Design Theory
10. MAT 584 Stochastic Processes

[1] Offered jointly with the Department of Economics
[2] Offered jointly with the School of Management and Entrepreneurship

Under Elective B students can also credit 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.

Contact Us

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The SNU 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.