SHIV NADAR UNIVERSITY

DEPARTMENT OF MATHEMATICS

SCHOOL OF NATURAL SCIENCES

UNDERGRADUATE MATHEMATICS PROSPECTUS

2013–14

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

The department offers the following degree programs at the undergraduate level:

- **Major in Mathematics** – This is a 4 year program leading to a **B.S. Mathematics** degree. While completing this program, the student may alongside complete a **Minor** from another department, or obtain a further **Specialization** within mathematics. By crediting certain higher level courses the student may also achieve an **Honours** degree.
- **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 the Institute for Innovations and Inventions with Mathematics and IT (IIIMIT), a research centre at SNU dedicated to applications of mathematics and computing to real-world problems. We have regular seminars, and have already hosted national conferences such as the *27th Annual Conference of the Ramanujan Mathematical Society* (October 2012) and the *Northern Regional Conference of the National Initiative in Mathematics Education* (November 2011, co-hosted with Ambedkar University, Delhi). We support collaboration with other institutions through grants for travel and workshops.

Research is further 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 such as JSTOR, Springer Link and SIAM.

At the 27th Annual Conference of the Ramanujan Mathematical Society, hosted by SNU:

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

SNU students with Professors Dipendra Prasad and Ravi Rao of the Tata Institute of Fundamental Research, Mumbai.

Profs M S Raghunathan (President, RMS) and R Balasubramanian (Director, Institute of Mathematical Sciences, Chennai) in a discussion with SNU students and faculty.

Lecture by Prof A Satyanarayana Reddy, Department of Mathematics, SNU.

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, encryption, computational methods, statistics, mathematical finance, mathematical biology 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 & Head Dean Undergraduate Studies	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
Neha Gupta Assistant Professor	PhD Warwick MSc Warwick	Quantum Groups, Category Theory
Ved Prakash Gupta Assistant Professor	PhD IMSc MSc Delhi	Operator Theory. Operator Algebras
Amber Habib Professor & UG Advisor Director, IIIMIT	PhD Berkeley MS (Int) IIT Kanpur	Representation Theory, Mathematical Finance, Mathematics Education
R Krishnan* Assistant Professor	PhD IMSc (submitted) MS (Int) IIT Kanpur	Analytic and Transcendental Number Theory
Ajit Kumar Assistant Professor	PhD Houston MS Houston	Partial Differential Equations, Finite Element Method
Sneh Lata Assistant Professor	PhD Houston MS Houston	Frame theory, Operator Theory and Function Theory
Vijay Patankar* Associate Professor	PhD Toronto MSc TIFR	Number Theory, Complexity Theory, Cryptography
I Venkat Appal Raju* Assistant Professor	PhD IIT Guwahati MSc Banaras	Stochastic Processes, Mathematical Finance, Insurance Models
A Satyanarayana Reddy Assistant Professor	PhD IIT Kanpur	Algebraic Graph Theory, Discrete Mathematics, Algebraic Number Theory
Niteesh Sahni Assistant Professor	MPhil Delhi MSc Delhi	Functional Analysis, Operator Theory, Dynamical Systems
Charu Sharma Assistant Professor	MS Houston	Bioinformatics, Computational Finance

(* Joining in April/May 2013)

Major in Mathematics

The basic undergraduate degree program offered by the Department of Mathematics is the four-year Bachelor of Science (BS) in Mathematics. By taking extra courses, in consultation with the Undergraduate Advisor of the Department, a student can also be eligible for award of any of the following degrees:

- BS Mathematics with Honours
- BS Mathematics with a Mathematics Specialization
- BS 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) Mathematics Projects

Every student has to gain a minimum number of credits to qualify for a degree. To qualify for an undergraduate degree in mathematics, the student also has to earn at least 4 credits (not counting towards the SGPA and CGPA calculations) by participating in workshops or training programs or internships. The minimal credit requirements for the different degrees are given below.

Credit Requirements for BS Mathematics		
S. No.	Category	Credits
1	CCC	24
2	UWE	18
3	Maths Core	67
4	Maths Elective	16
5	Maths Projects	12
	Total	**137**

Credit Requirements for BS Mathematics with Honours		
S. No.	Category	Credits
1	CCC	24
2	UWE	18
3	Maths Core	67
4	Maths Elective	12
5	Maths Projects	12
6	Honours Electives	12
	Total	**145**

Credit Requirements for BS Mathematics with Specialization		
S. No.	Category	Credits
1	CCC	24
2	UWE	18
3	Maths Core	67
4	Maths Specialization Electives	24
5	Maths Projects	12
	Total	**145**

At present the department offers a **Specialization in Mathematical Finance**, which can be essentially completed by using the elective slots in the 5th to 8th semesters. This specialization is described in detail later. Other specializations are expected to be finalized soon.

Credit Requirements for BS Mathematics with Minor		
S. No.	Category	Credits
1	CCC	24
2	UWE (including Minor credits)	30*
3	Maths Core	67
4	Maths Elective	16
5	Maths Projects	12
	Total	**149**

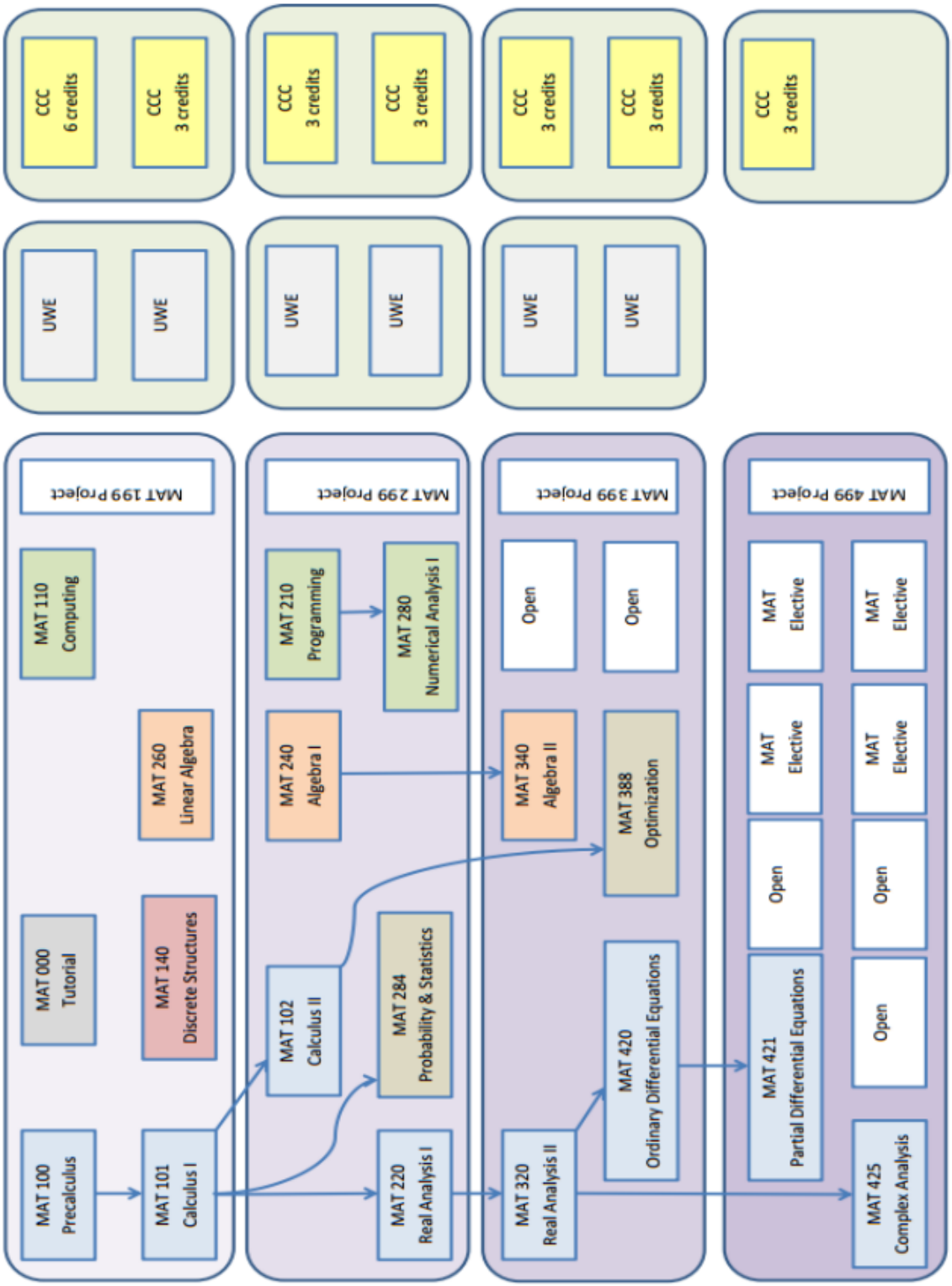
The Minor requirements will be set by the department offering it. It is expected that a student will complete the minor by concentrating his/her UWE choices accordingly. The 30 credits given here for this purpose under UWE are only indicative, and will vary with each Minor.

A semester-by-semester chart of the BS Mathematics curriculum is provided on the next page. The arrows show some of the dependencies among the courses. In addition:

- The named courses constitute the Maths Core component of the BS Mathematics degree.
- MAT Electives represent the Mathematics Elective courses.
- Open slots are completely unrestricted – the student may use them towards a Minor, a Specialization, or just to make up a backlog from earlier semesters.
- The actual semester in which a course is taken can be modified.

Among the highlights of the program are the four yearlong projects. These may take various forms from individual advanced reading or research to team projects, and involve both mathematics and its applications. These projects are meant to nurture communication skills, team-work, independent thought, and creativity.

Overview of the BS Mathematics Program



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 **27 credits** from the University Wide Elective (UWE) courses offered by the Department of Mathematics. These credits must satisfy the following *minimum* requirements:

1. 3 courses from **Group A** for a total of 12 credits: MAT 101 (Calculus I), MAT 240 (Algebra I), MAT 260 (Linear Algebra), MAT 280 (Numerical Analysis I), MAT 284 (Probability & Statistics)
2. 1 course from **Group B** (3 credits): MAT 199, 299, 399, 499 (Projects)
3. Remainder from any other UWEs offered by Department of Mathematics
4. The above is subject to the further requirement that a course should not count towards both Major and Minor requirements.
5. The credit requirement may be lowered to 23 credits for majors which already have a significant component of compulsory Mathematics courses.

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

How to Apply and Select Courses:

1. You have to register for the Minor.
2. You will select courses for the Minor in consultation with the UG Advisor for Mathematics.
3. You must sign up for the Minor before the end of your 6th semester. However, it is advisable to do so earlier so that there is sufficient time to plan your courses. The best time is during your 3rd and 4th semesters. Registration is also subject to availability of slots.
4. If you fail to complete the minor during your first 4 years, you may have to spend an extra semester to complete it. If you do so, any scholarship or fee waiver you were granted for your regular course of study will lapse and you will have to pay the full fees for the extra period.

Specialization in Mathematical Finance

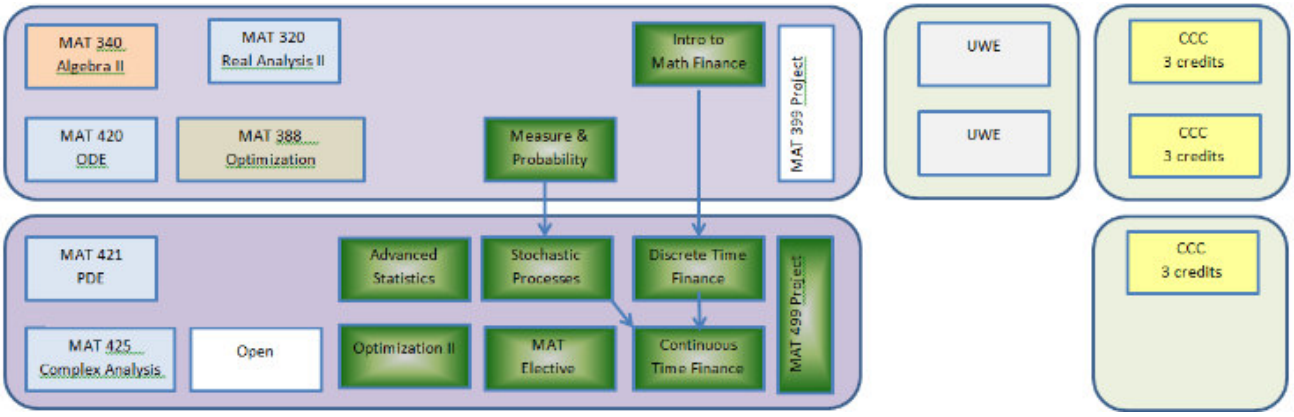
Majors in Mathematics can choose to specialize in certain areas, especially in applications of Mathematics. The department is already offering a Specialization in Mathematical Finance, with other specializations due to be formally announced soon.

Mathematical Finance is one of the modern study areas 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.

The structure of this specialization is as follows:

a) The student must credit the following courses: Introduction to Mathematical Finance, Discrete Time Finance, Continuous Time Finance, Measure & Probability, Stochastic Processes, Advanced Statistics, and Optimization II.
b) One Mathematics Elective to be selected from courses such as Numerical Linear Algebra, Numerical Differential Equations, Monte Carlo Techniques, etc.
c) The final year project (MAT 499) must be in Mathematical Finance.

Here is a view of the 3rd and 4th years of a student completing this specialization.



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.

The first semester for a mathematics major at SNU features the following mathematics courses:

MAT 000 Tutorial – This course consists of 3 hours of discussion every week with a faculty member. It 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 role of counter-examples, problem solving techniques, geometric intuition, the process of abstraction, etc. Time is also set aside for discussion of topics being studied in other courses.

MAT 100 Precalculus – A major portion of +2 school mathematics is devoted to Calculus, a subject which revolutionized both mathematics and physics. Yet the subject is all too often treated as just a collection of formulas and tricks. The student learns how to do a particular calculation, but is not able to judge when it makes sense to do it, or where it would be useful. At SNU we begin by laying the foundations with our Precalculus course. In this course we take up sets and functions, mathematical induction, number systems, real functions and limits.

MAT 110 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. They help bridge theoretical constructions with real world applications. This course introduces you to two very different kinds of mathematical software – MS Excel and Matlab, with a focus on applications.

MAT 199 Project – Students attending this course carry out a hands-on project over the full academic year. They work in groups on a topic chosen from applications of mathematics and computing, in areas such as finance, image recognition, encryption, coding theory, graph theory, etc.

The Project course continues into the second semester. In addition, there are the following mathematics courses:

MAT 101 Calculus I – This course covers one variable calculus and applications. It builds on the formal foundations provided by the Precalculus course 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.

MAT 140 Discrete Structures – This course covers finite processes and the formal structures used to describe them. The first part consists of a detailed exploration of relations and functions. The second part takes up graph theory and abstract algebra. This course is also compulsory for majors in Computer Science & Engineering.

MAT 260 Linear Algebra – 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.

Apart from these mathematics core courses, you will also take 9 CCC credits and 8 UWE credits (approx.) 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. Two that were offered in 2012-13 are:

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.

Finally, you can attend talks by visiting mathematicians and scientists and learn about the latest developments.

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 two major conferences apart from weekly seminars and school workshops. We have also won an international grant towards collaborating with a UK university.

- **Northern Regional Conference of the National Initiative for Mathematics Education** (NIME-NRC) was cohosted by SNU and Ambedkar University Delhi in October 2011. The conference was part of the process of collecting material and preparing a report for India's National Presentation at the 2012 International Conference on Mathematics education at Seoul.
- **27th Annual Conference of the Ramanujan Mathematical Society** was hosted by SNU in October 2012. The RMS is the premier body of mathematicians in India

and its annual conference is a unique coming together of mathematics faculty, students and enthusiasts from all over the country.

- **Collaboration with University of Essex** towards development of joint masters programs and research. The initial work is being carried out with the support of a British Council grant under the Knowledge Enterprise Partnerships scheme.
- **Visits** by mathematicians from institutions such as Indian Statistical Institute, Indian Institutes of Technology, South Asian University, etc. At the RMS Conference hosted by us, our students had extensive discussions with leading mathematicians about the discipline and careers related to it.

Course Catalog

Brief descriptions of the core courses offered by the department to its undergraduate majors are given below. The detailed syllabi can be downloaded from the SNU website.

Mathematics Core Courses

MAT 000 – Tutorial Students are introduced in a tutorial setting to issues regarding the nature and uses of Mathematics. The intent is to ease the transition from high school to university education, as well as to initiate the student into a more holistic view of Mathematics.
MAT 100 – Precalculus Introduction to modern mathematical language and reasoning: Sets and Functions, Proofs, Number Systems, Real Functions and Limits.
MAT 101 – Calculus I One variable calculus and applications. It forms the base for subsequent courses in advanced vector calculus and real analysis as well as for applications in probability, differential equations, optimization, etc.
MAT 102 – Calculus II The first part deals with series of numbers and functions. The second part is an introduction to multivariable calculus, finishing with the various versions of Stokes' theorem. 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.
MAT 110 – Computing An introduction to Matlab and Microsoft Excel as tools for mathematical computing. The focus is on their use in applications from the fields of Statistics, Finance, Image Processing etc. Student presentations of assignment solutions are a major component of the course.
MAT 140 – Discrete Structures This course covers finite processes and the formal structures used to describe them. The first part consists of a detailed exploration of relations and functions. The second part takes up graph theory and abstract algebra.

MAT 210 – Programming

An introduction to formal programming languages via Python 3.0. The programming activities are centered on mathematical models involving differential equations, algebraic systems, iterative processes, linear transformations, random processes etc. The course begins with Python language constructs and moves to an in-depth exploration of the SCIPY and NUMPY packages that hold the key to the desired mathematical simulations.

MAT 220 – Real 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

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.

MAT 280 – Numerical Analysis I

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.

MAT 284 – Probability & Statistics

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. The concluding portions on Statistics take up the problem of testing our theoretical models against actual data, as well as applying the models to data in order to make decisions.

MAT 320 – Real 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 388 – Optimization

Optimization deals with the problem of establishing the best & worst cases for a given situation. This course deals mostly with the special case of linear programming, which is commonly applied to problems of business and economics as well as industrial problems in transportation, energy and telecommunication.

MAT 420 – 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 421 – 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 425 – Complex Analysis This course takes up the theory of functions of complex numbers. Not only are complex numbers and functions important in their own right, but they are often the only means of solving problems about real numbers.

The student also has to do four year-long projects. These are numbered **MAT 199, 299, 399 and 499**.

Moreover, the student has to credit at least four elective courses. Examples of elective courses offered at SNU are:

MAT 440 – Number Theory

MAT 442 – Metric Spaces

MAT 460 – Advanced Linear Algebra

MAT 484 – Advanced Statistics

MAT 488 – Optimization II

MAT 490 – Introduction to Mathematical Finance

MAT 542 – Cryptography

MAT 584 – Stochastic Processes

MAT 592 – Signal and Image Processing

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 of the undergraduate program.