3.3.3.6 Mathematics and Applied Mathematics

Mathematics is the science of quantification and the art of precise reasoning.

Mathematics conceptualises the concrete and generalises the specific. It has evolved its own symbolic language with which it builds general theories about numbers, curves, surfaces and solids, and constructs axioms for abstract mathematical ideas. Its foundations are built on three main areas: algebra, analysis and geometry. Mathematics provides a framework for the laws of physics and chemistry and a theoretical toolkit for applications in the physical and biological sciences, computer science, engineering, operations research, economic and statistical sciences and many areas of organised human knowledge. The specialisation of mathematics for applications, especially in science and engineering, has led to a broad discipline usually referred to as “Applied Mathematics”.

While mathematics is itself an achievement of various ancient and modern civilisations which has become part of the heritage of world culture today, many of its specific results have been successfully implemented by technological advances in raising the quality of and lengthening human life. Ubiquitous devices such as medical scanning machines, biomedical implants, cell phones and computers are now so much a part of modern life that the mathematical principles that make them possible have been taken for granted. As Edward E. David (former president of Exxon R&D) once said, “Too few people recognise that the high technology so celebrated today is essentially a mathematical technology.”

Programme Structure and Curriculum Rationale

The Department of Mathematics offers the following undergraduate programmes leading to the degree of BSc (Hons) :

1. Major in Mathematics
   This is the flagship major that any leading university of the world is obliged to offer. Students will be exposed to all important areas of mathematical knowledge including algebra, logic, number theory and combinatorics, real and complex analysis, differential equations, geometry and topology with focus on mathematical foundations and fundamental techniques.
2. Major in Applied Mathematics
   In this major, students focus on mathematics that deals with algorithms, problem-solving techniques and applications to other areas of human concern. Topics offered include financial mathematics, optimisation and operations research, mathematical modelling, numerical methods and simulations, coding and cryptography, computational biology and many others. Students may choose one of the three options – Major in Applied Mathematics; Major in Applied Mathematics with Specialisation in Mathematical Modelling and Data Analytics (MMDA); or Major in Applied Mathematics with Specialisation in Operations Research and Financial Mathematics (ORFM).

These major programmes share a fundamental set of basic mathematical knowledge. While each of them develops its own specialised expertise, the mathematical training in all of them is guided by an educational philosophy that (i) fosters logical and critical thinking, and (ii) develops capabilities to

conceptualise, improvise and innovate during the process of formulating, analysing and solving problems.

Career Prospects

Mathematics and Applied Mathematics graduates find employment as operations research analysts in the airline, shipping and port industries; financial and risk analysts, actuaries, financial engineers and financial planners in banks, investment houses and insurance companies; data and system analysts, and cryptanalysts in multinational and defence organisations; software engineers in a range of organisations; lecturers, teachers, curriculum developers and publication officers in educational institutions and publishing houses; and administrators. Graduates are also well prepared for graduate studies in a range of disciplines, including mathematics, computer science, statistics and economics.

There are many mathematics courses that prepare a mathematics major student with the relevant skills to work in the specific area. The mathematics training in general also equips students with the analytical skills that are essential in many jobs, especially executive works. The list below serves as a guide:

Analysis, linear algebra	Engineering, science in general
Graph theory	Computer programming and algorithm design
Cryptography, number theory	Computer security
Numerical analysis, modelling	Engineering
Optimisation, operations research	Risk management, industrial scheduling and control
Probability, financial mathematics	Financial markets, insurance
Coding, wavelets	Signal processing, image and data compression

Special Programme in Mathematics (SPM)

This programme is specially designed for a select group of students who has a strong passion and aptitude for the mathematical sciences. The programme consists of a number of specially designed modules (“S-modules”) in foundational mathematics, which are taught in much greater depth and sophistication than their regular versions. In addition, under the close mentorship of Faculty members, students will participate in two semesters of undergraduate seminars in the form of topic modules. Participants of the SPM will have enhanced opportunities for undergraduate research programmes locally and overseas, as well as graduate programmes at the Department of Mathematics in NUS. Through SPM, students will build a firm foundation to pursue graduate programmes and future careers in mathematical sciences.

SPM Enrolment Eligibility

Students who have passed MA1100, MA1101R and MA1102R with very good grades, or have obtained official exemption for any of these modules, are welcome to apply. Applicants may be further assessed through interviews. Selected students will be enrolled in the SPM in the second semester of their first year or the first semester of their second year.

Participants of the SPM should generally be majoring in Mathematics or Applied Mathematics, though academically strong students majoring in Quantitative Finance, Statistics, Physics and Computer Science are also welcome to apply. In order to complete the SPM, a participant should pass 6 out of the following 7 modules:

MA2101S Linear Algebra II (S)
MA2108S Mathematical Analysis I (S)
MA2202S Algebra I (S)
MA3110S Mathematical Analysis II (S)
MA3211S Complex Analysis I (S)
MA4291 Undergraduate Topics in Mathematics I
MA4292 Undergraduate Topics in Mathematics II

SPM students may read two level 5000 modules (except MA5203, MA5205, MA5245, MA5247 and MA5248) in lieu of MA4291 and MA4292, subject to the approval of the Department.

When an SPM student goes for student exchange programme, he/she may read an equivalent overseas module in place of one S-module. Each student is only allowed to replace one S-module this way.

Graduation Requirements (Mathematics)

To be awarded a BSc or BSc (Hons) with a primary major in Mathematics, a candidate must satisfy the following:

MODULE LEVEL	MAJOR REQUIREMENTS	CUMULATIVE MAJOR MCS
Level-1000 (16 MCs)	1. Pass all the following modules - MA1100 Basic Discrete Mathematics or CS1231/CS1231S Discrete Structures - MA1101R Linear Algebra I - MA1102R Calculus - CS1010/CS1010E/CS1010S/CS1010X/CS1101S Programming Methodology* * CS1101S (4MCs wef AY2018/19) may be read as an alternative to CS1010% (4MCs) to facilitate relevant programmes. e.g. Double Degree Programme with School of Computing. Registration for this module is subject to host availability.	20
Level-2000 (24-28 MCs)	2. Pass all the following modules: • MA2101/MA2101S Linear Algebra II • MA2104 Multivariable Calculus • MA2108/MA2108S Mathematical Analysis I • MA2202/MA2202S Algebra I • MA2216/ST2131 Probability 3. Pass one additional module from List II, III, IV	40-44
Level-3000 (20-23 MCs)	4. Pass three modules from List MA3 5. Pass two additional modules from List III, IV	60-66
Level-4000 (32- 33 MCs)	6. Pass MA4199 Honours Project in Mathematics 7. Pass three modules from List MA4 8. Pass two additional modules from List IV	92-98
UROPS	At most one Mathematics UROPS module may be used to fulfil the requirements of Major in Mathematics	

List II:

- All MA modules at Level-2000, except those coded MA23XX
- PC2130 Quantum Mechanics I
- PC2132 Classical Mechanics
- ST2132 Mathematical Statistics
- EC2101 Microeconomic Analysis I

List III:

- All MA modules at Level-3000, except those coded MA33xx
- BSE3703 Econometric for Business I
- CS3230 Design & Analysis of Algorithms
- CS3234 Logic and Formal Systems
- DSA3102 Essential Data Analytics Tools: Convex Optimisation
- EC3101 Microeconomic Analysis II
- EC3303 Econometrics I
- PC3130 Quantum Mechanics II
- PC3236 Computational Methods in Physics
- PC3238 Fluid Dynamics
- ST3131 Regression Analysis
- ST3236 Stochastic Processes I

List IV:

- All MA modules at Level-4000 or higher
- CS4232 Theory of Computation
- CS4234 Optimisation Algorithms
- CS4236 Cryptography Theory and Practice
- CS5230 Computational Complexity
- CS5237 Computational Geometry and Applications
- DSA4211 High-Dimensional Statistical Analysis
- DSA4212 Optimisation for Large-Scale Data-Driven Inference
- EC4301 Microeconomics Analysis III
- EC5104/EC5104R Mathematical Economics
- PC4248 Relativity
- PC4274 Mathematical Methods in Physics III
- ST4238 Stochastic Processes II
- ST4245 Statistical Methods for Finance

List MA3:

- MA3110/MA3110S/MA3210 Mathematical Analysis II
- MA3111/MA3111S/MA3211/MA3211S Complex Analysis I
- MA3201 Algebra II
- MA3205 Set Theory
- MA3209 Metric and Topological Spaces
- MA3265 Introduction to Number Theory

List MA4:

- MA4203 Galois Theory
- MA4207 Mathematical Logic
- MA4221 Partial Differential Equations
- MA4229 Fourier Analysis and Approximation
- MA4262 Measure and Integration
- MA4271 Differential Geometry of Curves and Surfaces

- MA4273 Algebraic Geometry of Curves and Surfaces (offered wef AY2022/23)

SUMMARY OF REQUIREMENTS	BSC	BSC (HONS)
University Requirements	20 MCs	20 MCs
Faculty Requirements	4 – 8 MCs*	4 – 12 MCs*
Major Requirements	60 – 66 MCs	92 – 98 MCs
Unrestricted Elective Modules	26 – 36 MCs	30 – 44 MCs
Total	120 MCs	160 MCs

* Faculty Requirements of 12 MCs and 16 MCs (required for the BSc and BSc (Hons) programmes respectively) are partially fulfilled through the reading of CS/PC/ST modules within the major.

Note:

The number of MCs indicated under “Faculty Requirements” in the Summary of Requirements above refers to the number of MCs **apart** from major modules which can count towards the 12/16MCs of Faculty requirements for BSc/BSc(Hons).

Please note that the Academic Advisement (AA) system will indicate the **maximum** number of MCs you have to read for your Faculty requirements, apart from modules in your major which can count towards the Faculty requirements i.e. 12 for BSc(Hons) and 8 for BSc. It will not indicate the range seen above [4-8 for BSc or 4-12 for BSc(Hons)] which comes about due to certain major elective modules students can choose to read, which can count towards the 12/16MCs of Faculty requirements.

Graduation Requirements (Applied Mathematics)

To be awarded a BSc or BSc (Hons) with a primary major in Applied Mathematics, a candidate must satisfy the following:

I. BSc or BSc (Hons) with major in Applied Mathematics

MODULE LEVEL	MAJOR REQUIREMENTS	LEVEL MCS	CUMULATIVE MAJOR MCS
Level-1000	1. Pass all the following modules: - MA1100 Basic Discrete Mathematics or CS1231/CS1231S Discrete Structures - MA1101R Linear Algebra I - MA1102R Calculus - CS1010/CS1010E/CS1010S/CS1010X/CS1101S Programming Methodology* * CS1101S (4MCs wef AY2018/19) may be read as an alternative to CS1010% (4MCs) to facilitate relevant programmes. e.g. Double Degree Programme with School of Computing. Registration for this module is subject to host availability.	16	16
Level-2000	2. Pass all the following modules: • MA2101/MA2101S Linear Algebra II • MA2104 Multivariable Calculus • MA2108/MA2108S Mathematical Analysis I • MA2213 Numerical Analysis I • MA2216/ST2131 Probability 3. Pass one additional module from List II, III, IV	24-27	40-43
Level-3000	4. Pass three modules from List AM3 5. Pass two additional modules from List III, IV	20-23	60-66
Level-4000	6. Pass MA4199 Honours Project in Mathematics 7. Pass four modules from List AM4 8. Pass one additional module from List IV	32-33	92-98
UROPS	At most one Mathematics UROPS module may be used to fulfil the requirements of Major in Applied Mathematics		

II. BSc (Hons) with major in Applied Mathematics with specialisation in Mathematical Modelling and Data Analytics, MMDA

MODULE LEVEL	MAJOR REQUIREMENTS	LEVEL MCS	CUMULATIVE MAJOR MCS
Level 1000	1. Pass all the following modules: - MA1100 Basic Discrete Mathematics or CS1231/CS1231S Discrete Structures - MA1101R Linear Algebra I - MA1102R Calculus - CS1010/CS1010E/CS1010S/CS1010X/CS1101S Programming Methodology* * CS1101S (4MCs wef AY2018/19) may be read as an alternative to CS1010% (4MCs) to facilitate relevant programmes. e.g. Double Degree Programme with School of Computing. Registration for this module is subject to host availability.	16	16
Level 2000	2. Pass all the following modules: • MA2101/MA2101S Linear Algebra II • MA2104 Multivariable Calculus • MA2108/MA2108S Mathematical Analysis I • MA2213 Numerical Analysis I • MA2216/ST2131 Probability 3. Pass one additional module from List II, III, IV	24-27	40-43
Level 3000	4. Pass three modules from List AM3(A) 5. Pass two additional modules from List III, IV	20-23	60-66
Level 4000	6. Pass MA4199 Honours Project in Mathematics 7. Pass four modules from AM4(A) 8. Pass one additional module from List IV	32-33	92-98
UROPS	At most one Mathematics UROPS module may be used to fulfil the requirements of Major in Applied Mathematics		

III. BSc (Hons) with major in Applied Mathematics with specialisation in Operations Research and Financial Mathematics, ORFM

MODULE LEVEL	MAJOR REQUIREMENTS	LEVEL MCS	CUMULATIVE MAJOR MCS
Level 1000	1. Pass all the following modules: - MA1100 Basic Discrete Mathematics or CS1231/CS1231S Discrete Structures - MA1101R Linear Algebra I - MA1102R Calculus - CS1010/CS1010E/CS1010S/CS1010X/CS1101S Programming Methodology* * CS1101S (4MCs wef AY2018/19) may be read as an alternative to CS1010% (4MCs) to facilitate relevant programmes. e.g. Double Degree Programme with School of Computing. Registration for this module is subject to host availability.	16	16
Level 2000	2. Pass all the following modules: • MA2101/MA2101S Linear Algebra II • MA2104 Multivariable Calculus • MA2108/MA2108S Mathematical Analysis I • MA2213 Numerical Analysis I • MA2216/ST2131 Probability 3. Pass one additional module from List II, III, IV	24-27	40-43
Level 3000	4. Pass three modules from List AM3(B) 5. Pass two additional modules from List III, IV	20-23	60-66
Level 4000	6. Pass MA4199 Honours Project in Mathematics 7. Pass four modules from AM4(B) 8. Pass one additional module from List IV	32-33	92- 98
UROPS	At most one Mathematics UROPS module may be used to fulfil the requirements of Major in Applied Mathematics		

List II:

- All MA modules at level 2000, except those coded MA23XX
- PC2130 Quantum Mechanics I
- PC2132 Classical Mechanics

- ST2132 Mathematical Statistics
- EC2101 Microeconomic Analysis I

List III:

- All MA modules at level 3000, except those coded MA33xx
- BSE3703 Econometrics for Business I
- CS3230 Design & Analysis of Algorithms
- CS3234 Logic and Formal Systems
- DSA3102 Essential Data Analytics Tools: Convex Optimisation
- EC3101 Microeconomic Analysis II
- EC3303 Econometrics I
- PC3130 Quantum Mechanics II
- PC3236 Computational Methods in Physics
- PC3238 Fluid Dynamics
- ST3131 Regression Analysis
- ST3236 Stochastic Processes I

List IV:

- All MA modules at level 4000 or higher
- CS4232 Theory of Computation
- CS4234 Optimisation Algorithms
- CS4236 Cryptography Theory and Practice
- CS5230 Computational Complexity
- CS5237 Computational Geometry and Applications
- DSA4211 High-Dimensional Statistical Analysis
- DSA4212 Optimisation for Large-Scale Data-Driven Inference
- EC4301 Microeconomics Analysis III
- EC5104/EC5104R Mathematical Economics
- PC4248 Relativity
- PC4274 Mathematical Methods in Physics III
- ST4238 Stochastic Processes II
- ST4245 Statistical Methods for Finance

List AM3:

List AM3 consists of the following 2 baskets AM3(A) and AM3(B).

AM3(A)

- MA3220 Ordinary Differential Equations
- MA3227 Numerical Analysis II
- MA3233 Combinatorics and Graph II
- MA3264 Mathematical Modelling
- ST3131 Regression Analysis

AM3(B)

- MA3236 Nonlinear Programming
- MA3238 Stochastic Processes I
- MA3252 Linear and Network Optimization
- MA3269 Mathematical Finance I
- ST3131 Regression Analysis

List AM4:

List AM4 consists of the following 2 baskets AM4(A) and AM4(B).

AM4(A)

- MA4229 Fourier Analysis and Approximation
- MA4230 Matrix Computation
- MA4255 Numerical Methods in Differential Equations
- MA4261 Coding and Cryptography
- MA4268 Mathematics for Visual Data Processing
- MA4270 Data Modelling and Computation

AM4(B)

- MA4235 Topics in Graph Theory
- MA4254 Discrete Optimization
- MA4260 Stochastic Operations Research
- MA4264 Game Theory
- MA4269 Mathematical Finance II
- ST4245 Statistical Methods for Finance

SUMMARY OF REQUIREMENTS	BSC	BSC (HONS)
University Requirements	20 MCs	20 MCs
Faculty Requirements	4 – 8 MCs*	4 – 12 MCs*
Major Requirements	60 – 66 MCs	92 – 98 MCs
Unrestricted Elective Modules	26 – 36 MCs	30 – 44 MCs
Total	120 MCs	160 MCs

*Faculty Requirements of 12 MCs and 16 MCs (required for the BSc and BSc (Hons) programmes respectively) are partially fulfilled through the reading of CS/PC/ST modules within the major.

Note:

The number of MCs indicated under “Faculty Requirements” in the Summary of Requirements above refers to the number of MCs **apart** from major modules which can count towards the 12/16MCs of Faculty requirements for BSc/BSc(Hons).

Please note that the Academic Advisement (AA) system will indicate the **maximum** number of MCs you have to read for your Faculty requirements, apart from modules in your major which can count towards the Faculty requirements i.e. 12 for BSc(Hons) and 8 for BSc. It will not indicate the range seen above [4-8 for BSc or 4-12 for BSc(Hons)] which comes about due to certain major elective modules students can choose to read, which can count towards the 12/16MCs of Faculty requirements.