



Universiteit Utrecht



MASTER'S PROGRAMMES UTRECHT UNIVERSITY

- Mathematical Sciences
- Scientific Computing
- Stochastics and Financial Mathematics

Graduate School of Natural Sciences

Realise your master plan

Welcome to Mathematics

2

Utrecht University offers three Master's programmes in the field of Mathematics. This brochure outlines these international programmes, which educate specialists over a two-year period in English. It also introduces you to the environment in which you will study: Utrecht University and the city of Utrecht.

Research

Our department emphasises the fact that mathematics is an international language. We share our specialist knowledge within the Faculty of Science, concentrating on the Natural Science departments. Research subjects include all of the main mathematical categories: algebra, number theory, geometry, logic, applied and numerical analysis, stochastics, operations research, and the history of mathematics. Each research group participates in various international research schools and other prestigious centres and has close contacts with universities and research institutes around the world.

Education

The Department of Mathematics offers broad education, taught by a dedicated and international body of staff. Education and research go hand in hand. In addition to the three Master's programmes, we offer two Bachelor's programmes: one in Mathematics and one in Applied Mathematics.

Research and education truly come together in our Master's programmes. You will have access to the facilities used for research projects and in the second year, you will be given office space while writing your Master's thesis. We provide a stimulating atmosphere in which you can actively participate in projects and ongoing research, involving both fundamental questions and applications.

Utrecht University

- Is one of Europe's most prominent institutes of research and education. It engages in an extensive range of high-quality, innovative research and collaborates with universities and research centres all over the world. Interdisciplinarity, personal teaching and the benefits of an international environment are the main principles of education and research;
- Is one of Europe's top-rated research universities: in 2008 Utrecht was ranked the best university in the Netherlands, the 9th best in Europe and the 47th best in the world in the prestigious Shanghai 'Academic Ranking of World Universities';
- Is one of the oldest universities in the Netherlands, located in the historical city of Utrecht. Next to the city centre is a modern campus hosting its own sports and cultural centres;
- Offers an international environment: each year thousands of students from all over the world come to study at Utrecht University.



Facts & figures

The Faculty of Science in Utrecht is the largest of its kind in the Netherlands, with six departments: Biology, Chemistry, Information and Computing Sciences, Pharmaceutical Sciences, Physics and Mathematics. The statistics below relate to the Department of Mathematics:

- 25 tenured academic staff
- 10 post-docs
- 25 PhD students
- 65 Master's students
- 235 Bachelor's students

City of Utrecht

Utrecht is a lively city in the geographical centre of the Netherlands. It is not only an important junction where traffic, trade, distribution and services meet and mingle, but also a true knowledge centre. In addition to Utrecht University, it is home to important research institutes and several other institutes of higher education. With a population of 300,000, Utrecht is the fourth largest city in the Netherlands and with no fewer than 50,000 students, Utrecht is a real university city. More information about our city is displayed on www.uu.nl/internationalstudents > Living in the Netherlands > Utrecht city.

Scientific Computing

Scientific Computing is a fast-growing field that provides mathematical methods and software for computer simulations in a wide variety of application areas, from particle simulations for the study of protein folding to mesh calculations in climate change prediction. It's highly interdisciplinary, bringing together methods from numerical analysis, high-performance computing, and various application fields.

The programme focuses on analysing the large-scale systems that are key to various fields of science as well as many real-world applications. Examples include mathematical models that are used to predict the climate, weather, the flow of fluids and gases, the evolution of the economy and the stock market, among many others. You will learn to use the mathematical tools needed to tackle these problems efficiently and you will be able to practice applying generic solutions to a variety of application areas. You will learn to develop mathematical software and to use modern high-performance computers, such as massively parallel supercomputers, PC clusters, and multi-core PCs. Expertise in scientific computing is in high demand and, as a graduate, you will be able to pursue a career in a research institution, in industry or in management.

Structure

The programme is worth 120 ECTS, which is equivalent to two years of full-time study. There are five compulsory courses (which are together worth 37.5 ECTS):

- Numerical linear algebra
- Scientific computing laboratory

- Parallel algorithms
- Numerical partial differential equations
- Modelling and simulation.

In addition, five elective courses are offered in application areas and in relation to thesis research. Examples include Climate science, Materials science and Wavelets and Fourier transforms. Your Master's thesis, which makes up the final part of the programme (45 ECTS), can be completed either internally or externally, for instance in a company.

Entrance requirements

Applicants should have a Bachelor's degree or equivalent in a science subject with a strong mathematics component. In particular, sound knowledge of calculus and linear algebra is required, as well as elementary numerical analysis. In addition, the applicant should have good programming skills in C, C++, Java or another modern programming language.

Alessandro Sbrizzi - graduate Scientific Computing



"The subjects are all extremely interesting and the theories you learn can be applied to real-life problems. The Department of Mathematics in Utrecht has a great reputation in numerical mathematics and the teachers are open and keen

"The nice thing is that the theories you learn can be applied to real-life problems"

to help students understand the key topics. Also, you regularly find that what you're learning is a recent discovery that's been made by mathematicians in this department! That's what makes this study so exciting. Scientific Computing is future-oriented – many of the things we learn are on the cutting edge, so the opportunities to improve and apply them are virtually unlimited.

I'm now doing my research internship at the University Medical Center, in the research group working with the new 7 Tesla

MRI scanner. I'm combining techniques from Fourier Theory and Numerical Linear Algebra (two of the subjects in our curriculum). These techniques have been developed over the last decade and more work needs to be done to improve them. Within a couple of months I will graduate – unfortunately I will then have to leave this department, which I've come to love. I greatly enjoyed the years spent I've here and I'm sure the things I've learned will be very useful in my future career. "

Mathematical Sciences

4

Mathematics is the science of recognising and analysing structures, of identifying patterns and relationships, and of making models and predictions. That's why it plays such a crucial role in astronomy, physics, biology, chemistry, earth sciences, computer science, engineering, economics, finance, cryptography and logistics. Many applications of mathematics have first matured as parts of what is known as 'pure mathematics'. This form of mathematics is also constantly developing new insights, results and techniques.

The Scope of Mathematical Sciences

Versatility in the use of mathematics is an important part of the Master's programme in Mathematical Sciences, which offers you a rich spectrum of courses and a great deal of freedom in the choice of courses. This enables you to have a comprehensive education rather than engage in narrow specialisation. For example, as part of the programme, you can follow courses in algebra, number theory, geometry or statistics, which can be combined with analysis and decision theory. These are but a few examples. The list of subjects and research fields below will give you an idea of the breadth of topics you can study at Utrecht:

- algebra and number theory
- geometry
- logic
- analysis
- applied analysis
- numerical analysis
- stochastics

- operations research
- the history of mathematics

Of course, it's also possible to focus exclusively on one of the fields listed above.

Structure

This two-year programme is worth 120 ECTS points and all courses are elective. Following admission, all you will be assigned a tutor, with whose assistance you will select ten courses (75 ECTS in total). The remaining 45 ECTS will be devoted to your Master's thesis.

All courses last one semester. You will probably select courses of an introductory nature during the first semester of the first programme year, followed by more advanced courses later. Typical introductory courses include Partial differential equations, Numerical linear algebra, Differential geometry, Algebraic number theory and Probability theory.

National courses

To enhance the scope of the programme, we participate in two national activities. The first of these is the Dutch Master's programme, which consists of courses offered at a national level (usually held in Utrecht or Amsterdam). The Utrecht Department of Mathematics also participates in the Dutch research school the Mathematics Research Institute (MRI), along with several other universities. The MRI offers a series of lectures, focusing on a special theme that is selected each year. These courses are also open to you.

Lotte van der Zalm (Master's student in Mathematical Sciences)



"For nearly every mathematical discipline, there is at least one Utrecht University lecturer conducting research. As a result, the Mathematical Sciences programme addresses a wide range of related topics.

"The abstract nature of this discipline is appealing"

I opted to focus on Algebra. I find the abstract way of thinking involved in this discipline particularly appealing. The issues addressed often delve deeply into the discipline and can be incredibly challenging. It is quite enjoyable to work with other students. The high concentration of mathematics students at Utrecht University means that you can easily find someone to work with. Collaboration can often lead to solutions to difficult problems as each student has his/her own ideas.

I'm currently working on my Master's thesis 'Arithmetically equivalent fields'. I'm working under the highly effective supervision of my professor. A specialist in this field, he infuses me with a tremendous amount of inspiration. It is easy to consult with him as he makes himself quite accessible. Once when he had to stay at home to tend to his sick children, we discussed my thesis in his living room."

Aims

This programme is designed for students with a Bachelor’s background in mathematics. After completing the programme, you will have sufficient expertise in mathematical sciences to be able to work in a research-oriented position in industry, business and many other services, as well as to continue studying in a PhD programme. Studying mathematical sciences gives you a way of thinking which can also prove very useful in a professional career in which mathematics itself plays no direct role (e.g. in management or banking). Current employment prospects for mathematics graduates are good.



Why choose Utrecht?

- Two-year programme taught entirely in English
- the programme is consistently at the top of research rankings
- High-quality education
- International learning environment
- Opportunity to design your own study programme

Rational Points on Curves

This course is rooted in the theory of diophantine equations, in particular equations of the form $F(x,y)=0$ in the unknowns x,y which are required to be integral or rational. The function F is a polynomial in two variables. Diophantine equations belong to the most classical branches of mathematics, dating back to Diophantus of Alexandria (~200 AD). Alternatively, one can consider the problem of solving $F(x,y)=0$ in rationals or integers as the problem of finding points with rational or integer coordinates on the algebraic curve $F(x,y)=0$. This geometric point of view enables us to invoke techniques from geometry into our methods of solution. A highlight was Faltings’ theorem (1983) on the finiteness of the rational points on algebraic curves. We discuss some basic facts of the geometry of algebraic curves and devote attention to the classical theorem of Siegel on integer points and Faltings’ theorem on rational points on curves. We also discuss several special cases in which a complete solution is possible.

Ergodic Theory

Ergodic theory goes back to Boltzmann’s ergodic hypothesis concerning the equality of the time mean and the space mean of molecules in a gas. The evolution of ergodic theory is represented by the repeated application of a single map or by repeated applications of two or more commuting maps in case of ‘higher dimensional discrete time’. The first major contribution in ergodic theory is the generalisation of the strong law of large numbers to stationary and ergodic processes. This is known as the Birkhoff ergodic theorem. The second contribution is the introduction of entropy to ergodic theory by Kolmogorov. This notion was borrowed from the notion of entropy in information theory defined by Shannon. Roughly speaking, entropy is a measure of randomness of the system or the average information acquired under a single application of the underlying map. Entropy can be used to decide whether two ergodic systems are not ‘the same’.

Stochastics and Financial Mathematics

6

Randomness and chance play a crucial role in almost every aspect of life. This is not just apparent in the fluctuation of the price of stocks or the length and duration of a waiting list for an important medical operation, but also in weather, movements of molecules in a gas, and the evolution of a biological system. The aim of this programme is to provide you with a profound theoretical and practical background in probability theory and statistics, as well as its applications in other fields such as financial mathematics.

The Stochastics and Financial Mathematics programme is attractive not only for students with a Bachelor's degree in mathematics, but also in econometrics, actuarial sciences or any science degree that provides a basic knowledge of measure theory, probability theory and statistics. Graduates will be well prepared either to enrol in a PhD programme or to become a scientific researcher in a research laboratory, bank or a consultancy firm.

Structure

The programme is worth 120 ECTS points, which is equivalent to two years full-time study. It consists of 84 ECTS for courses plus one semester that is dedicated to writing your Master's thesis. During the first three semesters, you make a balanced choice of four to five courses per semester. Measuring Theoretic Probability is the only compulsory course. You can also follow one or two of the national courses from the Dutch Master programme (see the outline of the Mathematical Sciences programme). You will choose your preferred courses from the following list (which may vary slightly each year):

First year

- Measure Theoretic Probability
- Asymptotic Statistics
- Stochastic Optimisation
- Semiparametric Statistics
- Stochastic Processes for Finance
- Bayesian Statistics
- Industrial Statistics Financial Time Series
- Stochastic Integration
- Stochastic Processes
- High-dimensional data and multivariable analysis
- Stochastic Models for Genetic Evolution
- Critical Percolation, Conformal Invariance and Stochastic Loewner Evolution.

Second year

- Financial Stochastics Levy Processes
- Simulation Methods in Statistics Ergodic Theory
- Control of Stochastic Systems in Continuous Time
- Stochastic Models for Telecommunication Systems
- Portfolio Theory.

The last semester in the second year is devoted completely to your Master's thesis, under the supervision of at least one staff member from the Department of Mathematics at Utrecht University. The research leading up to your thesis can also take place in the form of an internship in the private sector.

Joint programme

Stochastics and Financial Mathematics is a joint programme with the VU Amsterdam, the University of Amsterdam and Leiden University. Depending on the course, lectures may be held in Utrecht, Amsterdam or Leiden.

Karma Dajani (associate professor)



"I am very proud to be part of this team"

"I'm driven to understand how things work at a fundamental level. Working as a mathematician is sometimes like entering a world with its own laws. There are different layers and levels of understanding and truth. Understanding

a new result is a strangely satisfying experience. For a moment, the world makes sense, and everything seems to be in its right place. This feeling of satisfaction and surge of energy comes when I see how the results can be applied in the world around us, certainly after working hard on a problem. There is little that compares to this.

My educational task is to offer courses close to my area of specialty and its applications in financial mathematics and

ergodic theory. Another key aspect, which I particularly enjoy because you contribute to helping students, is being the thesis advisor of the Stochastics and Financial Mathematics Master's programme.

I have the feeling that exciting things are happening in this department and that everyone is part of it. I am very proud to be part of this team."

Career prospects

After graduation you will receive the title Master of Science in Mathematics (MSc), specialising in Scientific Computing, Mathematical Sciences or Stochastics and Financial Mathematics. Regardless of the focus, this programme will provide you with a solid background in your field. In addition to entitling you to do research on various mathematical subjects as a PhD student, your title opens up many employment opportunities. Job applicants with extensive mathematical knowledge are much in demand.

Mathematical Sciences

Examples of mathematical areas and organisations in which our graduates are engaged:

- Efficient flow scheduling in resource sharing networks (CWI)
- Nonresponse adjustments using random forests (CBS)
- Geomagnetic reversals and stochastic processes (SRON-ESA)
- American stock options on a jump-diffusion model (Saen)

Scientific Computing

Positions acquired by graduates during the past year:

- Software developer at a stock exchange trading company
- Researcher at a bank risk management department
- Leader of a software development group (Ortec)
- Scientific programmer working on image processing (University Medical Centre Utrecht)

Graduate School of Natural Sciences

Talented Master's and PhD students at the Utrecht Graduate School of Natural Sciences (GSNS) acquire the knowledge, skills and insight needed to take on top positions around the world, including those in research. Graduates receive a sound academic training and gain an excellent understanding of the role played by the natural sciences in contemporary society. The GSNS provides a thorough fundamental scientific education, which you can adapt to your own needs by choosing specific courses and research subjects. Some of our Master's programmes, such as Game and Media Technology as well as Meteorology, Physical Oceanography and Climate, are unique worldwide.

Each year we organise several summer schools, teaching topics related to our Master's programmes. The Graduate School also facilitates incoming Master's student exchanges within the context of the Erasmus programme. Participating in a summer



Stochastics and Financial Mathematics

Available positions for our graduates include:

- Researcher, statistician or data analyst at a major company such as Shell, TNO, RIVM, Deloitte, and a number of major insurance companies
- Financial consultant at a financial organisations (e.g. at AOT or ING).

school or an exchange programme is a great opportunity to get to know our educational philosophy, the open and professional atmosphere here in the University, and the city of Utrecht.

All Utrecht Master's programmes that include mathematics, information and computer science, cognitive artificial intelligence, physics, and chemistry are taught within the GSNS. In order to ensure a high level of research in an international environment, we combine cutting-edge research with academic skills in our training, much of which is multidisciplinary.

In Utrecht we combine research and education in a natural way. All GSNS Master's programmes are firmly embedded in renowned Utrecht research institutes, which are equipped with modern facilities. The eight institutes and the Graduate School offer PhD students a stimulating environment in which to work, including contacts with top-class researchers such as Nobel Prize winning physicist Professor Gerard 't Hooft.

Practical matters

Mathematical Sciences

Duration: Two years

Language: English

Start date: 1 September, 1 February

Degree: Master of Science

Entrance requirements: Applicants should have a higher education degree and have knowledge of mathematics, equivalent to that of a University Utrecht BSc in Mathematics with a major in Mathematics.

Scientific Computing

Duration: Two years

Language: English

Start date: 1 September, 1 February

Degree: Master of Science

Entrance requirements: Applicants should have a BSc degree or equivalent in a science subject with a strong mathematics component. In particular, knowledge of calculus, linear algebra and elementary numerical methods, as well as some programming experience in a common programming language (e.g. C, C++ or Java) are required.

Stochastics and Financial Mathematics

Duration: Two years

Language: English

Start date: 1 September, 1 February

Degree: Master of Science

Entrance requirements: Applicants should have a BSc in Mathematics or a BSc with a strong mathematical component (e.g. physics, econometrics, actuarial sciences,

computer science or biology).

Admissions procedure

All admissions will be decided by the Admissions Committee, which may admit candidates conditionally or unconditionally. Applicants admitted conditionally must first complete certain courses to bring their knowledge up to the required level. A good knowledge of English is required for all students. Foreign students must pass the Test of English as a Foreign Language (TOEFL).

Application

There are three different deadlines for application:

'Early bird' deadline: for students who wish to apply for scholarships elsewhere or need an early notification of admission.

Main deadline: for students who completed their previous education outside the Netherlands.

Late deadline: for students from Utrecht University, other Dutch universities or institutions for higher professional education (HBO) and for students with foreign qualifications who do not need a visa or housing arranged by the university.

The specific deadlines and application forms for students with a Dutch qualification are available online at www.uu.nl/masters.

The specific deadlines and application forms for students with a foreign qualification

are available online at www.uu.nl/internationalmasters.

Tuition

All students who register at Utrecht University must pay annual tuition fees. Information on the current annual tuition fee can be found online (www.uu.nl/financialmatters).

Utrecht Feel at Home Service

To emphasise Utrecht's international orientation, Utrecht University offers the unique 'Utrecht Feel at Home Service', which guarantees housing to its foreign students and offers, for example, support for visa applications and financial assistance.

Further information

Study advisors

Mathematical Sciences: I.A.Kouznetsov@uu.nl

Scientific Computing: R.H.Bisseling@uu.nl

Stochastics and Financial Mathematics: K.Dajani1@uu.nl

Dutch Master's programme in Mathematics

www.mastermath.nl

For application and admission see

www.uu.nl/masters (for Dutch students)

www.uu.nl/internationalmasters (for international students)

On these websites you can also find the application deadlines and the general requirements for the prospective master students.

Frequently Asked Questions: www.uu.nl/qdesk

Financial information: www.grantfinder.nl